United States Patent Application Publication	20250256500
Kind Code	A1
Publication Date	August 14, 2025
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DISPLAY DEVICE, AND METHOD AND APPARATUS FOR MANUFACTURING THE SAME

Abstract

A display device includes a cover window including a curved portion, and a panel member laminated on the cover window. A method of manufacturing a display device includes mounting a cover window including a curved portion on a first jig including a curved portion, mounting a panel member on a second jig that conforms to a surface of the first jig, and laminating the cover window to the panel member by moving a first one of the first jig or the second jig to a first other one of the first jig or the second jig. An apparatus for manufacturing a display device includes a first jig including a mount surface that is partially curved to conform to a surface of a cover window, a second jig including a surface conforming to the mount surface and configured to contact a panel member, and a driving unit.

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Family ID: **48771287**

Appl. No.: **19/195487**

Filed: **April 30, 2025**

Foreign Application Priority Data

KR	10-2012-0071375	Jun. 29, 2012
KR	10-2013-0014650	Feb. 08, 2013
KR	10-2013-0062110	May. 30, 2013

Related U.S. Application Data

parent US continuation 18297586 20230407 parent-grant-document US 12317428 child US 19195487

Publication Classification

Int. Cl.: **B32B38/18** (20060101); **B32B3/04** (20060101); **B32B3/28** (20060101); **B32B7/12** (20060101); **B32B37/00** (20060101); **B32B37/18** (20060101); **B32B37/30** (20060101); **H05K5/02** (20060101); **H10K50/84** (20230101); **H10K59/80** (20230101)

U.S. Cl.:

CPC **B32B38/1866** (20130101); **B32B3/04** (20130101); **B32B3/28** (20130101); **B32B7/12** (20130101); **B32B37/0046** (20130101); **B32B37/18** (20130101); **B32B37/30** (20130101); **B32B38/1841** (20130101); **H05K5/0217** (20130101); **H10K50/841** (20230201); **H10K59/871** (20230201); B32B2307/412 (20130101); B32B2457/20 (20130101); B32B2457/206 (20130101); B32B2457/208 (20130101); Y10T156/10 (20150115); Y10T156/1002 (20150115); Y10T156/1744 (20150115); Y10T428/24628 (20150115); Y10T428/24653 (20150115)

Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS [0001] This application is a continuation of divisional of U.S. application Ser. No. 18/297,586, filed on Apr. 7, 2023, and claims priority to and the benefit of U.S. application Ser. No. 14/794,720, filed on Jul. 8, 2015, now U.S. Pat. No. 11,627,670, issued on Apr. 11, 2023, which is a continuation of U.S. patent application Ser. No. 13/931,795, filed on Jun. 28, 2013, now U.S. Pat. No. 11,523,522 B2, issued on Dec. 6, 2022, which claims priority to and the benefit of Korean Patent Application Nos. 10-2012-0071375, filed on Jun. 29, 2012, 10-2013-0014650, filed on Feb. 8, 2013, and 10-2013-0062110, filed on May 30, 2013 in the Korean Intellectual Property Office, the entire contents of all of which are incorporated herein by reference.

BACKGROUND
1. Field
[0002] Aspects of embodiments of the present invention relate to a display device, and a method and apparatus for manufacturing the display device.
2. Description of the Related Art
[0003] Electronic devices based on portability are widely used. Portable electronic devices that have recently been widely used include small electronic devices such as mobile phones as well as tablet personal computers (PCs). In order to support various functions, portable electronic devices include a display device for providing visual information such as an image to a user. Recently, as sizes of components for driving display devices have decreased, the importance of display devices in electronic devices has increased. Accordingly, display devices (such as flexible display devices) that bend at a set angle (for example, a predetermined angle) have been developed.
[0004] In general, flexible display devices that may bend at a set angle may be manufactured using a flexible process, such as being flexibly manufactured. Since a flexible display device may be formed of a flexible material, the flexible display device may have any of various shapes. A flexible display device may be manufactured by forming a light-emitting unit on a substrate to form a display unit, and sealing the display unit by using an encapsulation unit, which may increase a lifetime of the display unit. The substrate may be formed of a flexible material, and the

encapsulation unit may be formed, for example, as a substrate or a thin film. As designs of electronic devices have recently been diversified, demands for flexible display devices have increased.

SUMMARY

[0005] Embodiments of the present invention provide for a display device having a curved shape (for example, having an arc shape or a degree of curvature) that may enable efficient mass production, high reliability, and high quality. Further embodiments provide for a method and apparatus for manufacturing the display device.

[0006] According to an embodiment of the present invention, a display device is provided. The display device includes a cover window including a curved portion, and a panel member laminated on the cover window.

[0007] The panel member may be smaller in at least one of a length or a width than the cover window.

[0008] The display device may further include an adhesive layer between the panel member and the cover window.

[0009] The cover window may further include a flat portion extending from the curved portion.

[0010] The panel member may be laminated entirely on the flat portion.

[0011] The curved portion may include a plurality of curved portions.

[0012] The panel member may include a first panel portion laminated on the flat portion, and a second panel portion extending in a curved shape from the first panel portion and laminated on the curved portion.

[0013] The cover window may have a curved surface having a curvature radius.

[0014] A curvature radius of a portion of the cover window may be different from a curvature radius of another portion of the cover window.

[0015] The panel member may be formed on a recessed outer surface of the cover window or a protruding outer surface of the cover window.

[0016] The panel member may include at least one of a display panel or a touch screen panel (TSP).

[0017] The panel member may be flexible.

[0018] According to another embodiment of the present invention, a method of manufacturing a display device is provided. The method includes mounting a cover window including a curved portion on a first jig including a curved portion, mounting a panel member on a second jig that conforms to a surface of the first jig, and laminating the cover window to the panel member by moving a first one of the first jig or the second jig to a first other one of the first jig or the second jig.

[0019] At least a portion of the panel member may contact a surface of the second jig.

[0020] The panel member may be bent along an outer surface of the second jig during the mounting of the panel member on the second jig.

[0021] The panel member may be smaller in at least one of a length or a width than the cover window.

[0022] The panel member may be flat during the mounting of the panel member on the second jig. The laminating of the cover window to the panel member may include partially curving the panel member by the moving of the first one of the first jig or the second jig.

[0023] The first one of the first jig or the second jig may be above the first other one of the first jig or the second jig, or the first other one of the first jig or the second jig may be above the first one of the first jig or the second jig.

[0024] A second one of the first jig or the second jig may be formed by protruding toward or recessing away from a second other one of the first jig or the second jig.

[0025] The second other one of the first jig or the second jig may be formed by recessing away from or protruding toward the second one of the first jig or the second jig.

[0026] The mounting of the panel member may include fixing the panel member to the second jig.
[0027] The panel member may be flexible.
[0028] Outer surfaces of the cover window and the first jig may be curved surfaces each having a curvature radius.
[0029] A curvature radius of a portion of the cover window may be different from a curvature radius of another portion of the cover window. A curvature radius of a portion of an outer surface of the first jig may be different from a curvature radius of another portion of the outer surface of the first jig.
[0030] The panel member may be attached to a recessed outer surface of the cover window or a protruding outer surface of the cover window.
[0031] The panel member may include at least one of a display panel or a touch screen panel (TSP).
[0032] According to yet another embodiment of the present invention, an apparatus for manufacturing a display device is provided. The apparatus includes a first jig including a mount surface that is partially curved to conform to a surface of a cover window, a second jig including a surface conforming to the mount surface and configured to contact a panel member, and a driving unit connected to a first one of the first jig or the second jig and configured to move the first one of the first jig or the second jig.
[0033] The first jig may further include a first fixing unit for fixing the cover window to the mount surface. The second jig may further include a second fixing unit for fixing the panel member to the surface conforming to the mount surface.
[0034] The first fixing unit or the second fixing unit may include an absorption unit, and an absorption pump for evacuating air from the absorption unit.
[0035] The apparatus may further include a cushion unit at an outer surface of at least one of the first jig or the second jig.
[0036] The cushion unit may include a plurality of cushion units at respective ends of the at least one of the first jig or the second jig. A distance between the cushion units may be less than at least one of a length or a width of the panel member.
[0037] A second one of the first jig or the second jig may be formed by protruding toward or recessing away from another one of the first jig or the second jig.
[0038] The other one of the first jig or the second jig may be formed by recessing away from or protruding toward the second one of the first jig or the second jig.
[0039] An outer surface of the cover window and an outer surface of the first jig on which the cover window is configured to be seated may be curved surfaces each having a curvature radius.
[0040] A curvature radius of a portion of the cover window may be different from a curvature radius of another portion of the cover window. A curvature radius of a portion of an outer surface of the first jig on which the cover window is configured to be seated may be different from a curvature radius of another portion of the outer surface of the first jig.
[0041] The panel member may be configured to be attached to a recessed outer surface of the cover window or a protruding outer surface of the cover window.
[0042] The panel member may include at least one of a display panel or a touch screen panel (TSP).
[0043] The apparatus may further include a clamping unit spaced from the second jig and configured to support the panel member.
[0044] The clamping unit may include a plurality of clamping units. A distance between the clamping units may be less than at least one of a length or a width of the panel member when the clamping units support the panel member.
[0045] The apparatus may further include a linear driving unit coupled to the clamping unit and configured to linearly move the clamping unit.
[0046] The linear driving unit may be further configured to linearly move the clamping unit in a

same direction as a moving direction of the second jig.
[0047] The linear driving unit may be further configured to linearly move the clamping unit in a diagonal direction of a moving direction of the second jig.
[0048] At least one of the first jig or the second jig may further include a cushion unit at an outer surface of the at least one of the first jig or the second jig.
[0049] A second one of the first jig or the second jig may be formed by protruding toward or recessing away from another one of the first jig or the second jig.
[0050] The other one of the first jig or the second jig may be formed by protruding toward or recessing away from the second one of the first jig or the second jig.
[0051] An outer surface of the cover window and an outer surface of the first jig on which the cover window is configured to be seated may be curved surfaces each having a curvature radius.
[0052] A curvature radius of a portion of the cover window may be different from a curvature radius of another portion of the cover window. A curvature radius of a portion of an outer surface of the jig on which the cover window is configured to be seated may be different from a curvature radius of another portion of the outer surface of the first jig.
[0053] The panel member may be configured to be attached to a recessed outer surface of the cover window or a protruding outer surface of the cover window.
[0054] The panel member may include least one of a display panel or a touch screen panel (TSP).

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0055] The above and other features and aspects of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:
[0056] FIG. **1** is a cross-sectional view illustrating a display device according to an embodiment of the present invention;
[0057] FIG. **2** is a cross-sectional view illustrating a display panel of the display device of FIG. **1**;
[0058] FIG. **3** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **1** according to an embodiment of the present invention;
[0059] FIGS. **4**A through **4**C are cross-sectional views illustrating a method of manufacturing the display device of FIG. **1** according to an embodiment of the present invention;
[0060] FIG. **5** is a cross-sectional view illustrating a display device according to another embodiment of the present invention;
[0061] FIG. **6** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **5** according to an embodiment of the present invention;
[0062] FIGS. **7**A through **7**C are cross-sectional views illustrating a method of manufacturing the display device of FIG. **5** according to an embodiment of the present invention;
[0063] FIG. **8** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **5** according to another embodiment of the present invention;
[0064] FIGS. **9**A through **9**C are cross-sectional views illustrating a method of manufacturing the display device of FIG. **5** according to another embodiment of the present invention;
[0065] FIG. **10** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **5** according to yet another embodiment of the present invention;
[0066] FIG. **11** is a cross-sectional view illustrating a method of manufacturing the display device of FIG. **5** according to yet another embodiment of the present invention;
[0067] FIG. **12** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **5** according to still yet another embodiment of the present invention; and
[0068] FIG. **13** is a cross-sectional view illustrating a method of manufacturing the display device

of FIG. **5** according to still yet another embodiment of the present invention.
[0069] FIG. **14** is a cross-sectional view illustrating a display device according to yet another embodiment of the present invention;
[0070] FIG. **15** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **14**, according to an embodiment of the present invention;
[0071] FIG. **16** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **14**, according to another embodiment of the present invention;
[0072] FIG. **17** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **14**, according to yet another embodiment of the present invention;
[0073] FIG. **18** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **14**, according to still yet another embodiment of the present invention;
[0074] FIG. **19** is a cross-sectional view illustrating a display device according to still yet another embodiment of the present invention;
[0075] FIG. **20** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **19**, according to an embodiment of the present invention;
[0076] FIG. **21** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **19**, according to another embodiment of the present invention;
[0077] FIG. **22** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **19**, according to yet another embodiment of the present invention;
[0078] FIG. **23** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **19**, according to still yet another embodiment of the present invention;
[0079] FIG. **24** is a cross-sectional view illustrating a display device according to still another embodiment of the present invention;
[0080] FIG. **25** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **24**, according to an embodiment of the present invention;
[0081] FIG. **26** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **24**, according to another embodiment of the present invention;
[0082] FIG. **27** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **24**, according to yet another embodiment of the present invention;
[0083] FIG. **28** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **24**, according to still yet another embodiment of the present invention;
[0084] FIG. **29** is a cross-sectional view illustrating a display device according to a sixth embodiment of the present invention;
[0085] FIG. **30** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **29**, according to an embodiment of the present invention;
[0086] FIG. **31** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **29**, according to another embodiment of the present invention;
[0087] FIG. **32** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **29**, according to yet another embodiment of the present invention;
[0088] FIG. **33** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **29**, according to still yet another embodiment of the present invention;
[0089] FIG. **34** is a cross-sectional view illustrating a display device according to a seventh embodiment of the present invention;
[0090] FIG. **35** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **34**, according to an embodiment of the present invention;
[0091] FIG. **36** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **34**, according to another embodiment of the present invention;
[0092] FIG. **37** is a cross-sectional view illustrating an apparatus for manufacturing the display device of FIG. **34**, according to yet another embodiment of the present invention;
[0093] FIG. **38** is a cross-sectional view illustrating an apparatus for manufacturing the display

device of FIG. **34**, according to still yet another embodiment of the present invention.

DETAILED DESCRIPTION

[0094] Hereinafter, the present invention will be described more fully with reference to the accompanying drawings, in which exemplary embodiments are shown. The present invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. These embodiments are provided to make this disclosure more thorough, and to help convey concepts of the invention to one of ordinary skill in the art. The terminology used herein is for describing particular embodiments only and is not intended to be limiting of the present invention.

[0095] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be understood that, although the terms first, second, third, etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element.

[0096] In the embodiments of the present invention, examples of display devices include various display devices. For example, examples of display devices include liquid crystal display devices and organic light-emitting display devices. However, for convenience of description, it will be assumed that the display devices are organic light-emitting display devices. Herein, the use of the term "may," when describing embodiments of the present invention, refers to "one or more embodiments of the present invention." In addition, the use of alternative language, such as "or," when describing embodiments of the present invention, refers to "one or more embodiments of the present invention" for each corresponding item listed.

[0097] FIG. **1** is a cross-sectional view illustrating a display device **100** according to an embodiment of the present invention. FIG. **2** is a cross-sectional view illustrating a display panel **130** of the display device **100** of FIG. **1**.

[0098] Referring to FIGS. **1** and **2**, the display device **100** includes a cover window **110**, a panel member (for example, display panel **130**), and an adhesive layer **120**. In FIG. **1**, the cover window **110** is partially curved. That is, the cover window **110** has a flat portion **111** (on which the display panel **130** is laminated, with the adhesive layer **120** therebetween) and at least one end of the flat portion **111** is curved (e.g., a curved portion **112**). As shown in FIG. **1**, both ends of the flat portion **111** are curved (e.g., two curved portions **112**). As depicted, the cover window **110** includes the flat portion **111** and curved portions **112** that extend from the flat portion **111**. The curved portions **112** are formed on both ends of the flat portion **111**.

[0099] The panel member may include at least one of the display panel **130** or a touch screen panel (TSP). In one embodiment, the panel member may include only the display panel **130** and may be attached to the cover window **110**. In another embodiment, the panel member may include only the TSP and may be attached to the cover window **110**. In yet another embodiment, the panel member may include the display panel **130** and the TSP, and may be attached to the cover window **110**. However, for convenience of description, it will be assumed that the panel member includes only the display panel **130**.

[0100] The display panel **130** may be flexible. The display panel **130** may be formed such that a size of the display panel **130** is different from a size of the cover window **110**. As shown, the display panel **130** is smaller than the cover window **110**. For example, the display panel **130** is shorter in the at least one of a length or a width than the cover window **110** (due to the inward

curvature of the cover window **110**). For convenience of description, it will be assumed that the display panel **130** is shorter in width than the cover window **110** as described below in further detail. For example, the display panel **130** may be laminated entirely on the flat portion **111** (and not on any of the curved portions **112**). The display panel **130** includes a first substrate S and a light-emitting unit.

[0101] The display panel **130** may include an encapsulation unit B formed on the light-emitting unit. The encapsulation unit B may be formed as a thin film. In another embodiment, the encapsulation unit B may include a second substrate instead of or in addition to a thin film. For convenience of description, however, it will be assumed that the encapsulation unit B is formed as a thin film.

[0102] In FIG. **2**, the light-emitting unit is formed on the first substrate S. The light-emitting unit includes a thin film transistor (TFT, in this case a driving TFT), a passivation film **131** formed to cover the TFT, and an organic light-emitting device, such as an organic light emitting diode (OLED) **138** formed on the passivation film **131**. The first substrate S may be formed of a glass material, but the present invention is not limited thereto and, in other embodiments, the first substrate S may be formed of a plastic material or a metal material such as steel use stainless (SUS, or stainless steel) or titanium (Ti). In another embodiment, the first substrate S may include polyimide (PI). For convenience of description, it will be assumed that the first substrate S is formed of PI.

[0103] A buffer layer **132** formed of an organic compound and/or an inorganic compound such as SiOx (x≥1) or SiNx (x≥1) is formed on a top surface of the first substrate S. An active layer **133** having a set pattern (for example, a predetermined pattern) is formed on the buffer layer **132**, and then is covered by a gate insulating layer **134**. The active layer **133** includes a source region **133***a* and a drain region **133***c*, and a channel region **133***b* located between the source region **133***a* and the drain region **133***c*. The active layer **133** may be formed by forming an amorphous silicon film on the buffer layer **132**, crystallizing the amorphous silicon film to form a polycrystalline silicon film, and patterning the polycrystalline silicon film. The source and drain regions **133***a* and **133***c* of the active layer **133** are doped with impurities according to a type of the TFT such as a driving TFT (for example, driving TFT in FIG. **2**) or a switching TFT.

[0104] A gate electrode **135** corresponding to the channel region **113***b* of the active layer **133** and an interlayer insulating layer **136** covering the gate electrode **135** are formed on a top surface of the gate insulating layer **134**. After contact holes (for example, via-hole H**1**) are formed in the interlayer insulating layer **136** and the gate insulating layer **134**, a source electrode **137***a* and a drain electrode **137***b* are formed on the interlayer insulating layer **136** to respectively contact the source region **133***a* and the drain region **133***c*.

[0105] In some embodiments, a reflective film is formed at the same time (for example, in the same layer) as the source/drain electrodes **137***a* and **137***b* are formed as described above. Accordingly, each of the source/drain electrodes **137***a* and **137***b* may be formed of a material having high electrical conductivity and having a thickness great enough to reflect light. Each of the source/drain electrodes **137***a* and **137***b* may be formed of a metal material such as silver (Ag), magnesium (Mg), aluminum (AI), platinum (Pt), palladium (Pd), gold (Au), nickel (Ni), neodymium (Nd), iridium (Ir), chromium (Cr), lithium (Li), calcium (Ca), or a compound or alloy thereof.

[0106] The passivation film **131** is formed on the TFT. Then a pixel electrode **138***a* of the OLED **138** is formed on the passivation film **131**. The pixel electrode **138***a* contacts the drain electrode **137***b* of the TFT through a via-hole H**2** formed in the passivation film **131**. The passivation film **131** may be formed of an inorganic material and/or an organic material and have a single-layer structure or a multi-layer structure. As shown in FIG. **2**, the passivation film **131** is formed as a planarization film having a flat top surface regardless of any roughness or irregularities of a bottom surface. The passivation film **131** may be formed of a transparent insulating material to achieve a resonance effect.

[0107] After the pixel electrode **138***a* is formed on the passivation film **131**, a pixel-defining film **139** is formed of an organic material and/or an inorganic material to cover the pixel electrode **138***a* and the passivation film **131**, and is opened to expose the pixel electrode **138***a*. An organic light-emitting layer **138***b* and a counter electrode **138***c* are formed on at least the pixel electrode **138***a*. The pixel electrode **138***a* functions as an anode and the counter electrode **138***c* functions as a cathode, or vice versa.

[0108] The pixel electrode **138***a* may be formed of a material having a high work function, such as indium tin oxide (ITO), indium zinc oxide (IZO), In.sub.2O.sub.3, or ZnO. The counter electrode **138***c* may be formed of a metal material having a low work function such as Ag, Mg, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, or a compound or alloy thereof. For example, the counter electrode **138***c* may be formed of Mg, Ag, or Al to have a small thickness to function as a semi-transmissive reflective film. Accordingly, the counter electrode **138***c* may optically resonate to transmit light.

[0109] The pixel electrode **138***a* and the counter electrode **138***c* are insulated from each other by the organic light-emitting layer **138***b*, and apply voltages of different polarities to the organic light-emitting layer **138***b* for the organic light-emitting layer **138***b* to emit light. The organic light-emitting layer **138***b* may be formed of a low molecular weight organic material or a high molecular weight organic material.

[0110] If the organic light-emitting layer **138***b* is formed of a low molecular weight organic material, the light-emitting layer **138***b* may have a single-layer or multi-layer structure formed by stacking a hole injection layer (HIL), a hole transport layer (HTL), an emission layer (EML), an electron transport layer (ETL), and an electron injection layer (EIL). Examples of the low molecular weight organic material include copper phthalocyanine (CuPc), N,N′-Di(naphthalene-1-yl)-N,N′-diphenyl-benzidine (NPB), and tris-8-hydroxyquinoline aluminum (Alq3). The low molecular weight organic material is formed by using vacuum deposition. The HIL, the HTL, the ETL, and the EIL may be commonly applied to red, green, and blue pixels. Accordingly, in some embodiments, the common layers may cover all pixels, like the counter electrode **138***c*.

[0111] If the organic light-emitting layer **138***b* is formed of a high molecular weight organic material, the organic light-emitting layer **138***b* may have a structure including an HTL and an EML. The HTL may be formed of poly(3,4-ethylenedioxythiophene) (PEDOT) and the EML may be formed of a high molecular weight organic material based on polyphenylene vinylene (PPV) or polyfluorene. The high molecular weight organic material may be formed by using screen printing or inkjet printing. The organic light-emitting layer **138***b* is not limited thereto, and various examples may be formed, applied, deposited, etc., as would be apparent to one of ordinary skill in the art.

[0112] The encapsulation unit B may be formed as a thin film as described above. In further detail, the encapsulation unit B may be formed by alternately stacking at least one organic layer and at least one inorganic layer. In some embodiments, a plurality of inorganic layers or a plurality of organic layers may be provided.

[0113] The organic layer may be formed of a polymer, and may have a single-layer structure or a multi-layer structure formed of one or more selected from the group including polyethylene terephthalate, polyimide, polycarbonate, epoxy, polyethylene, and polyacrylate. In one embodiment, the organic layer may be formed of polyacrylate. In further detail, the organic layer may be formed by polymerizing a monomer composition including a diacrylate-based monomer and a triacrylate-based monomer. A monoacrylate-based monomer may be further included in the monomer composition. In one embodiment, a well-known photoinitiator such as TPO may be further included in the monomer composition, but other embodiments of the present embodiment are not necessarily limited thereto.

[0114] The inorganic layer may have a single-layer structure or a multi-layer structure including a metal oxide or a metal nitride. In further detail, the inorganic layer may include one or more selected from the group including SiNx, Al.sub.2O.sub.3, SiO.sub.2, and TiO.sub.2. In one

embodiment, an uppermost layer of the encapsulation unit B that is exposed to the outside may be an inorganic layer to reduce or prevent moisture from penetrating into the organic light-emitting device.

[0115] The encapsulation unit B may have at least one sandwich structure in which at least one organic layer is inserted between at least two inorganic layers. In another embodiment, the encapsulation unit B may have at least one sandwich structure in which at least one inorganic layer is inserted between at least two organic layers.

[0116] The encapsulation unit B may include a first inorganic layer, a first organic layer, and a second inorganic layer that are sequentially stacked on the display unit. In another embodiment, the encapsulation unit B may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, and a third inorganic layer that are sequentially stacked on the light-emitting unit. In another embodiment, the encapsulation unit B may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, a third inorganic layer, a third organic layer, and a fourth inorganic layer that are sequentially stacked on the light-emitting unit.

[0117] A halogenated metal layer including LiF may be further disposed between the light-emitting unit and the first inorganic layer. The halogenated metal layer may reduce or prevent the light-emitting unit from being damaged when the first inorganic layer is formed by using sputtering or plasma deposition.

[0118] The first organic layer may have an area smaller than that of the second inorganic layer, and the second organic layer may have an area smaller than that of the third inorganic layer. In one embodiment, the first organic layer may be completely covered by the second inorganic layer, and the second organic layer may be completely covered by the third inorganic layer.

[0119] The encapsulation unit B may include a second substrate as described above. The second substrate may be formed similarly to the first substrate S. For example, the second substrate may be formed of a glass material, but like the first substrate S, the present invention is not limited thereto and, in other embodiments, the second substrate may be formed of a different material, such as a plastic material.

[0120] The display device **100** may include a touch panel formed on the display panel **130** as described above. The touch panel may be located between the display panel **130** and the adhesive layer **120**. In other embodiments, the touch panel may be a panel positioned on the display panel **130**. For example, the touch panel may be formed on the encapsulation unit B. In another embodiment, the touch panel may be formed on the cover window **110** to have a panel shape or to have a pattern. As a method of forming a touch panel is well known to one of ordinary skill in the art, a detailed description thereof will not be given. In addition, for convenience of description, it will be assumed that a touch panel is not formed on the display panel **130**.

[0121] The display device **100** includes the adhesive layer **120** that is located between the display panel **130** and the cover window **110**. The adhesive layer **120** may be variously formed. For example, the adhesive layer **120** may include an adhesive film such as an optical clear adhesive (OCA) film or an adhesive material.

[0122] The adhesive layer **120** may have the same size as the display panel **130**. In other embodiments, the adhesive layer **120** may be smaller than the display panel **130**. The adhesive layer **120** is attached to one surface of the display panel **130** to laminate the display panel **130** to the cover window **110**. For example, the adhesive layer **120** may be applied to the encapsulation unit B.

[0123] Accordingly, the display device **100** that is partially curved may be attached to various electronic devices, and may easily display images having various shapes. A method of manufacturing the display device **100** will now be described with reference to FIGS. **3** through **4**C.

[0124] FIG. **3** is a cross-sectional view illustrating an apparatus **200** for manufacturing the display device **100** of FIG. **1** according to an embodiment of the present invention. FIGS. **4**A through **4**C are cross-sectional views illustrating a method of manufacturing the display device **100** of FIG. **1**

according to an embodiment of the present invention. The same elements as those in FIG. **1** are denoted by the same reference numerals.

[0125] Referring to FIGS. **3** through **4**C, the apparatus **200** includes a first jig **210** that is partially curved and has a mount surface **211** that conforms to one surface of the cover window **110**. In FIGS. **3** through **4**C, the first jig **210** has a shape similar to that of the cover window **110**. That is, the mount surface **211** of the first jig **210** is curved. In addition, the mount surface **211** has a flat portion on which the flat portion **111** of the cover window is mounted and the mount surface **211** has curved portions on which the curved portions **112** of the cover window are mounted. For example, the mount surface **211** may be formed by being recessed in the first jig **210**.

[0126] The apparatus **200** includes a second jig **220** that detachably couples to the first jig **210**. One surface of the second jig **220** conforms to the mount surface **211**. In FIGS. **3** through **4**C, one surface of the second jig **220** is curved in places to conform to the portions of the mount surface **211** that are curved, and is flat in places to conform to the portion of the mount surface **211** that is flat. That is, the second jig **220** is curved such that the second jig **220** protrudes toward the first jig **210**. The display panel **130** is mounted on the flat surface of the second jig **220**.

[0127] At least one of the first jig **210** or the second jig **220** may be formed of an elastic material. In addition, at least one of the first jig **210** or the second jig **220** may be formed of a hard material.

[0128] In particular, the elastic material may be a soft material having an elastic force such as silicon, rubber, or a soft synthetic resin. The hard material may be a material having a high hardness such as reinforced plastic or a metal.

[0129] Materials of the first jig **210** and the second jig **220** may be selected in various ways. For example, the first jig **210** may be formed of a metal and the second jig **220** may be formed of silicon. In another embodiment, the first jig **210** may be formed of rubber and the second jig **220** may be formed of plastic. However, for convenience of description, it will be assumed that both the first jig **210** and the second jig **220** are formed of hard materials.

[0130] The apparatus **200** may include a driving unit (such as second driving unit **225**) that is connected to at least one of the first jig **210** or the second jig **220**, and that moves the corresponding at least one of the first jig **210** or the second jig **220**. The driving unit may include a first driving unit that moves the first jig **210** and the second driving unit **225** that moves the second jig **220**. The first driving unit and the second driving unit **225** may be formed similarly. For convenience of description, it will be assumed that the second driving unit **225** is provided.

[0131] The second driving unit **225** may include any of various devices. For example, the second driving unit **225** may include a cylinder that operates by air pressure or oil pressure to move the second jig **220**. In other embodiments, the second driving unit **225** may include a motor that operates by electricity to move the second jig **220**. For convenience of description, it will be assumed that the second driving unit **225** includes a cylinder.

[0132] The apparatus **200** includes a fixing unit (for example, second fixing unit **240**) that prevents or helps prevent the cover window **110** mounted on the first jig **210** from moving, or that prevents or helps prevent the display panel **130** and the adhesive layer **120** mounted on the second jig **220** from separating from the second jig **220**. The fixing unit includes an absorption unit (for example, second absorption unit **241**) that is formed on at least one of the first jig **210** or the second jig **220**. In addition, the fixing unit includes an absorption pump (for example, second absorption pump **242**) that absorbs (for example, vacuums or evacuates) air from the absorption unit. In particular, the absorption pump may be provided outside a chamber C as described below. The fixing unit is not limited thereto and, in other embodiments, may be formed in other various ways as would be apparent to one of ordinary skill in the art. For example, the fixing unit may be a separate frame that is formed on the first jig **210** or the second jig **220**. As another example, the fixing unit may be an adhesive member having an adhesive force.

[0133] The fixing unit may include a first fixing unit that is provided on the first jig **210**, and includes a second fixing unit **240** that is provided on the second jig **220**. The first fixing unit and

the second fixing unit **240** may be formed similarly. For example, the first fixing unit and the second fixing unit **240** may fix the cover window **110** and the display panel **130**, respectively, by using air. In other embodiments, the first fixing unit and the second fixing unit **240** may fix the cover window **110** and the display panel **130**, respectively, by using a separate frame. However, for convenience of description, it will be assumed that only the second fixing unit **240** is used and the display panel **130** is fixed by using air.

[0134] Accordingly, the apparatus **200** may rapidly and easily manufacture the display device **100** having a curved shape and a simple structure. In addition, since the apparatus **200** may accurately laminate the cover window **110** having a curved shape to the display panel **130**, a defect rate may be reduced or minimized. A method of manufacturing the display device **100** by using the apparatus **200** will now be described with reference to FIGS. **4**A through **4**C.

[0135] In order to manufacture the display device **100**, the cover window **110** is first fabricated. The cover window **110** may include any of various materials. For example, the cover window **110** may be formed of a glass material or a plastic material. The cover window **110** is not limited thereto and, in other embodiments, may include any material as long as the cover window **110** is partially curved or capable of being partially curved.

[0136] After the cover window **110** is fabricated, it may be flat, in which case the curved portions **112** may be formed by bending both ends of the cover window **110**. For example, the curved portions **112** may be bent from the flat portion **111**. In FIGS. **4**A and **4**C, the curved portions **112** extend from the flat portion **111** as described above, and each has an arc shape having a set radius (for example, a predetermined radius) or degree of curvature. In other embodiments, each of the curved portions **112** may have, for example, an oval shape instead of the arc shape.

[0137] The display panel **130** may be manufactured before, during, or after the cover window **110** is manufactured. A method of manufacturing the display panel **130** may be substantially the same as a method of manufacturing a general display panel (as would be apparent to one of ordinary skill in the art) and thus, a further detailed description thereof will not be given.

[0138] Once the display panel **130** is prepared, the adhesive layer **120** is attached to one surface of the display panel **130**. For example, the adhesive layer **120** may be attached to the encapsulation unit B (or other second substrate) as described above with reference to FIG. **2**. The adhesive layer **120** may, for example, be attached as a film to the encapsulation unit B, or be applied as a material to the encapsulation unit B. However, for convenience of description, it will be assumed that the adhesive layer **120** is formed as a film.

[0139] After the adhesive layer **120** is attached to the display panel **130**, the cover window **110** and the display panel **130** are respectively mounted on the first jig **210** and the second jig **220**. That is, the cover window **110** is mounted on the first jig **210**, and the display panel **130** is mounted on the second jig **220**. The first jig **210** may be below the second jig **220** (for example, in a gravity direction).

[0140] Next, the distance between the first jig **210** and the second jig **220** is decreased. For example, the first jig **210** may move toward the second jig **220**, or the second jig **220** may move toward the first jig **210**. In other embodiments, both the first jig **210** and the second jig **220** may move closer to each other. However, for convenience of description, it will be assumed that the second jig **220** moves.

[0141] One surface of the first jig **210** is curved to conform (for example, closely attach) to one surface of the cover window **110**. In FIGS. **4**A and **4**C, the surface of the first jig **210** is curved by being recessed. In addition, the display panel **130** is mounted on one surface of the second jig **220**. The second fixing unit **240** fixes the display panel **130** to the surface of the second jig **220**.

[0142] In FIGS. **4**B and **4**C, when the display panel **130** is mounted on the second jig **220**, a second absorption unit **241** contacts, adheres, or is otherwise attached or fixed to one surface of the display panel **130**. The second absorption unit **241** is partially exposed through an outer surface of the second jig **220**. When the display panel **130** is positioned in this manner, the second absorption

pump **242** absorbs air from the second absorption unit **241** (for example, by creating a partial vacuum or a pressure difference). Since the display panel **130** closes (for example, occludes) all or a portion of the second absorption unit **241**, and air in the second absorption unit **241** is continuously absorbed (for example, vacuumed or evacuated), the second absorption unit **241** is in an almost vacuum state. When the second absorption pump **242** operates as described above, the display panel **130** attached to the second jig **220** is not separated from the second jig **220** due to the pressure difference.

[0143] In FIGS. **3** through **4**C, a plurality of second absorption units **241** is provided. The second absorption units **241** are exposed or partially exposed through an outer surface of the second jig **220** as described above and are spaced apart from one another by a set interval (for example, a predetermined interval, such as evenly spaced).

[0144] When the cover window **110**, the adhesive layer **120**, and the display panel **130** are prepared as described above, the second jig **220** is moved toward the first jig **210** by driving the second driving unit **225**. For example, the second driving unit **225** may be programmed to operate for a set period of time (for example, a predetermined period of time). When the second driving unit **225** operates in this manner, the second jig **220** approaches the first jig **210**. When the second jig **220** is continuously moved toward the first jig **210**, the adhesive layer **120** contacts the cover window **110**.

[0145] In FIG. **4**C, sizes of the adhesive layer **120** and the display panel **130** may be the same as or less than a size of the flat portion **111** as described above. That is, the display panel **130** may be formed such that a width of the display panel **130** is less than a width of the cover window **110**, and the adhesive layer **120** may be formed such that a width of the adhesive layer **120** is less than the width of the display panel **130**. Accordingly, when the second jig **220** is moved toward the first jig **210**, the adhesive layer **120** contacts one surface of the flat portion **111**. When the second driving unit **225** continuously operates, the adhesive layer **120** contacting the flat portion **111** is compressed against the flat portion **111**. Thus, the display panel **130** and the cover window **110** may be attached to each other through lamination.

[0146] In particular, when the cover window **110** and the display panel **130** contact each other, a load range applied when the first jig **210** and the second jig **220** compress the cover window **110** and the display panel **130** may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **110** and the display panel **130** may be reduced, and the cover window **110** and the display panel **130** may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **110** and the display panel **130** are attached to each other, the cover window **110** and the display panel **130** may be damaged, thereby reducing quality and reliability.

[0147] The operation may be performed, for example in an atmospheric state or a vacuum state (such as a near vacuum state). The apparatus **200** may include the first jig **210**, and the chamber C in which the second jig **220** is disposed. In addition, the apparatus **200** may include a pressure adjustment unit that adjusts a pressure of the chamber C. When a pressure in the chamber C is maintained in a vacuum state, vapor formation between the cover window **110** and the display panel **130** when the cover window **110** and the display panel **130** are laminated may be effectively prevented.

[0148] Accordingly, the method may rapidly and accurately manufacture the display device **100** having a curved shape. Since the method accurately laminates the cover window **110** having a curved shape to the display panel **130**, a defect rate may be reduced or minimized, and product quality may be improved.

[0149] FIG. **5** is a cross-sectional view illustrating a display device **300** according to another embodiment of the present invention.

[0150] Referring to FIG. **5**, the display device **300** includes a cover window **310**, a panel member **390**, and an adhesive layer **320**. The cover window **310** includes a flat portion **311** and curved portions **312**. The cover window **310** and the adhesive layer **320** are substantially the same as the

cover window **110** and adhesive layer **120** of FIG. **1** and thus, a detailed description thereof will not be repeated.

[0151] The panel member **390** may include a first panel member **391** that is seated on the flat portion **311**. In addition, the panel member **390** may include a second panel member **392** at least a portion of which is seated on the curved portions **312**. The panel member **390** may include at least one of the display panel **330** or the TSP as described above. For convenience of description, it will be assumed that the panel member **390** includes the display panel **330**.

[0152] In further detail, the display panel **330** includes a first display panel portion **331** that is laminated on the flat portion **311**. In addition, the display panel **330** includes second display panel portions **332** that extend from the first display panel portion **331** and are laminated or partially laminated on the curved portions **312**. The second display panel portions **332** extend in a curved shape from the first display panel portion **331**. Accordingly, since the display device **300** includes the cover window **310** that is curved and the display device **300** displays through a flat portion **311** and a curved portion **312**, a larger or maximum active area may be obtained. Further, due to the inward curvature of the cover window **310**, the display panel **330** may be smaller in the at least one of a length or a width than the cover window **310**. In addition, the display device **300** that is partially curved may be attached to various electronic devices, and may easily display images having various shapes. For convenience of description, however, it will be assumed that the display panel **330** is shorter in width than the cover window **310** as described below in further detail.

[0153] A method of manufacturing the display device **300** will now be described with reference to FIGS. **6** through **7**C.

[0154] FIG. **6** is a cross-sectional view illustrating an apparatus **400** for manufacturing the display device **300** of FIG. **5** according to an embodiment of the present invention. FIGS. **7**A through **7**C are cross-sectional views illustrating a method of manufacturing the display device **300** of FIG. **5** according to an embodiment of the present invention. The same members as those of FIG. **5** are denoted by the same reference numerals.

[0155] Referring to FIGS. **6** through **7**C, the apparatus **400** includes a first jig **410**, a second jig **420**, a driving unit (such as first driving unit **415**), and a fixing unit F (for example, first fixing unit **430** and second fixing unit **440**). The first jig **410**, the second jig **420**, the driving unit, and the fixing unit F are similar to the first jig **210**, the second jig **220**, the driving unit (for example, the second driving unit **225**), and the fixing unit (for example, second fixing unit **240**), respectively, as described above and thus, a detailed description thereof will not be repeated.

[0156] The driving unit may include the first driving unit **415** and a second driving unit, and the fixing unit F includes the first fixing unit **430** and the second fixing unit **440**. The first driving unit **415**, the second driving unit, the first fixing unit **430**, and the second fixing unit **440** are substantially the same as the first driving unit, the second driving unit **225**, the first fixing unit, and the second fixing unit **240**, respectively, as described above and thus, a detailed description thereof will not be repeated. However, it will be assumed that the driving unit including only the first driving unit **415** operates.

[0157] The apparatus **400** may include a cushion unit **490** provided on or a part of at least one of the first jig **410** or the second jig **420**. In this embodiment, a thickness of the cushion unit **490** may be greater than or equal to 0.5 mm and less than or equal to 3 mm. For convenience of description, however, it will be assumed that the cushion unit **490** is part of a surface of the second jig **420**.

[0158] In FIGS. **6** through **7**C, a plurality of cushion units **490** are part of respective end portions of the second jig **420** to face the first jig **410**. The cushion units **490** include a first cushion unit **491** and a second cushion unit **492** that are part of a surface of the second jig **420** and spaced apart by a set interval (for example, a predetermined interval) from each other. The distance S**1** between the first cushion unit **491** and the second cushion unit **492** is less than the at least one of a length or a width of the display panel **330**. For convenience of description, however, it will be assumed that the distance S**1** between the first cushion unit **491** and the second cushion unit **492** is less than the

width of the display panel **330**.
[0159] The cushion units **490** support the display panel **330** and help prevent air bubbles from being formed between the display panel **330** and the curved portions **312** when the second jig **420** and the first jig **410** are moved toward each other with the display panel **330** and the cover window **310**, respectively, therebetween.
[0160] Accordingly, the apparatus **400** may rapidly and easily manufacture the display device **300** having a curved shape and a simple structure. In addition, since the apparatus **400** may accurately laminate the cover window **310** having a curved shape to the display panel **330**, a defect rate may be reduced or minimized. Further, since the apparatus **400** (such as the second jig **420**) includes the cushion unit **490**, a defect rate that may increase during lamination of the display panel **330** to the cover window **310** on the curved portions **312** may be reduced.
[0161] A method of manufacturing the display device **300** will now be described with reference to FIGS. **6** through **7**C.
[0162] A method of manufacturing the display device **300** by using the apparatus **400** is similar to that described above. For example, the cover window **310** and the display panel **330** may be manufactured as described above and may be mounted on the first jig **410** and the second jig **420**, respectively (see FIG. **7**A). Next, the first fixing unit **430** and the second fixing unit **440** respectively fix the cover window **310** and the display panel **330** to the first jig **410** and the second jig **420**. When a first absorption pump **432** operates, a first absorption unit **431** is maintained in a vacuum (or near vacuum) state. Likewise, when a second absorption pump **442** operates, a second absorption unit **441** is maintained in a vacuum (or near vacuum) state. Accordingly, the cover window **310** and the display panel **330** are fixed to the first jig **410** and the second jig **420**, respectively.
[0163] In FIGS. **6** through **7**C, the first jig **410** is higher than the second jig **420** (for example, in a gravity direction). At least one of the first jig **410** or the second jig **420** then moves towards the other. For example, the first jig **410** may move toward the second jig **420**, or the second jig **420** may move toward the first jig **410**. In other embodiments, both the first jig **410** and the second jig **420** move closer to each other. However, for convenience of description, it will be assumed that the first jig **410** moves toward the second jig **420**. When the first jig **410** moves toward the second jig **420**, the first driving unit **415** operates. When the first driving unit **415** continuously operates, a curved surface of the cover window **310** contacts the adhesive layer **320**.
[0164] At first, the display panel **330** and the adhesive layer **320** may be flat against the second jig **420**. Then, when the adhesive layer **320** and the cover window **310** contact each other, both ends of the display panel **330** and the adhesive layer **320** may be curved (for example, through contact with the cover window **310** that is curved). Next, a first display panel portion **331** (that is flat) and second display panel portions **332** (that are curved) of the display panel **330** are formed. Accordingly, the first display panel portion **331** and the second display panel portions **332** are formed when the display panel **330** is adhered to the flat portion **311** and the curved portions **312**. The cover window **310** may be attached to the display panel **330** through lamination as the first driving unit **415** operates as described above (see FIGS. **5** and **7**C). In other embodiments, the display panel **330** and the adhesive layer **320** may be bent along an outer surface of the second jig **420** when the display panel **330** and the adhesive layer **320** are mounted on the second jig **420**.
[0165] In particular, when the cover window **310** and the display panel **330** contact each other, a load range applied when the first jig **410** and the second jig **420** compress the cover window **310** and the display panel **330** may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310** and the display panel **330** may be reduced, and thus the cover window **310** and the display panel **330** may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310** and the display panel **330** are attached to each other, the cover window **310** and the display panel **330** may be damaged, thereby reducing quality and reliability.

[0166] Accordingly, the method may rapidly and accurately manufacture the display device **300** having a curved shape. Since the method accurately laminates the cover window **310** having a curved shape to the display panel **330**, a defect rate may be reduced or minimized. In addition, since the method removes air bubbles that may be formed (or prevents air bubbles from being formed) after the display panel **330** and the curved portions **312** are compressed, product quality may be improved.
[0167] FIG. **8** is a cross-sectional view illustrating an apparatus **500** for manufacturing the display device **300** of FIG. **5** according to another embodiment of the present invention. FIGS. **9**A through **9**C are cross-sectional views illustrating a method of manufacturing the display device **300** of FIG. **5** according to another embodiment of the present invention.
[0168] Referring to FIGS. **8** through **9**C, the apparatus **500** includes a first jig **510**, a second jig **520**, a driving unit M (such as first driving unit **515** and second driving unit **525**), and a fixing unit (for example, first fixing unit **530**). The first jig **510**, the second jig **520**, the driving unit M, and the fixing unit are substantially the same as those described above and thus, a detailed description thereof will not be repeated. The driving unit M may include the first driving unit **515** and the second driving unit **525**, and the fixing unit includes the first fixing unit **530** (including first absorption unit **531** and first absorption pump **532**). The first driving unit **515**, the second driving unit **525**, and the first fixing unit **530** are substantially the same as those described above and thus, a detailed description thereof will not be repeated.
[0169] The apparatus **500** includes a clamping unit **550** that is spaced apart by a set interval (for example, a predetermined interval) from the second jig **520**, and supports the display panel **330** to which the adhesive layer **320** is applied. In other embodiments, the clamping unit **550** may be spaced apart by a set interval (for example, a predetermined interval) from the first jig **510**, and supports the cover window **310**. For convenience of description, however, it will be assumed that the clamping unit **550** is disposed adjacent to the second jig **520**.
[0170] The clamping unit **550** supports one or more ends of the display panel **330** and the adhesive layer **320** when they are inserted into the clamping unit **550**. In FIGS. **8** through **9**C, a plurality of clamping units **550** are provided, where a distance between the clamping units **550** is less than the at least one of a length or a width of the panel member (for example, display panel **330**) when the clamping units **550** are fixing the display panel **330**. The panel member may include at least one of the display panel **330** or the TSP as described above. Particularly, each of the clamping units **550** is placed at both ends of the cover window **310** in the direction of the at least one of a width or a length of the cover window **310**. For convenience of description, however, it will be assumed that a distance between the plurality of clamping units **550** is less than a width of the display panel **330** and the panel member includes the display panel **330**.
[0171] In FIGS. **8** through **9**C, the clamping units **550** face respective side surfaces of the second jig **520**, and fix respective ends of the display panel **330** and the adhesive layer **320**. The clamping units **550** include a first clamping unit **551** and a second clamping unit **552** that are spaced apart by a set interval (for example, a predetermined interval) from each other.
[0172] Accordingly, the apparatus **500** may rapidly and easily manufacture the display device **300** having a curved shape and a simple structure. In addition, since the apparatus **500** may accurately laminate the cover window **310** having a curved shape to the display panel **330**, a defect rate may be reduced or minimized. Further, since the apparatus **500** includes the clamping unit **550** to accurately align the display panel **330** and the cover window **310**, working efficiency may be improved.
[0173] A method of manufacturing the display device **300** by using the apparatus **500** will now be described with reference to FIGS. **9**A through **9**C.
[0174] First, the cover window **310** is formed, the display panel **330** is formed, and then the adhesive layer **320** is attached to the display panel **330**. The cover window **310** may be mounted on the first jig **510** as described above (see FIG. **9**A). Next, respective ends of the display panel **330** on

which the adhesive layer **320** is attached are fixed to the first clamping unit **551** and the second clamping unit **552**. For example, the respective ends of the display panel **330** may be fixed by being inserted into insertion grooves formed in the first clamping unit **551** and the second clamping unit **552**.

[0175] Once the display panel **330** and the adhesive layer **320** are fixed in this manner, middle portions of the display panel **330** and the adhesive layer **320** are curved upward (for example, with respect to a gravity direction). As shown in FIGS. **9**B and **9**C, since a distance S**2** between the first clamping unit **551** and the second clamping unit **552** is less than at least one of a width or a length of the display panel **330**, the middle portions of the display panel **330** protrude toward the first jig **510**. When the display panel **330** and the adhesive layer **320** are fixed, the display panel **330**, the adhesive layer **320**, and the cover window **310** may be compressed by moving at least one of the first jig **510** or the second jig **520**. For convenience of description, it will be assumed that the display panel **330**, the adhesive layer **320**, and the cover window **310** are compressed by moving both the first jig **510** and the second jig **520**.

[0176] When the first jig **510** and the second jig **520** move, the first driving unit **515** and the second driving unit **525** may operate to move the first jig **510** and the second jig **520** closer to each other. The middle portions of the display panel **330** and the adhesive layer **320** (which are curved downward) then contact the cover window **310**. For example, the middle portions of the display panel **330** and the adhesive layer **320** may first contact a portion of the flat portion **311**. When the first jig **510** and the second jig **520** continuously move, the display panel **330** and the adhesive layer **320** are adhered to the cover window **310** from the flat portion **311** as the first contacting portion to the curved portions **312**. That is, the display panel **330**, the adhesive layer **320**, and the cover window **310** contact in an order from the flat portion **311** to the curved portions **312**.

[0177] At some point (for example, after the adhesive layer **320** contacts the flat portion **311**), the second jig **520** may contact the display panel **330**, the display panel **330** may detach from the clamping unit **550**, and the first jig **510** and the second jig **520** may move closer to each other to further laminate the display panel **330** to the cover window **310**.

[0178] In particular, when the cover window **310** and the display panel **330** contact each other as described above, a load range applied when the first jig **510** and the second jig **520** compress the cover window **310** and the display panel **330** may be greater than or equal to 0.3 MPa and equal or less than 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310** and the display panel **330** may be reduced, and thus the cover window **310** and the display panel **330** may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa, when the cover window **310** and the display panel **330** are attached to each other, the cover window **310** and the display panel **330** may be damaged, thereby reducing quality and reliability.

[0179] Accordingly, the method may rapidly and accurately manufacture the display device **300** having a curved shape. In addition, since the method may accurately laminate the cover window **310** having a curved shape to the display panel **330**, a defect rate may be reduced or minimized. Further, since the method removes air bubbles that may be formed (or prevents air bubbles from being formed) after the display panel **330** and the curved portions **312** are compressed, product quality may be improved.

[0180] According to embodiments of the present invention, since a cover window that is partially curved and a display panel are rapidly and accurately laminated to each other, mass production, high reliability, and high quality may be achieved. In addition, since a display device may be manufactured rapidly, manufacturing time and costs may be reduced.

[0181] FIG. **10** is a cross-sectional view illustrating an apparatus **600** for manufacturing the display device **300** of FIG. **5** according to yet another embodiment of the present invention. FIG. **11** is a cross-sectional view illustrating a method of manufacturing the display device **300** of FIG. **5** according to yet another embodiment of the present invention.

[0182] Referring to FIGS. **10** and **11**, the apparatus **600** includes a first jig **610**, a second jig **620**, a driving unit M (including first driving unit **615** and second driving unit **625**), a clamping unit **650**, and a fixing unit (for example, first fixing unit **630**). The first jig **610** and the second jig **620** may be substantially the same as those described above and thus, a detailed description thereof will not be repeated.
[0183] The driving unit M may include the first driving unit **615** and the second driving unit **625**, and the fixing unit may include the first fixing unit **630**. The first driving unit **615**, the second driving unit **625**, and the first fixing unit **630** may be substantially the same as those described above and thus, a detailed description thereof will not be repeated. The first fixing unit **630** may include a first absorption unit **631** and a first absorption pump **632**.
[0184] The clamping unit **650** may include a first clamping unit **651** and a second clamping unit **652**. The first clamping unit **651** and the second clamping unit **652** may be substantially the same as those described above and thus, a detailed description thereof will not be repeated.
[0185] The apparatus **600** may include a first linear driving unit **660** and a second linear driving unit **670** which respectively vertically move the first clamping unit **651** and the second clamping unit **652** (for example, in a vertical direction with respect to gravity). The first linear driving unit **660** and the second linear driving unit **670** may be formed similarly and thus, the following description will focus on the first linear driving unit **660**.
[0186] The first linear driving unit **660** may include a first shaft **661** that is connected to the first clamping unit **651** and linearly moves. In one embodiment, the first linear driving unit **660** may include a first driving module **665** that drives the first shaft **661**. The first driving module **665** may include, for example, a cylinder or a motor. For convenience of description, however, it will be assumed that the first driving module **665** includes a motor. It will be further assumed that the first shaft **661** includes a ball screw that is lowered or raised as the first driving module **665** rotates.
[0187] The first linear driving unit **660** may include a first elastic unit **663** that surrounds the first shaft **661**. The first elastic unit **663** may include a compression spring, and may be formed of an elastic material such as rubber. For convenience of description, however, it will be assumed that the first elastic unit **663** includes a compression spring. The first elastic unit **663** may surround an outer surface of the first shaft **661** as described above and thus may provide a restoring force to the first clamping unit **651** when the first clamping unit **651** moves.
[0188] A method of manufacturing the display device **300** by using the apparatus **600** will be described. The cover window **310** and a panel member (for example, display panel **330**) may be formed, and then the adhesive layer **320** may be formed on the panel member. The panel member may include at least one of the display panel **330** or the TSP as described above. However, for convenience of description, it will be assumed that the panel member includes the display panel **330**. Respective ends of the display panel **330** on which the adhesive layer **320** is formed may be fixed to the first clamping unit **651** and the second clamping unit **652**. Once the display panel **330** is fixed to the first clamping unit **651** and the second clamping unit **652**, middle portions of the display panel **330** and the adhesive layer **320** may be curved upward (for example, with respect to a gravity direction). In further detail, since a distance S**3** between the first clamping unit **651** and the second clamping unit **652** is less than at least one of a width or a length of the display panel **330**, the middle portions may protrude toward the first jig **610**. In this case, it will be assumed that the distance S**3** between the first clamping unit **651** and the second clamping unit **652** is less than a width of the display panel **330**.
[0189] After the display panel **330** and the adhesive layer **320** are disposed in this manner, the display panel **330**, the adhesive layer **320**, and the cover window **310** may be compressed against one another by moving at least one of the first jig **610** or the second jig **620**. For convenience of description, however, it will be assumed that the display panel **330**, the adhesive layer **320**, and the cover window **310** are compressed by moving both the first jig **610** and the second jig **620**.
[0190] While the first jig **610** and the second jig **620** move in this manner, the first linear driving

unit **660** and the second linear driving unit **670** may operate to vertically move the first clamping unit **651** and the second clamping unit **652**. The first clamping unit **651** and the second clamping unit **652** may move at a speed similar to a speed at which the second jig **620** moves.
[0191] When the second jig **620**, the first clamping unit **651**, and the second clamping unit **652** are raised in this manner, the display panel **330** and the adhesive layer **320** may be raised while maintaining their curved states. When a distance between the first jig **610** and the second jig **620** reaches a set distance (for example, a predetermined distance), the first clamping unit **651** and the second clamping unit **652** may release from (for example, reduce their clamping force from) the display panel **330** and the adhesive layer **320**. During or after this releasing of the first clamping unit **651** and the second clamping unit **652**, the first linear driving unit **660** and the second linear driving unit **670** may lower the first clamping unit **651** and the second clamping unit **652**.
[0192] Next, the first driving unit **615** and the second driving unit **625** may continuously operate to bring the first jig **610** and the second jig **620** closer (for example, adjacent) to each other (for example, the second jig **520** may contact the display panel **330**). As the first jig **610** and the second jig **620** move closer, the display panel **330**, the adhesive layer **320**, and the cover window **310** may be compressed against one another (e.g., starting with the flat portion **311**). A method of compressing the display panel **330**, the adhesive layer **320**, and the cover window **310** may be performed in the same manner as that described above and thus, a detailed description thereof will not be repeated.
[0193] In particular, when the cover window **310** and the display panel **330** contact each other, a load range applied when the first jig **610** and the second jig **620** compress the cover window **310** and the display panel **330** may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310** and the display panel **330** may be reduced, and the cover window **310** and the display panel **330** may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310** and the display panel **330** are attached to each other, the cover window **310** and the display panel **330** may be damaged, thereby reducing quality and reliability.
[0194] Accordingly, the method may rapidly and accurately manufacture the display device **300** having a curved shape. Further, the method may reduce or minimize a defect rate by accurately laminating the cover window **310** having a curved shape to the display panel **330**. In addition, the method may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) after the display panel **330** and the curved portions **312** are compressed.
[0195] FIG. **12** is a cross-sectional view illustrating an apparatus **700** for manufacturing the display device **300** of FIG. **5** according to still yet another embodiment of the present invention. FIG. **13** is a cross-sectional view illustrating a method of manufacturing the display device **300** of FIG. **5** according to still yet another embodiment of the present invention.
[0196] Referring to FIGS. **12** and **13**, the apparatus **700** may include a first jig **710**, a second jig **720** (including a cushion unit **790**), a driving unit M (including first driving unit **715** and second driving unit **725**), a clamping unit **750** (including a first clamping unit **751** and a second clamping unit **752**), a fixing unit (for example, first fixing unit **730**), a first linear driving unit **760**, and a second linear driving unit **770**. The first jig **710** and the second jig **720** may be substantially the same as those described above and thus, a detailed description thereof will not be repeated.
[0197] The driving unit M may include the first driving unit **715** and the second driving unit **725**, and the fixing unit may include the first fixing unit **730**. The first driving unit **715**, the second driving unit **725**, and the first fixing unit **730** (which includes first absorption unit **731** and first absorption pump **732**) may be substantially the same as those described above and thus, a detailed description thereof will not be repeated.
[0198] The first linear driving unit **760** and the second linear driving unit **770** may linearly move the first clamping unit **751** and the second clamping unit **752**, respectively. The first linear driving

unit **760** and the second linear driving unit **770** may linearly move the first clamping unit **751** and the second clamping unit **752** in a diagonal direction, respectively, with respect to the second jig **720** (and, for example, with respect to a gravity direction). Since the second linear driving unit **770** may be formed similarly to the first linear driving unit **760**, the following description will focus on the first linear driving unit **760**.

[0199] In further detail, the first linear driving unit **760** may include a first shaft **761**, a first driving module **765**, and a first elastic unit **763**. The first shaft **761**, the first driving module **765**, and the first elastic unit **763** may be formed in a similar manner to those described above (such as the first linear driving unit **660** in FIGS. **10**-**11**) except that, the first shaft **761** is disposed in a diagonal direction to diagonally move the first clamping unit **751** with respect to the second jig **720**.

[0200] When the first linear driving unit **760** operates, the first driving module **765** may vary a length of the first shaft **761**. Since the first driving module **765** and the first shaft **761** are diagonally disposed with respect to the second jig **720** as described above, the first clamping unit **751** may be diagonally moved by varying the movement of the first shaft **761**.

[0201] For example, when the first driving module **765** operates to diagonally move the first shaft **761** downward with respect to the second jig **720**, the first clamping unit **751** may diagonally move downward with respect to the second jig **720** as the first shaft **761** moves. Likewise, when the first driving module **765** operates in an opposite direction to diagonally move the first shaft **761** upward with respect to the second jig **720**, the first clamping unit **751** may diagonally move upward with respect to the second jig **720** as the first shaft **761** moves. The first shaft **761** may include a ball screw as described above and thus may rotate as the first driving module **765** operates. The first shaft **761** may diagonally move downward or upward with respect to the second jig **720** as the first driving module **765** rotates.

[0202] The cushion unit **790** may be formed in various ways. For example, the cushion unit **790** may be part of an outer surface (e.g., a contacting surface, such as a surface that contacts the cover window **310** or the display panel **330**) of at least one of the first jig **710** or the second jig **720**. In another embodiment, the cushion unit **790** may be part of a portion of such an outer surface of at least one of the first jig **710** or the second jig **720**. In another embodiment, the cushion unit **790** is part of the apparatus **700** and covers such an outer surface of at least one of the first jig **710** or the second jig **720**. For ease of description, it will be assumed that the cushion unit **790** is part of an entire such outer surface of the second jig **720**.

[0203] A method of manufacturing the display device **300** may be similar to that described above. In further detail, a panel member (for example, display panel **330**) and the cover window **310** may be prepared, and then the adhesive layer **320** may be applied to the panel member. The panel member may include the display panel **330** and the TSP as described above. However, for convenience of description, it will be assumed that the panel member includes the display panel **330**. The display panel **330** to which the adhesive layer **320** is applied may be fixed by the first clamping unit **751** and the second clamping unit **752**. When the fixing is completed, the display panel **330**, the adhesive layer **320**, and the cover window **310** may be compressed against one another by moving at least one of the first jig **710** or the second jig **720**. A method of compressing the display panel **330**, the adhesive layer **320**, and the cover window **310** may be similar to that described above and thus, a detailed description thereof will not be repeated.

[0204] When the first jig **710** and the second jig **720** move in this manner, the first clamping unit **751** and the second clamping unit **752** may also move. The first clamping unit **751** and the second clamping unit **752** may be diagonally moved by the first linear driving unit **760** and the second linear driving unit **770**, respectively. The first clamping unit **751** and the second clamping unit **752** may be raised diagonally with respect to the second jig **720**.

[0205] When the first clamping unit **751** and the second clamping unit **752** are raised and then an interval between the first jig **710** and the second jig **720** reaches a preset interval, both ends of the display panel **330** may be released from the clamping unit **750**. The display panel **330** may be

laminated to the cover window **310** by the adhesive layer **320** beginning from a middle portion of the display panel **330** (corresponding to the flat portion **311** of the cover window **310**).
[0206] During or after the releasing of the first clamping unit **751** and the second clamping unit **752** from the display panel **330**, the first linear driving unit **760** and the second linear driving unit **770** may operate to lower the first clamping unit **751** and the second clamping unit **752**. The first clamping unit **751** and the second clamping unit **752** may be lowered diagonally with respect to the second jig **720**. While the first clamping unit **751** and the second clamping unit **752** are lowered, the first jig **710** and the second jig **720** may get closer to each other to compress the display panel **330**, the adhesive layer **320**, and the cover window **310** against one another. For example, the second jig **720** may contact the display panel **330**. A method of adhering the display panel **330** and the cover window **310** through compression may be similar to that described above.
[0207] When the display panel **330** and the cover window **310** are compressed by moving the first jig **710** and the second jig **720**, the cushion unit **790** may spread a force applied to the display panel **330** and the cover window **310**. In addition, the cushion unit **790** may help prevent the display panel **330** or the cover window **310** from being damaged by partially absorbing a force applied to the display panel **330** and the cover window **310**.
[0208] In particular, when the cover window **310** and the display panel **330** contact each other, a load range applied when the first jig **710** and the second jig **720** compress the cover window **310** and the display panel **330** may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310** and the display panel **330** may be reduced, and the cover window **310** and the display panel **330** may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310** and the display panel **330** are attached to each other, the cover window **310** and the display panel **330** may be damaged, thereby reducing quality and reliability.
[0209] Accordingly, the method may rapidly and accurately manufacture the display device **300**. Further, the method may reduce or minimize a defect rate by accurately laminating the cover window **310** having a curved surface to the display panel **330**. In addition, the method may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) after the display panel **330** and the curved portions **312** are compressed.
[0210] FIG. **14** is a cross-sectional view illustrating a display device **300***a* according to yet another embodiment of the present invention.
[0211] Referring to FIG. **14**, the display device **300***a* may include a cover window **310***a* and a panel member **390***a* as described above. In addition, the display device **300***a* may include a first adhesive layer **320***a* that is disposed between a panel member **390***a* and the cover window **310***a*. The panel member **390***a* may include a display panel **330***a* and a TSP **340***a* as described above. In particular, a second adhesive layer **350***a* may be provided between the display panel **330***a* and the TSP **340***a* to attach the display panel **330***a* and the TSP **340***a*.
[0212] The cover window **310***a* may be formed such that at least a portion of the cover window **310***a* is curved. In particular, the cover window **310** may be formed to have a curved surface having a curvature radius of R. The cover window **310***a* may be formed to have a curved surface having a set or predetermined curvature radius in at least one of a longitudinal direction or a width direction. In addition, the cover window **310***a* may be formed such that a surface on which an image or text is displayed after the panel member **390***a* is attached is convex. However, for convenience of description, it will be assumed that the cover window **310** is formed to have a curved surface having a set or predetermined curvature radius and the curved surface is formed in a width direction of the cover window **310***a*.
[0213] The first adhesive layer **320***a* and the second adhesive layer **350***a* may be formed of the same material. In further detail, the first adhesive layer **320***a* and the second adhesive layer **350***a* may be formed of a transparent material having an adhesive force. For example, the first adhesive layer **320***a* and the second adhesive layer **350***a* may include an optical clear adhesive (OCA) film

or an adhesive material.
[0214] Accordingly, since the display device **300***a* is formed to have a set or predetermined curvature radius, the display device **300***a* may be provided on various members.
[0215] FIG. **15** is a cross-sectional view illustrating an apparatus **400***a* for manufacturing the display device **300***a* of FIG. **14**, according to an embodiment of the present invention.
[0216] Referring to FIG. **15**, the apparatus **400***a* may include a first jig **410***a*, a second jig **420***a*, a driving unit M, a fixing unit (for example, first fixing unit **430***a*), and a cushion unit **490***a*. At least a portion of the first jig **410***a* may be formed equally or similarly to an outer surface of the cover window **310***a*. In further detail, the first jig **410***a* may have a curved surface on which the cover window **310***a* having a curved surface with a set or predetermined curvature radius is seated. In particular, the first jig **410***a* may be recessed away from the second jig **420***a*.
[0217] An outer surface of the second jig **420***a* may protrude toward the first jig **410***a* to correspond to or engage with a recessed portion of the first jig **410***a*. The outer surface of the second jig **420***a* may be a curved surface having a set or predetermined curvature radius.
[0218] The driving unit M may include a first driving unit **415***a* and a second driving unit **425***a*. The first driving unit **415***a* may linearly move the first jig **410***a* toward the second jig **420***a*, and the second driving unit **425***a* may linearly move the second jig **420***a* toward the first jig **410***a*. The first driving unit **415***a* and the second driving unit **425***a* may be formed in the same manner as or a similar manner to those described above.
[0219] In addition, the fixing unit may include a first fixing unit **430***a* provided on the first jig **410***a* and a second fixing unit provided on the second jig **420***a*. For convenience of description, it will be assumed that the fixing unit includes the first fixing unit **430***a*. In addition, the first fixing unit **430***a* and the second fixing unit may be formed in the same manner or a similar manner, and thus a detailed description of the second fixing unit will not be given.
[0220] The first fixing unit **430***a* may be formed in various ways. For example, the first fixing unit **430***a* may include an adhesive member, an adhesive chuck, or an electrostatic chuck. In addition, the first fixing unit **430***a* may include a first absorption unit **431***a* and a first absorption pump **432***a* that is connected to the first absorption unit **431***a*. In particular, the first fixing unit **430***a* is not limited thereto, and may include a clamp, or a protrusion that is provided on the first jig **410***a* and mechanically restricts the cover window **310***a*. However, for convenience of description, it will be assumed that the first fixing unit **430***a* includes the first absorption unit **431***a* and the first absorption pump **432***a*.
[0221] The cushion unit **490***a* may be provided on at least one of the first jig **410***a* or the second jig **420***a*. In this case, the cushion unit **490***a* is the same as or similar to that described above, and thus a detailed explanation thereof will not be repeated. In addition, for convenience of description, it will be assumed that the cushion unit **490***a* is provided only on the second jig **420***a* and is integrally formed on an outer surface of the second jig **420***a*.
[0222] A method of manufacturing the display device **300***a* by using the apparatus **400***a* will now be described. First, the cover window **310***a* and the panel member **390***a* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***a* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***a* and the display panel **330***a* may be adhered to each other by using the second adhesive layer **350***a*.
[0223] After the cover window **310***a* and the panel member **390***a* are manufactured and prepared as described above, the cover window **310***a* may be disposed on the first jig **410***a*. The cover window **310***a* may be formed to have a curved surface having a set or predetermined curvature radius of R as described above and may be seated on an outer surface of the first jig **410***a*. The first absorption pump **432***a* may operate to absorb (e.g., evacuate or vacuum) air out of the first absorption unit **431***a*, so that the cover window **310***a* may be fixed to the outer surface of the first jig **410***a*.
[0224] While the process is performed, the TSP **340***a* and the display panel **330***a* adhered by using

the second adhesive layer **350***a* may be disposed on the second jig **420***a*. The display panel **330***a* may be disposed to face the second jig **420***a*, and the TSP **340***a* may be disposed to face the first jig **410***a*.

[0225] After the TSP **340***a* and the display panel **330***a* are disposed as described above, the first adhesive layer **320***a* may be coated on the TSP **340***a*. The first adhesive layer **320***a* may be formed of the same material as or a similar material to that of the second adhesive layer **350***a*.

[0226] When the cover window **310***a*, the TSP **340***a*, and the display panel **330***a* are completely disposed as described above, the first jig **410***a* and the second jig **420***a* may be moved toward each other by driving the first driving unit **415***a* and the second driving unit **425***a*. A protruding portion of the second jig **420***a* may first contact the display panel **330***a*, and the first adhesive layer **320***a* and the cover window **310***a* may be sequentially laminated from a central portion of the display panel **330***a* to both end portions.

[0227] In particular, when the cover window **310***a* and the panel member **390***a* contact each other, a load range applied when the first jig **410***a* and the second jig **420***a* compress the cover window **310***a* and the panel member **390***a* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***a* and the panel member **390***a* may be reduced, and the cover window **310***a* and the panel member **390***a* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***a* and the panel member **390***a* are attached to each other, the cover window **310***a* and the panel member **390***a* may be damaged, thereby reducing quality and reliability.

[0228] While the process is performed, the cushion unit **490***a* may uniformly distribute a force applied to the cover window **310***a*, the TSP **340***a*, and the display panel **330***a*.

[0229] When the process is completed, the first driving unit **415***a* and the second driving unit **425***a* may operate to separate the first jig **410***a* and the second jig **420***a*. An operator may complete an operation by removing the completed display device **300***a* from the first jig **410***a* or the second jig **420***a*.

[0230] The operation may be performed in a vacuum state. In further detail, the apparatus **400***a* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **410***a*, the second jig **420***a*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **400***a* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***a* and the panel member **390***a* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a lamination process is completed.

[0231] Accordingly, the apparatus **400***a* may manufacture any type of display device **300***a*. In addition, the apparatus **400***a* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***a* and the panel member **390***a* when the cover window **310***a* and the panel member **390***a* are laminated.

[0232] FIG. **16** is a cross-sectional view illustrating an apparatus **500***a* for manufacturing the display device **300***a* of FIG. **14**, according to another embodiment of the present invention.

[0233] Referring to FIG. **16**, the apparatus **500***a* includes a first jig **510***a*, a second jig **520***a*, a driving unit M, a fixing unit (for example, first fixing unit **530***a*), and a cushion unit **590***a*. In this case, the first jig **510***a*, the second jig **520***a*, the driving unit M, the fixing unit, and the cushion unit **590***a* are substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0234] The driving unit M may include a first driving unit **515***a* and a second driving unit **525***a*, and the fixing unit may include a first fixing unit **530***a*. The first driving unit **515***a*, the second driving unit **525***a*, and the first fixing unit **530***a* (which includes a first absorption unit **531***a* and a first absorption pump **532***a*) are substantially the same as those described above, and thus a detailed

description thereof will not be repeated.
[0235] The apparatus **500***a* includes a clamping unit **550***a* that is spaced apart by a set or predetermined interval from at least one of the first jig **510***a* or the second jig **520***a*, and supports the panel member **390***a*. For convenience of description, however, it will be assumed that the clamping unit **550***a* is disposed adjacent to the second jig **520***a*.
[0236] The clamping unit **550***a* may support one end of the panel member **390***a* when the one end of the panel member **390***a* is inserted into the clamping unit **550***a*. A plurality of the clamping units **550***a* may be provided, where a distance between the clamping units **550***a* is less than a length or a width of the panel member **390***a*. The panel member **390***a* may include at least one of the display panel **330***a* or the TSP **340***a* as described above. For convenience of description, it will be assumed that the distance between the plurality of clamping units **550***a* is less than a width of the panel member **390***a* and the panel member **390***a* includes the display panel **330***a* and the TSP **340***a*.
[0237] In particular, the plurality of clamping units **550***a* face respective side surfaces of the second jig **520***a*, and fix both ends of the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a*. The plurality of clamping units **550***a* include a first clamping unit **551***a* and a second clamping unit **552***a* that are spaced apart by a set or predetermined interval from each other.
[0238] Accordingly, the apparatus **500***a* may rapidly and easily manufacture the display device **300***a* having a curved surface and a simple structure. In addition, since the apparatus **500***a* may accurately attach the cover window **310***a* having a curved surface to the panel member **390***a*, a product defect rate may be reduced or minimized.
[0239] In particular, since the apparatus **500***a* includes the clamping unit **550***a* to accurately align the panel member **390***a* and the cover window **310***a*, working efficiency may be improved.
[0240] A method of manufacturing the display device **300***a* by using the apparatus **500***a* will now be described with reference to FIG. **16**.
[0241] The cover window **310***a* may be formed as described above, the display panel **330***a* may be formed, and then the TSP **340***a* and the display panel **330***a* may be adhered by using the second adhesive layer **350***a*. The cover window **310***a* may be mounted on the first jig **510***a* as described above. The cover window **310***a* may be formed to have a curved surface having a predetermined curvature radius of R as described above and may be seated on an outer surface of the first jig **510***a*. A first absorption pump **532***a* may operate to absorb air of a first absorption unit **531***a* so that the cover window **310***a* is fixed to the outer surface of the first jig **510***a*.
[0242] While the process is performed, the TSP **340***a* and the display panel **330***a* adhered by using the second adhesive layer **350***a* as described above may be disposed on the second jig **520***a*. The display panel **330***a* may be disposed to face the second jig **520***a*, and the TSP **340***a* may be disposed to face the first jig **510***a*. In particular, respective ends of the TSP **340***a* on which the first adhesive layer **320***a* is attached are fixed to the first clamping unit **551***a* and the second clamping unit **552***a*. For example, the respective ends of panel member **390***a* may be fixed by being inserted into grooves formed in the first clamping unit **551***a* and the second clamping unit **552***a* as described above.
[0243] Once the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* are fixed in this manner, portions of the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* may be curved upward (for example, with respect to a gravity direction). In further detail, since a distance between the first clamping unit **551***a* and the second clamping unit **552***a* is less than at least one of a width or a length of at least one of the display panel **330***a* or the TSP **340***a*, the portions of the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* may protrude toward the first jig **510***a*.
[0244] When the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* are fixed as described above, the display panel **330***a*, the second adhesive layer

350*a*, the TSP **340***a*, the first adhesive layer **320***a*, and the cover window **310***a* may be compressed against each other by moving at least one of the first jig **510***a* or the second jig **520***a*. For convenience of description, it will be assumed that the first adhesive layer **320***a* and the cover window **310***a* are compressed by moving both the first jig **510***a* and the second jig **520***a*.

[0245] When the first jig **510***a* and the second jig **520***a* move, the first driving unit **515***a* and the second driving unit **525***a* may operate to move the first jig **510***a* and the second jig **520***a* closer to each other.

[0246] The upwardly curved portions of the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* first contact the cover window **310***a*. When the first jig **510***a* and the second jig **520***a* continuously move, the display panel **330***a*, the second adhesive layer **350***a*, the TSP **340***a*, and the first adhesive layer **320***a* may be laminated to the cover window **310***a* beginning from contact portions with the cover window **310***a* toward both end portions.

[0247] In particular, when the cover window **310***a* and the panel member **390***a* contact each other, a load range applied when the first jig **510***a* and the second jig **520***a* compress the cover window **310***a* and the panel member **390***a* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***a* and the panel member **390***a* may be reduced, and the cover window **310***a* and the panel member **390***a* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***a* and the panel member **390***a* are attached to each other, the cover window **310***a* and the panel member **390***a* may be damaged, thereby reducing quality and reliability.

[0248] In addition, when the first jig **510***a* and the second jig **520***a* move as described above, the TSP **340***a* and the display panel **330***a* may be fixed while the first clamping unit **551***a* and the second clamping unit **552***a* do not move.

[0249] The cushion unit **590***a* may uniformly distribute a force applied to the panel member **390***a* and the cover window **310***a* when the panel member **390***a* and the cover window **310***a* are compressed and laminated.

[0250] When the process is completed, the first driving unit **515***a* and the second driving unit **525***a* may operate to separate the first jig **510***a* and the second jig **520***a*. The operator may complete an operation by removing the completed display device **300***a* from the first jig **510***a* or the second jig **520***a*.

[0251] The operation may be performed in a vacuum state. In further detail, the apparatus **500***a* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **510***a*, the second jig **520***a*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **500***a* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***a* and the panel member **390***a* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0252] Accordingly, the apparatus **500***a* may rapidly and accurately manufacture any type of display device **300***a* having a curved surface. In particular, the apparatus **500***a* may reduce or minimize a product defect rate by accurately attaching the display panel **330***a* and the cover window **310***a* having a curved surface.

[0253] In addition, the apparatus **500***a* may reduce or minimize a product defect rate by effectively removing air bubbles or preventing air bubbles from being generated after the display panel **330***a* and the curved portions are compressed.

[0254] FIG. **17** is a cross-sectional view illustrating an apparatus **600***a* for manufacturing the display device **300***a* of FIG. **14**, according to yet another embodiment of the present invention.

[0255] Referring to FIG. **17**, the apparatus **600***a* includes a first jig **610***a*, a second jig **620***a*, a driving unit M, a clamping unit **650***a*, a fixing unit (for example, first fixing unit **630***a*), a linear

driving unit L, and a cushion unit **690***a*. The first jig **610***a*, the second jig **620***a*, the linear driving unit L, the clamping unit **650***a*, the fixing unit, and the cushion unit **690***a* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0256] The driving unit M may include a first driving unit **615***a* and a second driving unit **625***a*, and the fixing unit may include a first fixing unit **630***a*. The first driving unit **615***a*, the second driving unit **625***a*, and the first fixing unit **630***a* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated. In particular, the first fixing unit **630***a* may include a first absorption pump **632***a* and a first absorption unit **631***a*.
[0257] The clamping unit **650***a* may include a first clamping unit **651***a* and a second clamping unit **652***a*. The first clamping unit **651***a* and the second clamping unit **652***a* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0258] The apparatus **600***a* may include a linear driving unit L that includes a first linear driving unit **660***a* and a second linear driving unit **670***a* that respectively vertically move the first clamping unit **651***a* and the second clamping unit **652***a*. In particular, the first linear driving unit **660***a* and the second linear driving unit **670***a* may respectively linearly move the first clamping unit **651***a* and the second clamping unit **652***a* in the same direction as a direction in which the second jig **620***a* moves. The first linear driving unit **660***a* and the second linear driving unit **670***a* may be formed similarly, and thus the following description will focus on the first linear driving unit **660***a*.
[0259] The first linear driving unit **660***a* may include a first shaft **661***a* that is connected to the first clamping unit **651***a* and linearly moves the first clamping unit **651***a*. In addition, the first linear driving unit **660***a* may include a first driving module **665***a* that drives the first shaft **661***a*. The first driving module **665***a* may include a cylinder or a motor. For convenience of description, however, it will be assumed that the first driving module **665***a* includes a motor. It will be further assumed that the first shaft **661***a* includes a ball screw that is lowered or raised as the first driving module **665***a* rotates.
[0260] The first linear driving unit **660***a* may include a first elastic unit **663***a* that surrounds the first shaft **661***a*. The first elastic unit **663***a* may include a compression spring, and may be formed of an elastic material such as rubber. For convenience of description, however, it will be assumed that the first elastic unit **663***a* includes a compression spring.
[0261] The first elastic unit **663***a* may surround an outer surface of the first shaft **661***a* as described above and thus may provide a restoring force to the first clamping unit **651***a* when the first clamping unit **651***a* moves.
[0262] A method of manufacturing the display device **300***a* by using the apparatus **600***a* will be described. The cover window **310***a* and the panel member **390***a* may be manufactured and prepared. The panel member **390***a* may include at least one of the display panel **330***a* or the TSP **340***a* as described above. However, for convenience of description, it will be assumed that the panel member **390***a* includes both the display panel **330***a* and the TSP **340***a*.
[0263] Next, the cover window **310***a* may be disposed on the first jig **610***a*. The cover window **310***a* may be formed to have a curved surface having a predetermined curvature radius of R as described above, and may be seated on an outer surface of the first jig **610***a*. A first absorption pump **632***a* may absorb air of a first absorption unit **631***a* to fix the cover window **310***a* to the outer surface of the first jig **610***a*.
[0264] While the process is performed, the TSP **340***a* and the display panel **330***a* adhered by using the second adhesive layer **350***a* as described above may be disposed on the second jig **620***a*. The display panel **330***a* may be disposed to face the second jig **620***a* and the TSP **340***a* may be disposed to face the first jig **610***a*. In particular, the display panel **330***a* and the TSP **340***a* may be stacked, and an end of the display panel **330***a* and an end of the TSP **340***a* may be fixed by being inserted into the first clamping unit **651***a* and the second clamping unit **652***a*.
[0265] Next, the first adhesive layer **320***a* may be formed on the TSP **340***a*. Respective ends of the display panel **330***a* and the TSP **340***a* on which the first adhesive layer **320***a* is formed may be

fixed to the first clamping unit **651***a* and the second clamping unit **652***a*.

[0266] Once the panel member **390***a* is fixed to the first clamping unit **651***a* and the second clamping unit **652***a*, one portion of the panel member **390***a* may be curved upward (for example, with respect to a gravity direction). In further detail, since a distance between the first clamping unit **651***a* and the second clamping unit **652***a* is less than at least one of a width or a length of the panel member **390***a*, the upwardly curved portion may protrude toward the first jig **610***a*. In this case, it will be assumed that the distance between the first clamping unit **651***a* and the second clamping unit **652***a* is less than a width of the panel member **390***a*.

[0267] After the panel member **390***a* is disposed in this manner, the panel member **390***a* and the cover window **310***a* may be compressed against each other by moving at least one of the first jig **610***a* or the second jig **620***a*. For convenience of description, however, it will be assumed that the panel member **390***a* and the cover window **310***a* are compressed by moving both the first jig **610***a* and the second jig **620***a*.

[0268] While the first jig **610***a* and the second jig **620***a* move in this manner, the first linear driving unit **660***a* and the second linear driving unit **670***a* may operate to vertically move the first clamping unit **651***a* and the second clamping unit **652***a*. In particular, the first clamping unit **651***a* and the second clamping unit **652***a* may move at a speed similar to a speed at which the second jig **620***a* moves.

[0269] When the second jig **620***a*, the first clamping unit **651***a*, and the second clamping unit **652***a* are raised in this manner, the panel member **390***a* may be raised while maintaining its curved state. When a distance between the first jig **610***a* and the second jig **620***a* reaches a set distance (for example, a predetermined distance), the first clamping unit **651***a* and the second clamping unit **652***a* may release from (for example, reduce their clamping force from) the panel member **390***a*.

[0270] During or after this releasing of the first clamping unit **651***a* and the second clamping unit **652***a*, the first linear driving unit **660***a* and the second linear driving unit **670***a* may lower the first clamping unit **651***a* and the second clamping unit **652***a*.

[0271] Next, the first driving unit **615***a* and the second driving unit **625***a* may continuously operate to bring the first jig **610***a* and the second jig **620***a* closer (for example, adjacent) to each other (for example, the second jig **620***a* may contact panel member **390***a*). As the first jig **610***a* and the second jig **620***a* move closer, the panel member **390***a* and the cover window **310***a* may be compressed against each other. A method of compressing the panel member **390***a* and the cover window **310***a* may be performed in the same manner as that described above, and thus a detailed description thereof will not be repeated.

[0272] In particular, when the cover window **310***a* and the panel member **390***a* contact each other, a load range applied when the first jig **610***a* and the second jig **620***a* compress the cover window **310***a* and the panel member **390***a* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***a* and the panel member **390***a* may be reduced, and the cover window **310***a* and the panel member **390***a* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***a* and the panel member **390***a* are attached to each other, the cover window **310***a* and the panel member **390***a* may be damaged, thereby reducing quality and reliability.

[0273] The cushion unit **690***a* may uniformly distribute a force applied to the cover window **310***a* and the panel member **390***a* when the cover window **310***a* and the panel member **390***a* are laminated due to compression.

[0274] When the process is completed, the first driving unit **615***a* and the second driving unit **625***a* may operate to separate the first jig **610***a* and the second jig **620***a*. The operator may complete an operation by removing the completed display device **300***a* from the first jig **610***a* or the second jig **620***a*.

[0275] The operation may be performed in a vacuum state. In further detail, the apparatus **600***a*

may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **610***a*, the second jig **620***a*, the fixing unit, and the driving unit are disposed. In addition, the apparatus **600***a* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***a* and the panel member **390***a* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0276] Accordingly, the apparatus **600***a* may rapidly and accurately manufacture the display device **300***a* having a curved surface. In particular, the apparatus **600***a* may reduce or minimize a product defect rate by accurately attaching the panel member **390***a* and the cover window **310***a* having a curved surface.

[0277] In addition, the apparatus **600***a* may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) when the panel member **390***a* and the cover window **310***a* are compressed.

[0278] FIG. **18** is a cross-sectional view illustrating an apparatus **700***a* for manufacturing the display device **300***a* of FIG. **14**, according to still yet another embodiment of the present invention.

[0279] Referring to FIG. **18**, the apparatus **700***a* may include a first jig **710***a*, a second jig **720***a*, a driving unit M, a clamping unit **750***a*, a fixing unit (for example, first fixing unit **730***a*), a linear driving unit L, and a cushion unit **790***a*. The first jig **710***a* and the second jig **720***a* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0280] The driving unit M may include a first driving unit **715***a* and a second driving unit **725***a*, and the fixing unit may include a first fixing unit **730***a*. The first driving unit **715***a*, the second driving unit **725***a*, and the first fixing unit **730***a* (which includes first absorption unit **731***a* and first absorption pump **732***a*) may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0281] In addition, the clamping unit **750***a* may include a first clamping unit **751***a* and a second clamping unit **752***a*. The first clamping unit **751***a* and the second clamping unit **752***a* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0282] The linear driving unit L may include a first linear driving unit **760***a* and a second linear driving unit **770***a*, and the first linear driving unit **760***a* and the second linear driving unit **770***a* may linearly move the first clamping unit **751***a* and the second clamping unit **752***a*, respectively. In particular, the first linear driving unit **760***a* and the second linear driving unit **770***a* may linearly move the first clamping unit **751***a* and the second clamping unit **752***a* in a diagonal direction. Since the second linear driving unit **770***a* may be formed similarly to the first linear driving unit **760***a*, the following description will focus on the first linear driving unit **760***a*.

[0283] In further detail, the first linear driving unit **760***a* may include a first shaft **761***a*, a first driving module **765***a*, and a first elastic unit **763***a*. The first shaft **761***a*, the first driving module **765***a*, and the first elastic unit **763***a* may be formed in a similar manner to those described above (such as the first linear driving unit **760** in FIGS. **12-13**). The first shaft **761***a* is disposed in a diagonal direction to diagonally move the first clamping unit **751***a*.

[0284] In particular, when the first linear driving unit **760***a* operates, the first driving module **765***a* may vary a length of the first shaft **761***a*. Since the first driving module **765***a* and the first shaft **761***a* are diagonally disposed with respect to the second jig **720***a* as described above, the first clamping unit **751***a* may be diagonally moved by varying the movement of the first shaft **761***a*.

[0285] For example, when the first driving module **765***a* operates to diagonally move the first shaft **761***a* downward with respect to the second jig **720***a*, the first clamping unit **751***a* may diagonally move downward with respect to the second jig **720***a* as the first shaft **761***a* moves.

[0286] When the first driving module **765***a* operates in an opposite direction to diagonally move

the first shaft **761***a* upward with respect to the second jig **720***a*, the first clamping unit **751***a* may diagonally move upward with respect to the second jig **720***a* as the first shaft **761***a* moves.
[0287] The first shaft **761***a* may include a ball screw as described above and thus may rotate as the first driving module **765***a* operates. In particular, the first shaft **761***a* may diagonally move downward or upward with respect to the second jig **720***a* as the first driving module **765***a* rotates.
[0288] The cushion unit **790***a* may be formed in various ways. For example, the cushion unit **790***a* may be provided on an outer surface of at least one of the first jig **710***a* or the second jig **720***a*. For ease of description, it will be assumed that the cushion unit **790***a* is formed on an entire outer surface of the second jig **720***a*.
[0289] A method of manufacturing the display device **300***a* may be similar to that described above. In further detail, the panel member **390***a* and the cover window **310***a* may be manufactured and prepared. The panel member **390***a* may include the display panel **330***a* and the TSP **340***a* as described above. However, for convenience of description, it will be assumed that the panel member **390***a* includes both the display panel **330***a* and the TSP **340***a*.
[0290] After the cover window **310***a* and the panel member **390***a* are manufactured and prepared as described above, the cover window **310***a* may be disposed on the first jig **710***a*. The cover window **310***a* may be formed to have a curved surface having a predetermined curvature radius of R as described above, and may be seated on an outer surface of the first jig **710***a*. A first absorption pump **732***a* may operate to absorb air of a first absorption unit **731***a* so that the cover window **310***a* is fixed to the outer surface of the first jig **710***a*.
[0291] When the display panel **330***a* and the TSP **340***a* are completely manufactured as described above, the display panel **330***a* and the TSP **340***a* may be adhered by using the second adhesive layer **350***a*, and the first adhesive layer **320***a* may be coated on the TSP **340***a*.
[0292] Next, the TSP **340***a* and the display panel **330***a* may be disposed on the second jig **720***a*. The display panel **330***a* may be disposed to face the second jig **720**, and the TSP **340***a* may be disposed to face the first jig **710***a*. The panel member **390***a* manufactured as described above may be fixed by the first clamping unit **751***a* and the second clamping unit **752***a*. In further detail, since a distance between the first clamping unit **751***a* and the second clamping unit **752***a* is less than at least one of a width or a length of the panel member **390***a*, an upwardly curved portion of the panel member **390***a* may protrude toward the first jig **710***a*. In this case, it will be assumed that the distance between the first clamping unit **751***a* and the second clamping unit **752***a* is less than a width of the panel member **390***a*. When the fixing is completed, the panel member **390***a* and the cover window **310***a* may be compressed against each other by moving at least one of the first jig **710***a* or the second jig **720***a*. A method of compressing the panel member **390***a* and the cover window **310***a* may be similar to that described above, and thus a detailed description thereof will not be repeated.
[0293] When the first jig **710***a* and the second jig **720***a* move in this manner, the first clamping unit **751***a* and the second clamping unit **752***a* may also move. In particular, the first clamping unit **751***a* and the second clamping unit **752***a* may be diagonally moved by the first linear driving unit **760***a* and the second linear driving unit **770***a*, respectively. The first clamping unit **751***a* and the second clamping unit **752***a* may be raised diagonally.
[0294] When the first clamping unit **751***a* and the second clamping unit **752***a* are raised and then an interval between the first jig **710***a* and the second jig **720***a* reaches a preset interval, both ends of the panel member **390***a* may be released. The panel member **390***a* may be sequentially adhered to the cover window **310***a* beginning from a protruding portion toward both end portions.
[0295] After the releasing of the first clamping unit **751***a* and the second clamping unit **752***a*, the first linear driving unit **760***a* and the second linear driving unit **770***a* may operate to lower the first clamping unit **751***a* and the second clamping unit **752***a*. The first clamping unit **751***a* and the second clamping unit **752***a* may be lowered diagonally.
[0296] While the first clamping unit **751***a* and the second clamping unit **752***a* are lowered, the first

jig **710***a* and the second jig **720***a* may get closer to each other to compress the panel member **390***a* and the cover window **310***a*. In this case, a method of adhering the panel member **390***a* and the cover window **310***a* through compression may be similar to that described above.

[0297] When the panel member **390***a* and the cover window **310***a* are compressed by moving the first jig **710***a* and the second jig **720***a* as described above, the cushion unit **790***a* may distribute a force applied to the panel member **390***a* and the cover window **310***a*. In addition, the cushion unit **790***a* may help prevent the panel member **390***a* or the cover window **310***a* from being damaged by absorbing part of a force applied to the panel member **390***a* and the cover window **310***a*.

[0298] In particular, when the cover window **310***a* and the display panel **330***a* contact each other, a load range applied when the first jig **710***a* and the second jig **720***a* compress the cover window **310***a* and the panel member **390***a* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***a* and the panel member **390***a* may be reduced, and the cover window **310***a* and the panel member **390***a* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***a* and the panel member **390***a* are attached to each other, the cover window **310***a* and the panel member **390***a* may be damaged, thereby reducing quality and reliability.

[0299] After the process is completed, the first driving unit **715***a* and the second driving unit **725***a* may operate to separate the first jig **710***a* and the second jig **720***a*. The operator may complete an operation by removing the completed display device **300***a* from the first jig **710***a* or the second jig **720***a*.

[0300] The operation may be performed in a vacuum state. In further detail, the apparatus **700***a* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **710***a*, the second jig **720***a*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **700***a* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***a* and the panel member **390***a* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0301] Accordingly, the apparatus **700***a* may manufacture the display device **300***a* having a curved surface. In particular, the apparatus **700***a* may reduce or minimize a product defect rate by accurately attaching the display panel **330***a* and the cover window **310***a* having a curved surface.

[0302] In addition, the apparatus **700***a* may improve quality by removing air bubbles or preventing air bubbles from being generated after the display panel **330***a* and the curved portions are compressed.

[0303] FIG. **19** is a cross-sectional view illustrating a display device **300***b* according to still yet another embodiment of the present invention.

[0304] Referring to FIG. **19**, the display device **300***b* may include a cover window **310***b* and a panel member **390***b* as described above. In addition, the display device **300***b* may include a first adhesive layer **320***b* that is disposed between the panel member **390***b* and the cover window **310***b*. The panel member **390***b* may include a display panel **330***b* and a TSP **340***b* as described above. In particular, a second adhesive layer **350***b* may be provided between the display panel **330***b* and the TSP **340***b* to attach the display panel **330***b* and the TSP **340***b*.

[0305] At least a portion of the cover window **310***b* may be curved. The cover window **310***b* may be formed such that a surface on which an image or text is displayed is curved after then panel member **390***b* is attached. In particular, the cover window **310***b* may be formed to have at least one curved surface having a curvature radius. In some embodiments, the cover window **310***b* may be formed to have a first curved surface having a curvature radius of R**1**, a second curved surface having a curvature radius of R**2**, and may further include a third curved surface having a curvature radius of R**3** in at least one of a longitudinal direction or a width direction. In other embodiments,

the cover window **310***b* may further include curved surfaces having curvature radii of R**4**, R**5**, . . . , and RN (N is a natural number) in addition to the curved surfaces having the curvature radii of R**1**, R**2**, and R**3** (e.g., there may be a separate curvature radius of each portion or curved surface of the cover window **310***b*). However, for convenience of description, it will be assumed that the cover window **310***b* is formed to have the first, second, and third curved surfaces having the curvature radii of R**1**, R**2**, and R**3** in a width direction.

[0306] The first adhesive layer **320***b* and the second adhesive layer **350***b* may be formed of the same material. In further detail, the first adhesive layer **320***b* and the second adhesive layer **350***b* may be formed of an adhesive and transparent material. For example, the first adhesive layer **320***b* and the second adhesive layer **350***b* may include an optical clear adhesive film (OCA film) or an adhesive material.

[0307] Accordingly, since the display device **300***b* is formed to have a set or predetermined curvature radius, the display device **300***b* may be applied to various members.

[0308] FIG. **20** is a cross-sectional view illustrating an apparatus **400***b* for manufacturing the display device **300***b* of FIG. **19**, according to an embodiment of the present invention.

[0309] Referring to FIG. **20**, the apparatus **400***b* may include a first jig **410***b*, a second jig **420***b*, a driving unit M, a fixing unit (for example, first fixing unit **430***b*), and a cushion unit **490***b*. An outer surface of the first jig **410***b* on which the cover window **310***b* is seated may be formed equally or similarly to an outer surface of the cover window **310***b* contacting the outer surface of the first jig **410***b*. In further detail, the first jig **410***b* may have at least two curved surfaces having curvature radii of R**1**′, R**2**′, R**3**′, . . . , like the cover window **310***b*. In particular, the first jig **410***b* may be formed by being recessed away from the second jig **420***b*.

[0310] An outer surface of the second jig **420***b* may protrude toward the first jig **410***b* to correspond to or engage with a recessed portion of the first jig **410***b* (e.g., the first jig **410***b* may have a recessed outer surface). The outer surface of the second jig **420***b* may be at least two curved surfaces having set or predetermined curvature radii.

[0311] The driving unit M may include a first driving unit **415***b* and a second driving unit **425***b*. The first driving unit **415***b* may linearly move the first jig **410***b* toward the second jig **420***b*, and the second driving unit **425***b* may linearly move the second jig **420***b* toward the first jig **410***b*. The first driving unit **415***b* and the second driving unit **425***b* may be formed in the same manner as or a similar manner to those described above.

[0312] In addition, the fixing unit may include a first fixing unit **430***b* provided on the first jig **410***b* and a second fixing unit provided on the second jig **420***b*. For convenience of description, it will be assumed that the fixing unit includes the first fixing unit **430***b*. In addition, the first fixing unit **430***b* and the second fixing unit may be formed in the same manner or a similar manner, and thus a detailed description of the second fixing unit will not be given.

[0313] The first fixing unit **430***b* may be formed in various ways. For example, the first fixing unit **430***b* may include an adhesive member, an adhesive chuck, or an electrostatic chuck. In addition, the first fixing unit **430***b* may include a first absorption unit **431***b* and a first absorption pump **432***b* that is connected to the first absorption unit **431***b*. In particular, the first fixing unit **430***b* is not limited thereto, and may include a clamp, or a protrusion that is provided on the first jig **410***b* and mechanically restricts the cover window **310***b*. However, for convenience of description, it will be assumed that the first fixing unit **430***b* includes the first absorption unit **431***b* and the first absorption pump **432***b*.

[0314] The cushion unit **490***b* may be provided on at least one of the first jig **410***b* or the second jig **420***b*. In this case, the cushion unit **490***b* is the same as or similar to that described above, and thus a detailed description thereof will not be repeated. In addition, for convenience of description, it will be assumed that the cushion unit **490***b* is provided only on the second jig **420***b* and is integrally formed on an outer surface of the second jig **420***b*.

[0315] A method of manufacturing the display device **300***b* by using the apparatus **400***b* will now

be described. First, the cover window **310***b* and the panel member **390***b* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***b* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the panel member **390***b* may adhere the TSP **340***b* and the display panel **330***b* by using the second adhesive layer **350***b*.

[0316] After the cover window **310***b* and the panel member **390***b* are manufactured and prepared as described above, the cover window **310***b* may be disposed on the first jig **410***b*. The cover window **310***b* may be formed to have at least two curved surfaces having curvature radii as described above and may be seated on an outer surface of the first jig **410***b*. The first absorption pump **432***b* may operate to absorb (e.g., evacuate or vacuum) air out of the first absorption unit **431***b*, so that the cover window **310***b* may be fixed to the outer surface of the first jig **410***b*.

[0317] While the process is performed, the TSP **340***b* and the display panel **330***b* adhered by using the second adhesive layer **350***b* may be disposed on the second jig **420***b*. The display panel **330***b* may be disposed to face the second jig **420***b*, and the TSP **340***b* may be disposed to face the first jig **410***b*.

[0318] After the TSP **340***b* and the display panel **330***b* are disposed as described above, the first adhesive layer **320***b* may be coated on the TSP **340***b*. The first adhesive layer **320***b* may be formed of the same material as or a similar material to that of the second adhesive layer **350***b*.

[0319] When the cover window **310***b*, the TSP **340***b*, and the display panel **330***b* are completely disposed as described above, the first jig **410***b* and the second jig **420***b* may be moved toward each other by driving the first driving unit **415***b* and the second driving unit **425***b*. A protruding portion of the second jig **420***b* may first contact the display panel **330***b*, and the first adhesive layer **320***b* and the cover window **310***b* may be sequentially laminated from central portions of the display panel **330***b* to both end portions.

[0320] In particular, when the cover window **310***b* and the panel member **390***b* contact each other, a load range applied when the first jig **410***b* and the second jig **420***b* compress the cover window **310***b* and the panel member **390***b* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***b* and the panel member **390***b* may be reduced, and the cover window **310***b* and the panel member **390***b* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***b* and the panel member **390***b* are attached to each other, the cover window **310***b* and the panel member **390***b* may be damaged, thereby reducing quality and reliability.

[0321] While the process is performed, the cushion unit **490***b* may uniformly distribute a force applied to the panel member **390***b* and the cover window **310***b*.

[0322] When the process is completed, the first driving unit **415***b* and the second driving unit **425***b* may operate to separate the first jig **410***b* and the second jig **420***b*. The operator may complete an operation by removing the completed display device **300***b* from the first jig **410***b* or the second jig **420***b*.

[0323] The operation may be performed in a vacuum state. In further detail, the apparatus **400***b* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **410***b*, the second jig **420***b*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **400***b* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***b* and the panel member **390***b* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0324] Accordingly, the apparatus **400***b* may manufacture any type of display device **300***b*. In addition, the apparatus **400***b* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***b* and the panel

member **390***b* when the cover window **310***b* and the panel member **390***b* are laminated.
[0325] FIG. **21** is a cross-sectional view illustrating an apparatus **500***b* for manufacturing the display device **300***b* of FIG. **19**, according to another embodiment of the present invention.
[0326] Referring to FIG. **21**, the apparatus **500***b* includes a first jig **510***b*, a second jig **520***b*, a driving unit M, a fixing unit (for example, first fixing unit **530***b*), and a cushion unit **590***b*. In this case, the first jig **510***b*, the second jig **520***b*, the driving unit M, the fixing unit, and the cushion unit **590***b* are substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0327] The driving unit M may include a first driving unit **515***b* and a second driving unit **525***b*, and the fixing unit may include a first fixing unit **530***b*. The first driving unit **515***b*, the second driving unit **525***b*, and the first fixing unit **530***b* (which includes a first absorption unit **531***b* and a first absorption pump **532***b*) are substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0328] The apparatus **500***b* includes a clamping unit **550***b* that is spaced apart by a set or predetermined interval from at least one of the first jig **510***b* or the second jig **520***b*, and supports the panel member **390***b*. For convenience of description, however, it will be assumed that the clamping unit **550***b* is disposed adjacent to the second jig **520***b*.
[0329] The clamping unit **550***b* may support one end of the panel member **390***b* when the one end of the panel member **390***b* is inserted into the clamping unit **550***b*. A plurality of the clamping units **550***b* may be provided, where a distance S**4** between the clamping units **550***b* is less than a length or a width of the panel member **390***b*. The panel member **390***b* may include at least one of the display panel **330***b* or the TSP **340***b* as described above. For convenience of description, it will be assumed that the distance S**4** between the plurality of clamping units **550***b* is less than a width of the panel member **390***b* and the panel member **390***b* includes the display panel **330***b* and the TSP **340***b*.
[0330] In particular, the plurality of clamping units **550***b* face respective side surfaces of the second jig **520***b*, and fix both ends of the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b*. The plurality of clamping units **550***b* include a first clamping unit **551***b* and a second clamping unit **552***b* that are spaced apart by a set or predetermined interval from each other.
[0331] Accordingly, the apparatus **500***b* may rapidly and easily manufacture the display device **300***b* having a curved surface and a simple structure. In addition, since the apparatus **500***b* may accurately attach the cover window **310***b* having a curved surface to the panel member **390***b*, a product defect rate may be reduced or minimized.
[0332] In particular, since the apparatus **500***b* includes the clamping unit **550***b* to accurately align the panel member **390***b* and the cover window **310***b*, working efficiency may be improved.
[0333] A method of manufacturing the display device **300***b* by using the apparatus **500***b* will now be described with reference to FIG. **21**.
[0334] The cover window **310***b* may be formed as described above, the display panel **330***b* may be formed, and then the TSP **340***b* and the display panel **330***b* may be adhered by using the second adhesive layer **350***b*. The cover window **310***b* may be mounted on the first jig **510***b* as described above.
[0335] Next, respective ends of the TSP **340***b* on which the first adhesive layer **320***b* is attached are fixed to the first clamping unit **551***b* and the second clamping unit **552***b*. For example, the respective ends of panel member **390***b* may be fixed by being inserted into grooves formed in the first clamping unit **551***b* and the second clamping unit **552***b* as described above.
[0336] Once the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* are fixed in this manner, portions of the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* may be curved upward (for example, with respect to a gravity direction). In further detail, since a distance S**4** between the first

clamping unit **551***b* and the second clamping unit **552***b* is less than at least one of a width or a length of at least one of the display panel **330***b* or the TSP **340***b*, the portions of the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* may protrude toward the first jig **510***b*.

[0337] When the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* are fixed as described above, the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, the first adhesive layer **320***b*, and the cover window **310***b* may be compressed against each other by moving at least one of the first jig **510***b* or the second jig **520***b*. For convenience of description, it will be assumed that the first adhesive layer **320***b* and the cover window **310***b* are compressed by moving both the first jig **510***b* and the second jig **520***b*.

[0338] When the first jig **510***b* and the second jig **520***b* move, the first driving unit **515***b* and the second driving unit **525***b* may operate to move the first jig **510***b* and the second jig **520***b* closer to each other.

[0339] The upwardly curved portions of the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* first contact the cover window **310***b*. When the first jig **510***b* and the second jig **520***b* continuously move, the display panel **330***b*, the second adhesive layer **350***b*, the TSP **340***b*, and the first adhesive layer **320***b* may be laminated to the cover window **310***b* beginning from contact portions with the cover window **310***b* toward both end portions.

[0340] In particular, when the cover window **310***b* and the panel member **390***b* contact each other, a load range applied when the first jig **510***b* and the second jig **520***b* compress the cover window **310***b* and the panel member **390***b* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***b* and the panel member **390***b* may be reduced, and the cover window **310***b* and the panel member **390***b* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***b* and the panel member **390***b* are attached to each other, the cover window **310***b* and the panel member **390***b* may be damaged, thereby reducing quality and reliability.

[0341] The cushion unit **590***b* may uniformly distribute a force applied to the panel member **390***b* and the cover window **310***b* when the panel member **390***b* and the cover window **310***b* are compressed and laminated.

[0342] The operation may be performed in a vacuum state. In further detail, the apparatus **500***b* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **510***b*, the second jig **520***b*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **500***b* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***b* and the panel member **390***b* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0343] Accordingly, the apparatus **500***b* may rapidly and accurately manufacture any type of display device **300***b* having a curved surface. In particular, the apparatus **500***b* may reduce or minimize a product defect rate by accurately attaching the display panel **330***b* and the cover window **310***b* having a curved surface.

[0344] In addition, the apparatus **500***b* may reduce or minimize a product defect rate by effectively removing air bubbles or preventing air bubbles from being generated after the display panel **330***b* and the curved portions are compressed.

[0345] FIG. **22** is a cross-sectional view illustrating an apparatus **600***b* for manufacturing the display device **300***b* of FIG. **19**, according to yet another embodiment of the present invention.

[0346] Referring to FIG. **22**, the apparatus **600***b* includes a first jig **610***b*, a second jig **620***b*, a driving unit M, a clamping unit **650***b*, a fixing unit (for example, first fixing unit **630***b*), a linear driving unit L, and a cushion unit **690***b*. The first jig **610***b*, the second jig **620***b*, the linear driving

unit L, the clamping unit **650***b*, the fixing unit, and the cushion unit **690***b* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0347] The driving unit M may include a first driving unit **615***b* and a second driving unit **625***b*, and the fixing unit may include a first fixing unit **630***b*. The first driving unit **615***b*, the second driving unit **625***b*, and the first fixing unit **630***b* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated. In particular, the first fixing unit **630***b* may include a first absorption pump **632***b* and a first absorption unit **631***b*.
[0348] The clamping unit **650***b* may include a first clamping unit **651***b* and a second clamping unit **652***b*. The first clamping unit **651***b* and the second clamping unit **652***b* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0349] The apparatus **600***b* may include a linear driving unit L that includes a first linear driving unit **660***b* and a second linear driving unit **670***b* that respectively vertically move the first clamping unit **651***b* and the second clamping unit **652***b*. The first linear driving unit **660***b* and the second linear driving unit **670***b* may be formed similarly, and thus the following description will focus on the first linear driving unit **660***b*.
[0350] The first linear driving unit **660***b* may include a first shaft **661***b* that is connected to the first clamping unit **651***b* and linearly moves the first clamping unit **651***b*. In addition, the first linear driving unit **660***b* may include a first driving module **665***b* that drives the first shaft **661***b*. The first driving module **665***b* may include a cylinder or a motor. For convenience of description, however, it will be assumed that the first driving module **665***b* includes a motor. It will be further assumed that the first shaft **661***b* includes a ball screw that is lowered or raised as the first driving module **665***b* rotates.
[0351] The first linear driving unit **660***b* may include a first elastic unit **663***b* that surrounds the first shaft **661***b*. The first elastic unit **663***b* may include a compression spring, and may be formed of an elastic material such as rubber. For convenience of description, however, it will be assumed that the first elastic unit **663***b* includes a compression spring.
[0352] The first elastic unit **663***b* may surround an outer surface of the first shaft **661***b* as described above and thus may provide a restoring force to the first clamping unit **651***b* when the first clamping unit **651***b* moves.
[0353] A method of manufacturing the display device **300***b* by using the apparatus **600***b* will be described. The cover window **310***b* and the panel member **390***b* may be manufactured and prepared. The panel member **390***b* may include at least one of the display panel **330***b* or the TSP **340***b* as described above. However, for convenience of description, it will be assumed that the panel member **390***b* includes both the display panel **330***b* and the TSP **340***b*.
[0354] The display panel **330***b* and the TSP **340***b* may be attached by using the second adhesive layer **350***b*, and then the first adhesive layer **320***b* may be formed on the TSP **340***b*. Respective ends of the display panel **330***b* and the TSP **340***b* on which the first adhesive layer **320***b* is formed may be fixed to the first clamping unit **651***b* and the second clamping unit **652***b*.
[0355] Once the panel member **390***b* is fixed to the first clamping unit **651***b* and the second clamping unit **652***b*, one portion of the panel member **390***b* may be curved upward (for example, with respect to a gravity direction). In further detail, since a distance S**5** between the first clamping unit **651***b* and the second clamping unit **652***b* is less than at least one of a width or a length of the panel member **390***b*, the upwardly curved portion may protrude toward the first jig **610***b*. In this case, it will be assumed that the distance S**5** between the first clamping unit **651***b* and the second clamping unit **652***b* is less than a width of the panel member **390***b*.
[0356] After the panel member **390***b* is disposed in this manner, the panel member **390***b* and the cover window **310***b* may be compressed against each other by moving at least one of the first jig **610***b* or the second jig **620***b*. For convenience of description, however, it will be assumed that the panel member **390***b* and the cover window **310***b* are compressed by moving both the first jig **610***b* and the second jig **620***b*.

[0357] While the first jig **610***b* and the second jig **620***b* move in this manner, the first linear driving unit **660***b* and the second linear driving unit **670***b* may operate to vertically move the first clamping unit **651***b* and the second clamping unit **652***b*. In particular, the first clamping unit **651***b* and the second clamping unit **652***b* may move at a speed similar to a speed at which the second jig **620***b* moves.
[0358] When the second jig **620***b*, the first clamping unit **651***b*, and the second clamping unit **652***b* are raised in this manner, the panel member **390***b* may be raised while maintaining its curved state. When a distance between the first jig **610***b* and the second jig **620***b* reaches a set distance (for example, a predetermined distance), the first clamping unit **651***b* and the second clamping unit **652***b* may release from (for example, reduce their clamping force from) the panel member **390***b*.
[0359] During or after this releasing of the first clamping unit **651***b* and the second clamping unit **652***b*, the first linear driving unit **660***b* and the second linear driving unit **670***b* may lower the first clamping unit **651***b* and the second clamping unit **652***b*.
[0360] Next, the first driving unit **615***b* and the second driving unit **625***b* may continuously operate to bring the first jig **610***b* and the second jig **620***b* closer (for example, adjacent) to each other (for example, the second jig **620***b* may contact panel member **390***b*). As the first jig **610***b* and the second jig **620***b* move closer, the panel member **390***b* and the cover window **310***b* may be compressed against each other. A method of compressing the panel member **390***b* and the cover window **310***b* may be performed in the same manner as that described above, and thus a detailed description thereof will not be repeated.
[0361] In particular, when the cover window **310***b* and the panel member **390***b* contact each other, a load range applied when the first jig **610***b* and the second jig **620***b* compress the cover window **310***b* and the panel member **390***b* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***b* and the panel member **390***b* may be reduced, and the cover window **310***b* and the panel member **390***b* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***b* and the panel member **390***b* are attached to each other, the cover window **310***b* and the panel member **390***b* may be damaged, thereby reducing quality and reliability.
[0362] The cushion unit **690***b* may uniformly distribute a force applied to the cover window **310***b* and the panel member **390***b* when the cover window **310***b* and the panel member **390***b* are laminated due to compression.
[0363] The operation may be performed in a vacuum state. In further detail, the apparatus **600***b* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **610***b*, the second jig **620***b*, the fixing unit, and the driving unit are disposed. In addition, the apparatus **600***b* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***b* and the panel member **390***b* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.
[0364] Accordingly, the apparatus **600***b* may rapidly and accurately manufacture the display device **300***b* having a curved surface. In particular, the apparatus **600***b* may reduce or minimize a product defect rate by accurately attaching the panel member **390***b* and the cover window **310***b* having a curved surface.
[0365] In addition, the apparatus **600***b* may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) when the panel member **390***b* and the cover window **310***b* are compressed.
[0366] FIG. **23** is a cross-sectional view illustrating an apparatus **700***b* for manufacturing the display device **300***b* of FIG. **19**, according to still yet another embodiment of the present invention.
[0367] Referring to FIG. **23**, the apparatus **700***b* may include a first jig **710***b*, a second jig **720***b*, a

driving unit M, a clamping unit **750***b*, a fixing unit (for example, first fixing unit **730***b*), a linear driving unit L, and a cushion unit **790***b*. The first jig **710***b* and the second jig **720***b* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0368] The driving unit M may include a first driving unit **715***b* and a second driving unit **725***b*, and the fixing unit may include a first fixing unit **730***b*. The first driving unit **715***b*, the second driving unit **725***b*, and the first fixing unit **730***b* (which includes first absorption unit **731***b* and first absorption pump **732***b*) may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0369] In addition, the clamping unit **750***b* may include a first clamping unit **751***b* and a second clamping unit **752***b*. The first clamping unit **751***b* and the second clamping unit **752***b* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0370] The linear driving unit L may include a first linear driving unit **760***b* and a second linear driving unit **770***b*, and the first linear driving unit **760***b* and the second linear driving unit **770***b* may linearly move the first clamping unit **751***b* and the second clamping unit **752***b*, respectively. In particular, the first linear driving unit **760***b* and the second linear driving unit **770***b* may linearly move the first clamping unit **751***b* and the second clamping unit **752***b* in a diagonal direction. Since the second linear driving unit **770***b* may be formed similarly to the first linear driving unit **760***b*, the following description will focus on the first linear driving unit **760***b*.

[0371] In further detail, the first linear driving unit **760***b* may include a first shaft **761***b*, a first driving module **765***b*, and a first elastic unit **763***b*. The first shaft **761***b*, the first driving module **765***b*, and the first elastic unit **763***b* may be formed in a similar manner to those described above (such as the first linear driving unit **760** in FIGS. **12-13**). The first shaft **761***b* is disposed in a diagonal direction to diagonally move the first clamping unit **751***b*.

[0372] In particular, when the first linear driving unit **760***b* operates, the first driving module **765***b* may vary a length of the first shaft **761***b*. Since the first driving module **765***b* and the first shaft **761***b* are diagonally disposed with respect to the second jig **720***b* as described above, the first clamping unit **751***b* may be diagonally moved by varying the movement of the first shaft **761***b*.

[0373] For example, when the first driving module **765***b* operates to diagonally move the first shaft **761***b* downward with respect to the second jig **720***b*, the first clamping unit **751***b* may diagonally move downward with respect to the second jig **720***b* as the first shaft **761***b* moves.

[0374] When the first driving module **765***b* operates in an opposite direction to diagonally move the first shaft **761***b* upward with respect to the second jig **720***b*, the first clamping unit **751***b* may diagonally move upward with respect to the second jig **720***b* as the first shaft **761***b* moves.

[0375] The first shaft **761***b* may include a ball screw as described above and thus may rotate as the first driving module **765***b* operates. In particular, the first shaft **761***b* may diagonally move downward or upward with respect to the second jig **720***b* as the first driving module **765***b* rotates.

[0376] The cushion unit **790***b* may be formed in various ways. For example, the cushion unit **790***b* may be provided on an outer surface of at least one of the first jig **710***b* or the second jig **720***b*. For ease of description, it will be assumed that the cushion unit **790***b* is formed on an entire outer surface of the second jig **720***b*.

[0377] A method of manufacturing the display device **300***b* may be similar to that described above. In further detail, the panel member **390***b* and the cover window **310***b* may be manufactured and prepared. The panel member **390***b* may include the display panel **330***b* and the TSP **340***b* as described above. However, for convenience of description, it will be assumed that the panel member **390***b* includes both the display panel **330***b* and the TSP **340***b*.

[0378] When the display panel **330***b* and the TSP **340***b* are completely manufactured as described above, the display panel **330***b* and the TSP **340***b* may be adhered by using the second adhesive layer **350***b*, and the first adhesive layer **320***b* may be coated on the TSP **340***b*.

[0379] The panel member **390***b* manufactured as described above may be fixed by the first clamping unit **751***b* and the second clamping unit **752***b*. In further detail, since a distance S**6** between the first clamping unit **751***b* and the second clamping unit **752***b* is less than at least one of a width or a length of the panel member **390***b*, an upwardly curved portion of the panel member **390***b* may protrude toward the first jig **710***b*. In this case, it will be assumed that the distance S**6** between the first clamping unit **751***b* and the second clamping unit **752***b* is less than a width of the panel member **390***b*. When the fixing is completed, the panel member **390***b* and the cover window **310***b* may be compressed against each other by moving at least one of the first jig **710***b* or the second jig **720***b*. A method of compressing the panel member **390***b* and the cover window **310***b* may be similar to that described above, and thus a detailed description thereof will not be repeated.
[0380] When the first jig **710***b* and the second jig **720***b* move in this manner, the first clamping unit **751***b* and the second clamping unit **752***b* may also move. In particular, the first clamping unit **751***b* and the second clamping unit **752***b* may be diagonally moved by the first linear driving unit **760***b* and the second linear driving unit **770***b*, respectively. The first clamping unit **751***b* and the second clamping unit **752***b* may be raised diagonally.
[0381] When the first clamping unit **751***b* and the second clamping unit **752***b* are raised and then an interval between the first jig **710***b* and the second jig **720***b* reaches a preset interval, both ends of the panel member **390***b* may be released. The panel member **390***b* may be sequentially adhered to the cover window **310***b* beginning from a protruding portion toward both end portions.
[0382] After the releasing of the first clamping unit **751***b* and the second clamping unit **752***b*, the first linear driving unit **760***b* and the second linear driving unit **770***b* may operate to lower the first clamping unit **751***b* and the second clamping unit **752***b*. The first clamping unit **751***b* and the second clamping unit **752***b* may be lowered diagonally.
[0383] While the first clamping unit **751***b* and the second clamping unit **752***b* are lowered, the first jig **710***b* and the second jig **720***b* may get closer to each other to compress the panel member **390***b* and the cover window **310***b*. In this case, a method of adhering the panel member **390***b* and the cover window **310***b* through compression may be similar to that described above.
[0384] When the panel member **390***b* and the cover window **310***b* are compressed by moving the first jig **710***b* and the second jig **720***b* as described above, the cushion unit **790***b* may distribute a force applied to the panel member **390***b* and the cover window **310***b*. In addition, the cushion unit **790***b* may help prevent the panel member **390***b* or the cover window **310***b* from being damaged by absorbing part of a force applied to the panel member **390***b* and the cover window **310***b*.
[0385] In particular, when the cover window **310***b* and the display panel **330***b* contact each other, a load range applied when the first jig **710***b* and the second jig **720***b* compress the cover window **310***b* and the panel member **390***b* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***b* and the panel member **390***b* may be reduced, and the cover window **310***b* and the panel member **390***b* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***b* and the panel member **390***b* are attached to each other, the cover window **310***b* and the panel member **390***b* may be damaged, thereby reducing quality and reliability.
[0386] The operation may be performed in a vacuum state. In further detail, the apparatus **700***b* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **710***b*, the second jig **720***b*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **700***b* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***b* and the panel member **390***b* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.
[0387] Accordingly, the apparatus **700***b* may manufacture the display device **300***b* having a curved

surface. In particular, the apparatus **700***b* may reduce or minimize a product defect rate by accurately attaching the display panel **330***b* and the cover window **310***b* having a curved surface.
[0388] In addition, the apparatus **700***b* may improve quality by removing air bubbles or preventing air bubbles from being generated after the display panel **330***b* and the curved portions are compressed.
[0389] FIG. **24** is a cross-sectional view illustrating a display device **300***c* according to still another embodiment of the present invention.
[0390] Referring to FIG. **24**, the display device **300***c* may include a cover window **310***c* and a panel member **390***c*. The panel member **390***c* may include at least one of a TSP **340***c* or a display panel **330***c*. However, for convenience of description, it will be assumed that the panel member **390***c* includes both the TSP **340***c* and the display panel **330***c*.
[0391] The panel member **390***c* may include a first adhesive layer **320***c*, the TSP **340***c*, a second adhesive layer **350***c*, and the display panel **330***c*. In particular, the first adhesive layer **320***c*, the TSP **340***c*, the second adhesive layer **350***c*, and the display panel **330***c* are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.
[0392] At least a portion of the cover window **310***c* may be curved. In further detail, a middle portion of the cover window **310***c* may be flat and both ends of the middle portion may be curved. The cover window **310***c* may be formed of a glass material or a plastic material as described above. In particular, the cover window **310***c* may be formed such that a surface to which the display panel **330***c* is attached and on which an image or text is displayed is concave.
[0393] In the display device **300***c* formed as described above, the cover window **310***c*, the TSP **340***c*, and the display panel **330***c* may be adhered and fixed by the first adhesive layer **320***c* and the second adhesive layer **350***c*.
[0394] The TSP **340***c* and the display panel **330***c* may be attached to a protruding outer surface of the cover window **310***c*. In further detail, the TSP **340***c* and the display panel **330***c* may be provided on a protruding portion, instead of a recessed portion, of the curved cover window **310***c*.
[0395] Accordingly, the display device **300***c* shaped as described above may be applied to various members.
[0396] FIG. **25** is a cross-sectional view illustrating an apparatus **400***c* for manufacturing the display device **300***c* of FIG. **24**, according to an embodiment of the present invention.
[0397] Referring to FIG. **25**, the apparatus **400***c* may include a first jig **410***c*, a second jig **420***c*, a driving unit M, a fixing unit (for example, first fixing unit **430***c*), and a cushion unit **490***c*. At least a portion of the first jig **410***c* may be formed equally or similarly to an outer surface of the cover window **310***c*. In further detail, an outer surface of the first jig **410***c* on which the cover window **310***c* is seated may be the same as or similar in shape to an outer surface of the cover window **310***c* seated on the outer surface of the first jig **410***c*. In particular, the first jig **410***c* may protrude toward the second jig **420***c*.
[0398] An outer surface of the second jig **420***c* may be recessed away from the first jig **410***c* to correspond to or engage with a protruding portion of the first jig **410***c*.
[0399] The driving unit M may include a first driving unit **415***c* and a second driving unit **425***c*. The first driving unit **415***c* may linearly move the first jig **410***c* toward the second jig **420***c*, and the second driving unit **425***c* may linearly move the second jig **420***c* toward the first jig **410***c*. The first driving unit **415***c* and the second driving unit **425***c* may be formed in the same manner as or a similar manner to those described above.
[0400] In addition, the fixing unit may include a first fixing unit **430***c* provided on the first jig **410***c* and a second fixing unit provided on the second jig **420***c*. For convenience of description, it will be assumed that the fixing unit includes the first fixing unit **430***c*. In addition, the first fixing unit **430***c* and the second fixing unit may be formed in the same manner or a similar manner, and thus a detailed description of the second fixing unit will not be given.
[0401] The first fixing unit **430***c* may be formed in various ways. For example, the first fixing unit

430*c* may include an adhesive member, an adhesive chuck, or an electrostatic chuck. In addition, the first fixing unit **430***c* may include a first absorption unit, and a first absorption pump that is connected to the first absorption unit as described above. In particular, the first fixing unit **430***c* is not limited thereto, and may include a clamp, or a protrusion that is provided on the first jig **410***c* and mechanically restricts the cover window **310***c*. However, for convenience of description, it will be assumed that the first fixing unit **430***c* includes an adhesive member and is provided on an outer surface of a first cushion unit **493***c*.

[0402] The cushion unit **490***c* may be provided on at least one of the first jig **410***c* or the second jig **420***c*. A size of the cushion unit **490***c* may be less than a size of at least one of the cover window **310***c* or the panel member **390***c*. In further detail, the cushion unit **490***c* may be disposed only on a contact portion with at least one of the cover window **310***c* or the panel member **390***c*, and may be disposed to extend beyond the contact portion. The cushion unit **490***c* may be the same as or similar to that described above, and thus a detailed description thereof will not be repeated.

[0403] The cushion unit **490***c* may include the first cushion unit **493***c* that is provided on a surface of the first jig **410***c*, and a second cushion unit **491***c* that is provided on a surface of the second jig **420***c*. The first cushion unit **493***c* and the second cushion unit **491***c* may be integrally formed and respectively provided on the first jig **410***c* and the second jig **420***c*. In addition, a plurality of the first cushion units **493***c* and the second cushion units **491***c* may be formed, and the plurality of first cushion units **493***c* and the plurality of second cushion units **491***c* may be provided on an outer surface of the first jig **410***c* and an outer surface of the second jig **420***c*, respectively, and spaced apart from each other. However, for convenience of description, it will be assumed that the first cushion unit **493***c* and the second cushion unit **491***c* are respectively provided on the first jig **410***c* and the second jig **420***c*.

[0404] A method of manufacturing the display device **300***c* by using the apparatus **400***c* will now be described. First, the cover window **310***c* and the panel member **390***c* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***c* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***c* and the display panel **330***c* may be adhered to each other by using the second adhesive layer **350***c*.

[0405] After the cover window **310***c* and the panel member **390***c* are manufactured and prepared as described above, the cover window **310***c* may be disposed on the first jig **410***c*. The cover window **310***c* may be adhered and fixed to the first fixing unit **430***c*. In particular, a size of the first fixing unit **430***c* may be less than a size of the cover window **310***c*.

[0406] While the process is performed, the TSP **340***c* and the display panel **330***c* adhered by using the second adhesive layer **350***c* may be disposed on the second jig **420***c*. The display panel **330***c* may be disposed to face the second jig **420***c*, and the TSP **340***c* may be disposed to face the first jig **410***c*.

[0407] After the TSP **340***c* and the display panel **330***c* are disposed as described above, the first adhesive layer **320***c* may be coated on the TSP **340***c*. The first adhesive layer **320***c* may be formed of the same material as or a similar material to that of the second adhesive layer **350***c*.

[0408] When the panel member **390***c* is completely disposed as described above, the first jig **410***c* and the second jig **420***c* may be moved toward each other by driving the first driving unit **415***c* and the second driving unit **425***c*.

[0409] In particular, when the cover window **310***c* and the panel member **390***c* contact each other, a load range applied when the first jig **410***c* and the second jig **420***c* compress the cover window **310***c* and the panel member **390***c* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***c* and the panel member **390***c* may be reduced, and the cover window **310***c* and the panel member **390***c* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***c* and the panel member **390***c* are attached to each

other, the cover window **310***c* and the panel member **390***c* may be damaged, thereby reducing quality and reliability.

[0410] While the process is performed, the first cushion unit **493***c* and the second cushion unit **491***c* may uniformly distribute a force applied to the cover window **310***c*, the TSP **340***c*, and the display panel **330***c*.

[0411] When the process is completed, the first driving unit **415***c* and the second driving unit **425***c* may operate to separate the first jig **410***c* and the second jig **420***c*. The operator may complete an operation by removing the completed display device **300***c* from the first jig **410***c* or the second jig **420***c*.

[0412] The operation may be performed in a vacuum state. In further detail, the apparatus **400***c* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **410***c*, the second jig **420***c*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **400***c* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***c* and the panel member **390***c* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a lamination process is completed.

[0413] Accordingly, the apparatus **400***c* may manufacture any type of display device **300***c*. In addition, the apparatus **400***c* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***c* and the panel member **390***c* when the cover window **310***c* and the panel member **390***c* are laminated.

[0414] FIG. **26** is a cross-sectional view illustrating an apparatus **500***c* for manufacturing the display device **300***c* of FIG. **24**, according to another embodiment of the present invention.

[0415] Referring to FIG. **26**, the apparatus **500***c* may include a first jig **510***c*, a second jig **520***c*, a driving unit M, a fixing unit (for example, first fixing unit **530***c*), a cushion unit **590***c*, and a clamping unit **550***c*. In this case, the first jig **510***c*, the second jig **520***c*, the driving unit M, the fixing unit, and the cushion unit **590***c* (including a first cushion unit **593***c* and a second cushion unit **591***c*) are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.

[0416] The clamping unit **550***c* may include a first clamping unit **551***c* and a second clamping unit **552***c*. The first clamping unit **551***c* and the second clamping unit **552***c* may be disposed to face each other on a side surface of the first jig **510***c* or the second jig **520***c*. However, for convenience of description, it will be assumed that the first clamping unit **551***c* and the second clamping unit **552***c* are disposed to face each other on a side surface of the second jig **520***c*. In addition, the first clamping unit **551***c* and the second clamping unit **552***c* are formed in the same or similar manner as those described above, and thus a detailed description thereof will not be repeated.

[0417] A method of manufacturing the display device **300***c* by using the apparatus **500***c* will now be described. First, the cover window **310***c* and the panel member **390***c* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***c* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***c* and the display panel **330***c* may be adhered by using the second adhesive layer **350***c*.

[0418] After the cover window **310***c* and the panel member **390***c* are manufactured and prepared as described above, the cover window **310***c* may be disposed on the first jig **510***c*. The cover window **310***c* may be adhered and fixed by a first fixing unit **530***c*.

[0419] While the process is performed, the TSP **340***c* and the display panel **330***c* adhered by using the second adhesive layer **350***c* as described above may be disposed on the second jig **520***c*. The display panel **330***c* may be disposed to face the second jig **520***c*, and the TSP **340***c* may be disposed to face the first jig **510***c*. In particular, the display panel **330***c* and the TSP **340***c* may be stacked, and an end of the display panel **330***c* and an end of the TSP **340***c* may be fixed by being inserted into the first clamping unit **551***c* and the second clamping unit **552***c*.

[0420] After the TSP **340***c* and the display panel **330***c* are disposed as described above, the first adhesive layer **320***c* may be coated on the TSP **340***c*. The first adhesive layer **320***c* may be formed of the same or similar material as that of the second adhesive layer **350***c*.
[0421] When the cover window **310***c*, the TSP **340***c*, and the display panel **330***c* are completely disposed as described above, the first jig **510***c* and the second jig **520***c* may be moved toward each other by driving a first driving unit **515***c* and a second driving unit **525***c*. A flat portion of the cover window **310***c* may first contact the first adhesive layer **320***c*, and curved ends of the cover window **310***c* may sequentially contact the first adhesive layer **320***c* to be laminated.
[0422] In particular, when the cover window **310***c* and the panel member **390***c* contact each other as described above, a load range applied when the first jig **510***c* and the second jig **520***c* compress the cover window **310***c* and the panel member **390***c* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***c* and the panel member **390***c* may be reduced, and the cover window **310***c* and the panel member **390***c* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***c* and the panel member **390***c* are attached to each other, the cover window **310***c* and the panel member **390***c* may be damaged, thereby reducing quality and reliability.
[0423] In addition, when the first jig **510***c* and the second jig **520***c* move as described above, the TSP **340***c* and the display panel **330***c* may be fixed while the first clamping unit **551***c* and the second clamping unit **552***c* do not move.
[0424] While the process is performed, the first cushion unit **593***c* and the second cushion unit **591***c* may uniformly distribute a force applied to the cover window **310***c*, the TSP **340***c*, and the display panel **330***c*.
[0425] When the process is completed, the first driving unit **515***c* and the second driving unit **525***c* may operate to separate the first jig **510***c* and the second jig **520***c*. The operator may complete an operation by removing the completed display device **300***c* from the first jig **510***c* or the second jig **520***c*.
[0426] The operation may be performed in a vacuum state. In further detail, the apparatus **500***c* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **510***c*, the second jig **520***c*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **500***c* may include a pressure adjustment unit for adjusting a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***c* and the panel member **390***c* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.
[0427] Accordingly, the apparatus **500***c* may manufacture any type of display device **300***c*. In addition, the apparatus **500***c* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***c* and the panel member **390***c* when the cover window **310***c* and the panel member **390***c* are laminated.
[0428] FIG. **27** is a cross-sectional view illustrating an apparatus **600***c* for manufacturing the display device **300***c* of FIG. **24**, according to yet another embodiment of the present invention.
[0429] Referring to FIG. **27**, the apparatus **600***c* may include a first jig **610***c*, a second jig **620***c*, a driving unit M, a fixing unit (for example, first fixing unit **630***c*), a cushion unit **690***c*, a clamping unit **650***c*, and a linear driving unit L. In this case, the first jig **610***c*, the second jig **620***c*, the driving unit M, the fixing unit, the cushion unit **690***c* (including a first cushion unit **693***c* and a second cushion unit **691***c*), and the clamping unit **650***c* are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.
[0430] The linear driving unit L may include a first linear driving unit **660***c* that is provided on a first clamping unit **651***c* and linearly moves the first clamping unit **651***c*, and a second linear driving unit **670***c* that is provided on a second clamping unit **652***c* and linearly moves the second

clamping unit **652***c*. In particular, the first linear driving unit **660***c* and the second linear driving unit **670***c* may respectively linearly move the first clamping unit **651***c* and the second clamping unit **652***c* in the same direction as a direction in which the second jig **620***c* moves (e.g., in a moving direction of the second jig **620***c*). The first linear driving unit **660***c* and the second linear driving unit **670***c* may be formed in the same or similar manner. For convenience of description, the following description will focus on the first linear driving unit **660***c*.

[0431] The first linear driving unit **660***c* may include a first shaft **661***c* that is connected to the first clamping unit **651***c* and linearly moves. In addition, the first linear driving unit **660***c* may include a first driving module **665***c* that drives the first shaft **661***c*. The first driving module **665***c* may be formed to include a cylinder or a motor. However, for convenience of description, it will be assumed that the first driving module **665***c* includes a motor. In addition, it will be assumed that the first shaft **661***c* includes a ball screw that is raised and lowered as the first driving module **665***c* rotates.

[0432] The first linear driving unit **660***c* may include a first elastic unit **663***c* that surrounds the first shaft **661***c*. The first elastic unit **663***c* may include a compression spring, or may be formed of an elastic material such as rubber. However, for convenience of description, it will be assumed that the first elastic unit **663***c* includes a compression spring.

[0433] The first elastic unit **663***c* may be disposed to surround an outer surface of the first shaft **661***c* as described above, and thus may provide a restoring force to the first clamping unit **651***c* when the first clamping unit **651***c* moves.

[0434] A method of manufacturing the display device **300***c* by using the apparatus **600***c* will now be described. First, the cover window **310***c* and the panel member **390***c* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***c* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***c* and the display panel **330***c* may be adhered to each other by using the second adhesive layer **350***c*.

[0435] After the cover window **310***c* and the panel member **390***c* are manufactured and prepared as described above, the cover window **310***c* may be disposed on the first jig **610***c*. The cover window **310***c* may be adhered and fixed by the first fixing unit **630***c*. In addition, the cover window **310***c* may be disposed such that a protruding portion faces the second jig **620***c*.

[0436] While the process is performed, the TSP **340***c* and the display panel **330***c* adhered by using the second adhesive layer **350***c* as described above may be disposed on the second jig **620***c*. The display panel **330***c* may be disposed to face the second jig **620***c*, and the TSP **340***c* may be disposed to face the first jig **610***c*. In particular, the display panel **330***c* and the TSP **340***c* may be stacked, and an end of the display panel **330***c* and an end of the TSP **340***c* may be fixed by being inserted into the first clamping unit **651***c* and the second clamping unit **652***c*. In addition, a central portion of the display panel **330***c* and a central portion of the TSP **340***c* may be disposed adjacent to a recessed portion of the second jig **620***c*, or may be disposed adjacent to the cover window **310***c*. However, for convenience of description, it will be assumed that a central portion of the display panel **330***c* and a central portion of the TSP **340***c* are disposed adjacent to a recessed portion of the second jig **620***c*.

[0437] After the TSP **340***c* and the display panel **330***c* are disposed as described above, the first adhesive layer **320***c* may be coated on the TSP **340***c*. The first adhesive layer **320***c* may be formed of the same or similar material as that of the second adhesive layer **350***c*. In another embodiment, the first adhesive layer **320***c* may be coated on the TSP **340***c* before the display panel **330***c* and the TSP **340***c* are disposed on the first clamping unit **651***c* and the second clamping unit **652***c*.

[0438] When the cover window **310***c*, the TSP **340***c*, and the display panel **330***c* are completely disposed as described above, the first jig **610***c* and the second jig **620***c* may be moved toward each other by driving a first driving unit **615***c* and a second driving unit **625***c*. The cover window **310***c* and the panel member **390***c* may sequentially contact and laminated beginning from a flat portion

of the cover window **310***c* toward both ends of the panel member **390***c*.
[0439] In particular, when the cover window **310***c* and the panel member **390***c* contact each other, a load range applied when the first jig **610***c* and the second jig **620***c* compress the cover window **310***c* and the panel member **390***c* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***c* and the panel member **390***c* may be reduced, and the cover window **310***c* and the panel member **390***c* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***c* and the panel member **390***c* are attached to each other, the cover window **310***c* and the panel member **390***c* may be damaged, thereby reducing quality and reliability.
[0440] In addition, when the first jig **610***c* and the second jig **620***c* move as described above, the first clamping unit **651***c* and the second clamping unit **652***c* may fix the TSP **340***c* and the display panel **330***c* while linearly moving as the first jig **610***c* and the second jig **620***c* move. The first linear driving unit **660***c* and the second linear driving unit **670***c* may be controlled based on a linear movement of at least one of the first jig **610***c* or the second jig **620***c*.
[0441] While the process is performed, the first cushion unit **693***c* and the second cushion unit **691***c* may uniformly distribute a force applied to the cover window **310***c*, the TSP **340***c*, and the display panel **330***c*.
[0442] When the process is completed, the first driving unit **615***c* and the second driving unit **625***c* may operate to separate the first jig **610***c* and the second jig **620***c*. The operator may complete an operation by removing the completed display device **300***c* from the first jig **610***c* or the second jig **620***c*.
[0443] The operation may be performed in a vacuum state. In further detail, the apparatus **600***c* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **610***c*, the second jig **620***c*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **600***c* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***c* and the panel member **390***c* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a process is completed.
[0444] Accordingly, the apparatus **600***c* may manufacture any type of display device **300***c*. In addition, the apparatus **600***c* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***c* and the panel member **390***c* when the cover window **310***c* and the panel member **390***c* are laminated.
[0445] FIG. **28** is a cross-sectional view illustrating an apparatus **700***c* for manufacturing the display device **300***c* of FIG. **24**, according to still yet another embodiment of the present invention.
[0446] Referring to FIG. **28**, the apparatus **700***c* may include a first jig **710***c*, a second jig **720***c*, a driving unit M, a fixing unit (for example, first fixing unit **730***c*), a cushion unit **790***c*, a clamping unit **750***c*, and a linear driving unit L. In this case, the first jig **710***c*, the second jig **720***c*, the driving unit M, the fixing unit, the cushion unit **790***c*, the clamping unit **750***c*, and the linear driving unit L are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.
[0447] The linear driving unit L may include a first linear driving unit **760***c* that is provided on a first clamping unit **751***c* and linearly moves the first clamping unit **751***c*, and a second linear driving unit **770***c* that is provided on a second clamping unit **752***c* and linearly moves the second clamping unit **752***c*. The first linear driving unit **760***c* and the second linear driving unit **770***c* may respectively linearly move the first clamping unit **751***c* and the second clamping unit **752***c* in a diagonal direction. In particular, the first linear driving unit **760***c* and the second linear driving unit **770***c* may linearly move the first clamping unit **751***c* and the second clamping unit **752***c* such that movement directions of the first clamping unit **751***c* and the second clamping unit **752***c* form

angles with respect to a movement direction of the second jig **720***c*.

[0448] A method of manufacturing the display device **300***c* by using the apparatus **700***c* will now be described. First, the cover window **310***c* and the panel member **390***c* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***c* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***c* and the display panel **330***c* may be adhered to each other by using the second adhesive layer **350***c*.

[0449] After the cover window **310***c* and the panel member **390***c* are manufactured and prepared as described above, the cover window **310***c* may be disposed on the first jig **710***c*. The cover window **310***c* may be adhered and fixed by the first adhesive layer **320***c*.

[0450] While the process is performed, the TSP **340***c* and the display panel **330***c* adhered by using the second adhesive layer **350***c* as described above may be disposed on the second jig **720***c*. The display panel **330***c* may be disposed to face the second jig **720***c*, and the TSP **340***c* may be disposed to face the first jig **710***c*. In particular, the display panel **330***c* and the TSP **340***c* may be stacked, and an end of the display panel **330***c* and an end of the TSP **340***c* may be fixed by being inserted into the first clamping unit **751***c* and the second clamping unit **752***c*. The display panel **330***c* and the TSP **340***c* may be disposed such that central portions are lower in position than other portions due to the first clamping unit **751***c* and the second clamping unit **752***c*.

[0451] After the TSP **340***c* and the display panel **330***c* are disposed as described above, the first adhesive layer **320***c* may be coated on the TSP **340***c*. The first adhesive layer **320***c* may be formed of the same or similar material as that of the second adhesive layer **350***c*. In another embodiment, the first adhesive layer **320***c* may be coated on the TSP **340***c* before the display panel **330***c* and the TSP **340***c* are disposed on the first clamping unit **751***c* and the second clamping unit **752***c* as described above.

[0452] When the cover window **310***c*, the TSP **340***c*, and the display panel **330***c* are completely disposed as described above, the first jig **710***c* and the second jig **720***c* may be moved toward each other by driving a first driving unit **715***c* and a second driving unit **725***c*. A flat portion of the cover window **310***c* may first contact the first adhesive layer **320***c*, and both end portions of the cover window **310***c* may sequentially contact the first adhesive layer **320***c* to be laminated.

[0453] In particular, when the cover window **310***c* and the panel member **390***c* contact each other, a load range applied when the first jig **710***c* and the second jig **720***c* compress the cover window **310***c* and the panel member **390***c* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***c* and the panel member **390***c* may be reduced, and the cover window **310***c* and the panel member **390***c* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***c* and the panel member **390***c* are attached to each other, the cover window **310***c* and the panel member **390***c* may be damaged, thereby reducing quality and reliability.

[0454] In addition, when the first jig **710***c* and the second jig **720***c* move as described above, the first clamping unit **751***c* and the second clamping unit **752***c* may fix the TSP **340***c* and the display panel **330***c* while linearly moving as the first jig **710***c* and the second jig **720***c* move. The first linear driving unit **760***c* and the second linear driving unit **770***c* may be controlled based on a linear movement of at least one of the first jig **710***c* or the second jig **720***c*.

[0455] While the process is performed, a first cushion unit **793***c* and a second cushion unit **791***c* may uniformly distribute a force applied to the cover window **310***c*, the TSP **340***c*, and the display panel **330***c*.

[0456] When the process is completed, the first driving unit **715***c* and the second driving unit **725***c* may operate to separate the first jig **710***c* and the second jig **720***c*. The operator may complete an operation by removing the completed display device **300***c* from the first jig **710***c* or the second jig **720***c*.

[0457] The operation may be performed in a vacuum state. In further detail, the apparatus **700***c* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **710***c*, the second jig **720***c*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **700***c* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***c* and the panel member **390***c* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a process is completed.

[0458] Accordingly, the apparatus **700***c* may manufacture any type of display device **300***c*. In addition, the apparatus **700***c* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***c* and the panel member **390***c* when the cover window **310***c* and the panel member **390***c* are laminated.

[0459] FIG. **29** is a cross-sectional view illustrating a display device **300***d* according to a sixth embodiment of the present invention.

[0460] Referring to FIG. **29**, the display device **300***d* may include a cover window **310***d* and a panel member **390***d* as described above. In addition, the display device **300***d* may include a first adhesive layer **320***d* that is disposed between the panel member **390***d* and the cover window **310***d*. The panel member **390***d* may include a display panel **330***d* and a TSP **340***d* as described above. In particular, a second adhesive layer **350***d* may be provided between the display panel **330***d* and the TSP **340***d* to attach the display panel **330***d* and the TSP **340***d*.

[0461] The cover window **310***d* may be formed such that at least a portion of the cover window **310***d* is curved. In particular, the cover window **310***d* may be formed such that a surface to which the panel member **390***d* is attached and on which an image or text is displayed is curved. In particular, the cover window **310***d* may be formed to have a curved surface having a curvature radius of R. The cover window **310***d* may be formed to have a curved surface having a set or predetermined curvature radius in a longitudinal direction or a width direction. However, for convenience of description, it will be assumed that the cover window **310***d* is formed to have a curved surface having a set or predetermined curvature radius and the curved surface is formed in a width direction of the cover window **310***d*.

[0462] In particular, the cover window **310***d* may be formed such that a convex portion of the cover window **310***d* faces the first adhesive layer **320***d*. The TSP **340***d*, the second adhesive layer **350***d*, and the display panel **330***d* may be attached and fixed to a convex outer surface of the cover window **310***d* on the first adhesive layer **320***d*.

[0463] Accordingly, since the display device **300***d* is formed to have a set or predetermined curvature radius, the display device **300***d* may be applied to various members.

[0464] FIG. **30** is a cross-sectional view illustrating an apparatus **400***d* for manufacturing the display device **300***d* of FIG. **29**, according to an embodiment of the present invention.

[0465] Referring to FIG. **30**, the apparatus **400***d* may include a first jig **410***d*, a second jig **420***d*, a driving unit M, a fixing unit (for example, first fixing unit **430***d*), and a cushion unit **490***d* (including a first cushion unit **493***d* and a second cushion unit **491***d*). An outer surface of the first jig **410***d* on which the cover window **310***d* is seated may be the same as or similar to an outer surface of the cover window **310***d* contacting the first jig **410***d*. In further detail, the first jig **410***d* may have a curved surface having a set or predetermined curvature radius to correspond to the cover window **310***d*. In particular, the first jig **410***d* may be formed to protrude toward the second jig **420***d*.

[0466] An outer surface of the second jig **420***d* may be recessed away from the first jig **410***d* to correspond to or engage with a protruding portion of the first jig **410***d*. The outer surface of the second jig **420***d* may be a curved surface having a set or predetermined curvature radius.

[0467] The driving unit M may include a first driving unit **415***d* and a second driving unit **425***d*. The first driving unit **415***d* may linearly move the first jig **410***d* toward the second jig **420***d*, and the

second driving unit **425***d* may linearly move the second jig **420***d* toward the first jig **410***d*. The first driving unit **415***d* and the second driving unit **425***d* may be formed in the same manner as or a similar manner to those described above.

[0468] In addition, the fixing unit may include a first fixing unit **430***d* provided on the first jig **410***d* and a second fixing unit provided on the second jig **420***d*. For convenience of description, it will be assumed that the fixing unit includes the first fixing unit **430***d*. In addition, the first fixing unit **430***d* and the second fixing unit may be formed in the same manner or a similar manner, and thus a detailed description of the second fixing unit will not be given.

[0469] The first fixing unit **430***d* may be formed in various ways. For example, the first fixing unit **430***d* may include an adhesive member, an adhesive chuck, or an electrostatic chuck. In addition, the first fixing unit **430***d* may include a first absorption unit, and a first absorption pump that is connected to the first absorption unit. In particular, the first fixing unit **430***d* is not limited thereto, and may include a clamp, or a protrusion that is provided on the first jig **410***d* and mechanically restricts the cover window **310***d*. However, for convenience of description, it will be assumed that the first fixing unit **430***d* includes an adhesive member.

[0470] A method of manufacturing the display device **300***d* by using the apparatus **400***d* will now be described. First, the cover window **310***d* and the panel member **390***d* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***d* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***d* and the display panel **330***d* may be adhered to each other by using the second adhesive layer **350***d*.

[0471] After the cover window **310***d* and the panel member **390***d* are manufactured and prepared as described above, the cover window **310***d* may be disposed on the first jig **410***d*. The cover window **310***d* may be formed to have a curved surface having a set or predetermined curvature radius of R as described above and may be seated on an outer surface of the first jig **410***d*. The first fixing unit **430***d* may adhere and fix the cover window **310***d*.

[0472] While the process is performed, the TSP **340***d* and the display panel **330***d* adhered by using the second adhesive layer **350***d* may be disposed on the second jig **420***d*. The display panel **330***d* may be disposed to face the second jig **420***d*, and the TSP **340***d* may be disposed to face the first jig **410***d*.

[0473] After the TSP **340***d* and the display panel **330***d* are disposed as described above, the first adhesive layer **320***d* may be coated on the TSP **340***d*. The first adhesive layer **320***d* may be formed of the same material as or a similar material to that of the second adhesive layer **350***d*.

[0474] When the cover window **310***d*, the TSP **340***d*, and the display panel **330***d* are completely disposed as described above, the first jig **410***d* and the second jig **420***d* may be moved toward each other by driving the first driving unit **415***d* and the second driving unit **425***d*. A protruding portion of the cover window **310***d* may first contact the first adhesive layer **320***d*, and the first adhesive layer **320***d* and the cover window **310***d* may be sequentially laminated from central portions of the display panel **330***d* toward both end portions.

[0475] In particular, when the cover window **310***d* and the panel member **390***d* contact each other, a load range applied when the first jig **410***d* and the second jig **420***d* compress the cover window **310***d* and the panel member **390***d* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***d* and the panel member **390***d* may be reduced, and the cover window **310***d* and the panel member **390***d* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***d* and the panel member **390***d* are attached to each other, the cover window **310***d* and the panel member **390***d* may be damaged, thereby reducing quality and reliability.

[0476] While the process is performed, the cushion unit **490***d* may uniformly distribute a force applied to the cover window **310***d*, the TSP **340***d*, and the display panel **330***d*.

[0477] When the process is completed, the first driving unit **415***d* and the second driving unit **425***d* may operate to separate the first jig **410***d* and the second jig **420***d*. The operator may complete an operation by removing the completed display device **300***d* from the first jig **410***d* or the second jig **420***d*.

[0478] The operation may be performed in a vacuum state. In further detail, the apparatus **400***d* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **410***d*, the second jig **420***d*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **400***d* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***d* and the panel member **390***d* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0479] Accordingly, the apparatus **400***d* may manufacture any type of display device **300***d*. In addition, the apparatus **400***d* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***d* and the panel member **390***d* when the cover window **310***d* and the panel member **390***d* are laminated.

[0480] FIG. **31** is a cross-sectional view illustrating an apparatus **500***d* for manufacturing the display device **300***d* of FIG. **29**, according to another embodiment of the present invention.

[0481] Referring to FIG. **31**, the apparatus **500***d* may include a first jig **510***d*, a second jig **520***d*, a driving unit M, a fixing unit (for example, first fixing unit **530***d*), a cushion unit **590***d*, and a clamping unit **550***d*. In this case, the first jig **510***d*, the second jig **520***d*, the driving unit M, the fixing unit, and the cushion unit **590***d* (including a first cushion unit **593***d* and a second cushion unit **591***d*) are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.

[0482] The clamping unit **550***d* may include a first clamping unit **551***d* and a second clamping unit **552***d*. The first clamping unit **551***d* and the second clamping unit **552***d* may be disposed to face each other on a side surface of the first jig **510***d* or the second jig **520***d*. However, for convenience of description, it will be assumed that the first clamping unit **551***d* and the second clamping unit **552***d* are disposed to face each other on a side surface of the second jig **520***d*. In addition, the first clamping unit **551***d* and the second clamping unit **552***d* are formed in the same or similar manner as those described above, and thus a detailed description thereof will not be repeated.

[0483] A method of manufacturing the display device **300***d* by using the apparatus **500***d* will now be described. First, the cover window **310***d* and the panel member **390***d* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***d* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***d* and the display panel **330***d* may be adhered by using the second adhesive layer **350***d*.

[0484] After the cover window **310***d* and the panel member **390***d* are manufactured and prepared as described above, the cover window **310***d* may be disposed on the first jig **510***d*. The cover window **310***d* may be formed to have a curved surface having a set or predetermined curvature radius of R as described above and may be seated on an outer surface of the first jig **510***d*. The cover window **310***d* may be adhered and fixed by the first fixing unit **530***d*.

[0485] While the process is performed, the TSP **340***d* and the display panel **330***d* adhered by using the second adhesive layer **350***d* as described above may be disposed on the second jig **520***d*. The display panel **330***d* may be disposed to face the second jig **520***d*, and the TSP **340***d* may be disposed to face the first jig **510***d*. The display panel **330***d* and the TSP **340***d* may be stacked, and an end of the display panel **330***d* and an end of the TSP **340***d* may be fixed by being inserted into the first clamping unit **551***d* and the second clamping unit **552***d*.

[0486] After the TSP **340***d* and the display panel **330***d* are disposed as described above, the first adhesive layer **320***d* may be coated on the TSP **340***d*. The first adhesive layer **320***d* may be formed of the same or similar material as that of the second adhesive layer **350***d*.

[0487] When the cover window **310***d*, the TSP **340***d*, and the display panel **330***d* are completely disposed as described above, the first jig **510***d* and the second jig **520***d* may be moved toward each other by driving a first driving unit **515***d* and a second driving unit **525***d*. A protruding portion of the cover window **310***d* may first contact the first adhesive layer **320***d*, and the first adhesive layer **320***d* and the cover window **310***d* may be sequentially laminated from central portions of the display panel **330***d* toward both end portions.

[0488] In particular, when the cover window **310***d* and the panel member **390***d* are adhered to each other as described above, a load range applied when the first jig **510***d* and the second jig **520***d* compress the cover window **310***d* and the panel member **390***d* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***d* and the panel member **390***d* may be reduced, and the cover window **310***d* and the panel member **390***d* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***d* and the panel member **390***d* are attached to each other, the cover window **310***d* and the panel member **390***d* may be damaged, thereby reducing quality and reliability.

[0489] In addition, when the first jig **510***d* and the second jig **520***d* move as described above, the TSP **340***d* and the display panel **330***d* may be fixed while the first clamping unit **551***d* and the second clamping unit **552***d* do not move.

[0490] While the process is performed, the first cushion unit **593***d* and the second cushion unit **591***d* may uniformly distribute a force applied to the cover window **310***d*, the TSP **340***d*, and the display panel **330***d*.

[0491] When the process is completed, the first driving unit **515***d* and the second driving unit **525***d* may operate to separate the first jig **510***d* and the second jig **520***d*. The operator may complete an operation by removing the completed display device **300***d* from the first jig **510***d* or the second jig **520***d*.

[0492] The operation may be performed in a vacuum state. In further detail, the apparatus **500***d* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **510***d*, the second jig **520***d*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **500***d* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***d* and the panel member **390***d* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0493] Accordingly, the apparatus **500***d* may manufacture any type of display device **300***d*. In addition, the apparatus **500***d* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***d* and the panel member **390***d* when the cover window **310***d* and the panel member **390***d* are laminated.

[0494] FIG. **32** is a cross-sectional view illustrating an apparatus **600***d* for manufacturing the display device **300***d* of FIG. **29**, according to yet another embodiment of the present invention.

[0495] Referring to FIG. **32**, the apparatus **600***d* may include a first jig **610***d*, a second jig **620***d*, a driving unit M, a fixing unit (for example, first fixing unit **630***d*), a cushion unit **690***d*, a clamping unit **650***d*, and a linear driving unit L. In this case, the first jig **610***d*, the second jig **620***d*, the driving unit M, the fixing unit, the cushion unit **690***d*, and the clamping unit **650***d* are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.

[0496] The linear driving unit L may include a first linear driving unit **660***d* that is provided on a first clamping unit **651***d* and linearly moves the first clamping unit **651***d*, and a second linear driving unit **670***d* that is provided on a second clamping unit **652***d* and linearly moves the second clamping unit **652***d*. In particular, the first linear driving unit **660***d* and the second linear driving unit **670***d* may respectively linearly move the first clamping unit **651***d* and the second clamping unit **652***d* in the same direction as a direction in which the second jig **620***d* moves. The first linear

driving unit **660***d* and the second linear driving unit **670***d* may be formed in the same or similar manner. For convenience of description, the following description will focus on the first linear driving unit **660***d*.

[0497] The first linear driving unit **660***d* may include a first shaft **661***d* that is connected to the first clamping unit **651***d* and linearly moves the first clamping unit **651***d*. In addition, the first linear driving unit **660***d* may include a first driving module **665***d* that drives the first shaft **661***d*. The first driving module **665***d* may be formed to include a cylinder or a motor. However, for convenience of description, it will be assumed that the first driving module **665***d* includes a motor. In addition, it will be assumed that the first shaft **661***d* includes a ball screw that is raised and lowered as the first driving module **665***d* rotates.

[0498] The first linear driving unit **660***d* may include a first elastic unit **663***d* that surrounds the first shaft **661***d*. The first elastic unit **663***d* may include a compression spring, or may be formed of an elastic material such as rubber. However, for convenience of description, it will be assumed that the first elastic unit **663***d* includes a compression spring.

[0499] The first elastic unit **663***d* may be disposed to surround an outer surface of the first shaft **661***d* as described above, and thus may provide a restoring force to the first clamping unit **651***d* when the first clamping unit **651***d* moves.

[0500] A method of manufacturing the display device **300***d* by using the apparatus **600***d* will now be described. First, the cover window **310***d* and the panel member **390***d* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***d* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***d* and the display panel **330***d* may be adhered to each other by using the second adhesive layer **350***d*.

[0501] After the cover window **310***d* and the panel member **390***d* are manufactured and prepared as described above, the cover window **310***d* may be disposed on the first jig **610***d*. The cover window **310***d* may be formed to have a curved surface having a set or predetermined curvature radius of R as described above, and may be seated on an outer surface of the first jig **610***d*. The cover window **310***d* may be adhered and fixed by the first fixing unit **630***d*.

[0502] While the process is performed, the TSP **340***d* and the display panel **330***d* adhered by using the second adhesive layer **350***d* as described above may be disposed on the second jig **620***d*. The display panel **330***d* may be disposed to face the second jig **620***d*, and the TSP **340***d* may be disposed to face the first jig **610***d*. In particular, the display panel **330***d* and the TSP **340***d* may be stacked, and an end of the display panel **330***d* and an end of the TSP **340***d* may be fixed by being inserted into a first clamping unit **651***d* and a second clamping unit **652***d*.

[0503] The display panel **330***d* and the TSP **340***d* may be disposed such that at least one portion protrudes more than other portions toward the cover window **310***d* or toward the second jig **620***d*. However, for convenience of description, it will be assumed that at least one portion of the display panel **330***d* and the TSP **340***d* protrudes more than other portions toward the second jig **620***d*.

[0504] After the TSP **340***d* and the display panel **330***d* are disposed as described above, the first adhesive layer **320***d* may be coated on the TSP **340***d*. The first adhesive layer **320***d* may be formed of the same or similar material as that of the second adhesive layer **350***d*.

[0505] When the cover window **310***d*, the TSP **340***d*, and the display panel **330***d* are completely disposed as described above, the first jig **610***d* and the second jig **620***d* may be moved toward each other by driving a first driving unit **615***d* and a second driving unit **625***d*. A protruding portion of the cover window **310***d* may first contact the first adhesive layer **320***d*, and the first adhesive layer **320***d* and the cover window **310***d* may be sequentially laminated from central portions of the display panel **330***d* toward both end portions.

[0506] In particular, when the cover window **310***d* and the panel member **390***d* contact each other, a load range applied when the first jig **610***d* and the second jig **620***d* compress the cover window **310***d* and the panel member **390***d* may be greater than or equal to 0.3 MPa and less than or equal to

0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***d* and the panel member **390***d* may be reduced, and the cover window **310***d* and the panel member **390***d* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***d* and the panel member **390***d* are attached to each other, the cover window **310***d* and the panel member **390***d* may be damaged, thereby reducing quality and reliability.

[0507] In addition, when the first jig **610***d* and the second jig **620***d* move as described above, the first clamping unit **651***d* and the second clamping unit **652***d* may fix the TSP **340***d* and the display panel **330***d* while linearly moving as the first jig **610***d* and the second jig **620***d* move. The first linear driving unit **660***d* and the second linear driving unit **670***d* may be controlled based on a linear movement of at least one of the first jig **610***d* or the second jig **620***d*.

[0508] While the process is performed, a first cushion unit **693***d* and a second cushion unit **691***d* may uniformly distribute a force applied to the cover window **310***d*, the TSP **340***d*, and the display panel **330***d*.

[0509] When the process is completed, the first driving unit **615***d* and the second driving unit **625***d* may operate to separate the first jig **610***d* and the second jig **620***d*. The operator may complete an operation by removing the completed display device **300***d* from the first jig **610***d* or the second jig **620***d*.

[0510] The operation may be performed in a vacuum state. In further detail, the apparatus **600***d* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **610***d*, the second jig **620***d*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **600***d* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***d* and the panel member **390***d* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a process is completed.

[0511] Accordingly, the apparatus **600***d* may manufacture any type of display device **300***d*. In addition, the apparatus **600***d* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***d* and the panel member **390***d* when the cover window **310***d* and the panel member **390***d* are laminated.

[0512] FIG. **33** is a cross-sectional view illustrating an apparatus **700***d* for manufacturing the display device **300***d* of FIG. **29**, according to still yet another embodiment of the present invention.

[0513] Referring to FIG. **33**, the apparatus **700***d* may include a first jig **710***d*, a second jig **720***d*, a driving unit M, a fixing unit (for example, first fixing unit **730***d*), a cushion unit **790***d*, a clamping unit **750***d*, and a linear driving unit L. In this case, the first jig **710***d*, the second jig **720***d*, the driving unit M, the fixing unit, the cushion unit **790***d*, the clamping unit **750***d*, and the linear driving unit L are the same as or similar to those described above, and thus a detailed description thereof will not be repeated.

[0514] The linear driving unit L may include a first linear driving unit **760***d* that is provided on the first clamping unit **751***d* and linearly moves the first clamping unit **751***d*, and a second linear driving unit **770***d* that is provided on the second clamping unit **752***d* and linearly moves the second clamping unit **752***d*. The first linear driving unit **760***d* and the second linear driving unit **770***d* may respectively linearly move the first clamping unit **751***d* and the second clamping unit **752***d* in a diagonal direction. In particular, the first linear driving unit **760***d* and the second linear driving unit **770***d* may linearly move the first clamping unit **751***d* and the second clamping unit **752***d* such that movement directions of the first clamping unit **751***d* and the second clamping unit **752***d* form angles with respect to a movement direction of the second jig **720***d*.

[0515] A method of manufacturing the display device **300***d* by using the apparatus **700***d* will now be described. First, the cover window **310***d* and the panel member **390***d* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***d* is similar to that

described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***d* and the display panel **330***d* may be adhered to each other by using the second adhesive layer **350***d*.

[0516] After the cover window **310***d* and the panel member **390***d* are manufactured and prepared as described above, the cover window **310***d* may be disposed on the first jig **710***d*. The cover window **310***d* may be formed to have a curved surface having a set or predetermined curvature radius of R as described above, and may be seated on an outer surface of the first jig **710***d*. The cover window **310***d* may be adhered and fixed by the first fixing unit **730***d*.

[0517] While the process is performed, the TSP **340***d* and the display panel **330***d* adhered by using the second adhesive layer **350***d* as described above may be disposed on the second jig **720***d*. The display panel **330***d* may be disposed to face the second jig **720***d*, and the TSP **340***d* may be disposed to face the first jig **710***d*. In particular, the display panel **330***d* and the TSP **340***d* may be stacked, and an end of the display panel **330***d* and an end of the TSP **340***d* may be fixed by being inserted into the first clamping unit **751***d* and the second clamping unit **752***d*.

[0518] The display panel **330***d* and the TSP **340***d* may be disposed such that central portions are lower in position than other portions due to the first clamping unit **751***d* and the second clamping unit **752***d*. In other embodiments, the display panel **330***d* and the TSP **340***d* may be disposed such that central portions are higher in position than other portions. However, for convenience of description, it will be assumed that central portions of the display panel **330***d* and the TSP **340***d* are lower in position than other portions.

[0519] After the TSP **340***d* and the display panel **330***d* are disposed as described above, the first adhesive layer **320***d* may be coated on the TSP **340***d*. The first adhesive layer **320***d* may be formed of the same or similar material as that of the second adhesive layer **350***d*.

[0520] When the cover window **310***d*, the TSP **340***d*, and the display panel **330***d* are completely disposed as described above, the first jig **710***d* and the second jig **720***d* may be moved toward each other by driving a first driving unit **715***d* and a second driving unit **725***d*. A protruding portion of the cover window **310***d* may first contact the first adhesive layer **320***d*, and the first adhesive layer **320***d* and the cover window **310***d* may be sequentially laminated from central portions of the display panel **330***d* toward both end portions.

[0521] In particular, when the cover window **310***d* and the panel member **390***d* contact each other, a load range applied when the first jig **710***d* and the second jig **720***d* compress the cover window **310***d* and the panel member **390***d* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***d* and the panel member **390***d* may be reduced, and the cover window **310***d* and the panel member **390***d* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***d* and the panel member **390***d* are attached to each other, the cover window **310***d* and the panel member **390***d* may be damaged, thereby reducing quality and reliability.

[0522] In addition, when the first jig **710***d* and the second jig **720***d* move as described above, the first clamping unit **751***d* and the second clamping unit **752***d* may fix the TSP **340***d* and the display panel **330***d* while linearly moving as the first jig **710***d* and the second jig **720***d* move. The first linear driving unit **760***d* and the second linear driving unit **770***d* may be controlled based on a linear movement of at least one of the first jig **710***d* or the second jig **720***d*.

[0523] While the process is performed, a first cushion unit **793***d* and a second cushion unit **791***d* may uniformly distribute a force applied to the cover window **310***d*, the TSP **340***d*, and the display panel **330***d*.

[0524] When the process is completed, the first driving unit **715***d* and the second driving unit **725***d* may operate to separate the first jig **710***d* and the second jig **720***d*. The operator may complete an operation by removing the completed display device **300***d* from the first jig **710***d* or the second jig **720***d*.

[0525] The operation may be performed in a vacuum state. In further detail, the apparatus **700***d* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **710***d*, the second jig **720***d*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **700***d* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***d* and the panel member **390***d* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after a process is completed.

[0526] Accordingly, the apparatus **700***d* may manufacture any type of display device **300***d*. In addition, the apparatus **700***d* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***d* and the panel member **390***d* when the cover window **310***d* and the panel member **390***d* are laminated.

[0527] FIG. **34** is a cross-sectional view illustrating a display device **300***e* according to a seventh embodiment of the present invention.

[0528] Referring to FIG. **34**, the display device **300***e* may include a cover window **310***e* and a panel member **390***e* as described above. In addition, the display device **300***e* may include a first adhesive layer **320***e* that is disposed between the panel member **390***e* and the cover window **310***e*. The panel member **390***e* may include a display panel **330***e* and a TSP **340***e* as described above. In particular, a second adhesive layer **350***e* may be provided between the display panel **330***e* and the TSP **340***e* to attach the display panel **330***e* and the TSP **340***e*.

[0529] At least a portion of the cover window **310***e* may be curved. The cover window **310***e* may be formed such that a surface to which the panel member **390***e* is attached and on which an image or text is displayed is concave.

[0530] The cover window **310***e* may be formed to have at least one curved surface having a curvature radius. In some embodiments, the cover window **310***e* may be formed to have a first curved surface having a curvature radius of R**1**, a second curved surface having a curvature radius of R**2**, and may further include a third curved surface having a curvature radius of R**3** in a longitudinal direction or a width direction. In other embodiments, the cover window **310***e* may further include curved surfaces having curvature radii of R**4**, R**5**, . . . , and RN (N is a natural number) in addition to the curved surfaces having the curvature radii of R**1**, R**2**, and R**3**. However, for convenience of description, it will be assumed that the cover window **310***e* is formed to have the first, second, and third curved surfaces having the curvature radii of R**1**, R**2**, and R**3** in a width direction.

[0531] In particular, the cover window **310***e* may be formed to protrude toward the first adhesive layer **320***e*. The TSP **340***e*, the second adhesive layer **350***e*, and the display panel **330***e* may be sequentially stacked and fixed to a protruding outer surface of the cover window **310***e* on the first adhesive layer **320***e*. Accordingly, since the display device **300***e* is formed to have a set or predetermined curvature radii, the display device **300***e* may be applied to various members.

[0532] FIG. **35** is a cross-sectional view illustrating an apparatus **400***e* for manufacturing the display device **300***e* of FIG. **34**, according to an embodiment of the present invention.

[0533] Referring to FIG. **35**, the apparatus **400***e* may include a first jig **410***e*, a second jig **420***e*, a driving unit M, a fixing unit (for example, first fixing unit **430***e*), and a cushion unit **490***e*. An outer surface of the first jig **410***e* on which the cover window **310***e* is seated may be formed equally or similarly to an outer surface of the cover window **310***e* contacting the outer surface of the first jig **410***e*. In further detail, the first jig **410***e* may have at least two curved surfaces having curvature radii of R**1**′, R**2**′, R**3**′, . . . , like the cover window **310***e*. In particular, the first jig **410***e* may be formed to protrude toward the second jig **420***e*.

[0534] An outer surface of the second jig **420***e* may be recessed away from the first jig **410***e* to correspond to or engage with a protruding portion of the first jig **410***e*. The outer surface of the second jig **420***e* may include at least two curved surfaces having set or predetermined curvature

radii.
[0535] The driving unit M may include a first driving unit **415***e* and a second driving unit **425***e*. The first driving unit **415***e* may linearly move the first jig **410***e* toward the second jig **420***e*, and the second driving unit **425***e* may linearly move the second jig **420***e* toward the first jig **410***e*. The first driving unit **415***e* and the second driving unit **425***e* may be formed in the same manner as or a similar manner to those described above.
[0536] In addition, the fixing unit may include a first fixing unit **430***e* provided on the first jig **410***e* and a second fixing unit provided on the second jig **420***e*. For convenience of description, it will be assumed that the fixing unit includes the first fixing unit **430***e*. In addition, the first fixing unit **430***e* and the second fixing unit may be formed in the same manner or a similar manner, and thus a detailed description of the second fixing unit will not be given.
[0537] The first fixing unit **430***e* may be formed in various ways. For example, the first fixing unit **430***e* may include an adhesive member, an adhesive chuck, or an electrostatic chuck. In addition, the first fixing unit **430***e* may include a first absorption unit, and a first absorption pump that is connected to the first absorption unit. In particular, the first fixing unit **430***e* is not limited thereto, and may include a clamp, or a protrusion that is provided on the first jig **410***e* and mechanically restricts the cover window **310***e*. However, for convenience of description, it will be assumed that the first fixing unit **430***e* includes an adhesive member.
[0538] The cushion unit **490***e* may be provided on at least one of the first jig **410***e* or the second jig **420***e*. In this case, the cushion unit is the same as or similar to that described above, and thus a detailed description thereof will not be repeated. In addition, for convenience of description, it will be assumed that the cushion unit is provided on each of the first jig **410***e* and the second jig **420***e*.
[0539] A method of manufacturing the display device **300***e* by using the apparatus **400***e* will now be described. First, the cover window **310***e* and the panel member **390***e* may be manufactured and prepared. In this case, a method of manufacturing the cover window **310***e* is similar to that described above, and thus a detailed description thereof will not be repeated. In addition, the TSP **340***e* and the display panel **330***e* may be adhered by using the second adhesive layer **350***e*.
[0540] After the cover window **310***e* and the panel member **390***e* are manufactured and prepared as described above, the cover window **310***e* may be disposed on the first jig **410***e*. The cover window **310***e* may be formed to have at least two curved surfaces having curvature radii as described above and may be seated on an outer surface of the first jig **410***e*. The cover window **310***e* may be adhered and fixed by the first fixing unit **430***e*.
[0541] While the process is performed, the TSP **340***e* and the display panel **330***e* adhered by using the second adhesive layer **350***e* may be disposed on the second jig **420***e*. The display panel **330***e* may be disposed to face the second jig **420***e*, and the TSP **340***e* may be disposed to face the first jig **410***e*.
[0542] After the TSP **340***e* and the display panel **330***e* are disposed as described above, the first adhesive layer **320***e* may be coated on the TSP **340***e*. The first adhesive layer **320***e* may be formed of the same material as or a similar material to that of the second adhesive layer **350***e*.
[0543] When the cover window **310***e*, the TSP **340***e*, and the display panel **330***e* are completely disposed as described above, the first jig **410***e* and the second jig **420***e* may be moved toward each other by driving the first driving unit **415***e* and the second driving unit **425***e*. A protruding portion of the cover window **310***e* may first contact the first adhesive layer **320***e*, and the first adhesive layer **320***e* and the cover window **310***e* may be sequentially laminated from central portions of the display panel **330***e* to both end portions.
[0544] In particular, when the cover window **310***e* and the panel member **390***e* contact each other, a load range applied when the first jig **410***e* and the second jig **420***e* compress the cover window **310***e* and the panel member **390***e* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***e* and the panel member **390***e* may be reduced, and the cover window **310***e* and the panel

member **390***e* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***e* and the panel member **390***e* are attached to each other, the cover window **310***e* and the panel member **390***e* may be damaged, thereby reducing quality and reliability.

[0545] While the process is performed, a first cushion unit **493***e* and a second cushion unit **491***e* may uniformly distribute a force applied to the panel member **390***e* and the cover window **310***e*.

[0546] When the process is completed, the first driving unit **415***e* and the second driving unit **425***e* may operate to separate the first jig **410***e* and the second jig **420***e*. The operator may complete an operation by removing the completed display device **300***e* from the first jig **410***e* or the second jig **420***e*.

[0547] The operation may be performed in a vacuum state. In further detail, the apparatus **400***e* may include a chamber (see, for example, chamber C in FIG. **4**C) in which the first jig **410***e*, the second jig **420***e*, the fixing unit, and the driving unit M are disposed. In addition, the apparatus **400***e* may include a pressure adjustment unit that adjusts a pressure in the chamber. The pressure adjustment unit may maintain a pressure in the chamber in a vacuum state when the cover window **310***e* and the panel member **390***e* are laminated. In addition, the pressure adjustment unit may restore and maintain a pressure in the chamber in an atmospheric pressure state after the process is completed.

[0548] Accordingly, the apparatus **400***e* may manufacture any type of display device **300***e*. In addition, the apparatus **400***e* may reduce or minimize a product defect rate by effectively removing vapors or preventing vapors from being generated between the cover window **310***e* and the panel member **390***e* when the cover window **310***e* and the panel member **390***e* are laminated.

[0549] FIG. **36** is a cross-sectional view illustrating an apparatus **500***e* for manufacturing the display device **300***e* of FIG. **34**, according to another embodiment of the present invention.

[0550] Referring to FIG. **36**, the apparatus **500***e* includes a first jig **510***e*, a second jig **520***e*, a driving unit M, a fixing unit (for example, first fixing unit **530***e*), and a cushion unit **590***e*. In this case, the first jig **510***e*, the second jig **520***e*, the driving unit M, the fixing unit, and the cushion unit **590***e* are substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0551] The driving unit M may include a first driving unit **515***e* and a second driving unit **525***e*, and the fixing unit may include a first fixing unit **530***e*. In this case, the first driving unit **515***e*, the second driving unit **525***e*, and the first fixing unit **530***e* are substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0552] The apparatus **500***e* includes a clamping unit **550***e* that is spaced apart by a set or predetermined interval from at least one of the first jig **510***e* or the second jig **520***e*, and supports the panel member **390***e*. For convenience of description, however, it will be assumed that the clamping unit **550***e* is disposed adjacent to the second jig **520***e*.

[0553] The clamping unit **550***e* may support the panel member **390***e* when one end of the panel member **390***e* is inserted into the clamping unit **550***e*. A plurality of the clamping units **550***e* may be provided, where a distance S**7** between the clamping units **550***e* is less than a length or a width of the panel member **390***e*. The panel member **390***e* may include at least one of the display panel **330***e* or the TSP **340***e* as described above. For convenience of description, it will be assumed that the distance S**7** between the plurality of clamping units **550***e* is less than a width of the panel member **390***e* and the panel member **390***e* includes the display panel **330***e* and the TSP **340***e*.

[0554] In particular, the plurality of clamping units **550***e* face respective side surfaces of the second jig **520***e*, and fix both ends of the display panel **330***e*, the second adhesive layer **350***e*, the TSP **340***e*, and the first adhesive layer **320***e*. The plurality of clamping units **550** include a first clamping unit **551***e* and a second clamping unit **552***e* that are spaced apart by a set or predetermined interval from each other.

[0555] Accordingly, the apparatus **500***e* may rapidly and easily manufacture the display device

300*e* having a curved surface and a simple structure. In addition, since the apparatus **500***e* may accurately attach the cover window **310***e* having a curved surface to the panel member **390***e*, a product defect rate may be reduced or minimized.

[0556] In particular, since the apparatus **500***e* includes the clamping unit **550***e* to accurately align the panel member **390***e* and the cover window **310***e*, working efficiency may be improved.

[0557] A method of manufacturing the display device **300***e* by using the apparatus **500***e* will now be described.

[0558] The cover window **310***e* may be formed as described above, the display panel **330***e* may be formed, and then the TSP **340***e* and the display panel **330***e* may be adhered by using the second adhesive layer **350***e*. The cover window **310***e* may be mounted on the first jig **510***e* as described above.

[0559] When the process is completed, the first adhesive layer **320***e* may be formed on the TSP **340***e*, which may then be fixed to the first clamping unit **551***e* and the second clamping unit **552***e*. A method of fixing the TSP **340***e* may include inserting and fixing both ends of the TSP **340***e* into insertion grooves formed in the first clamping unit **551***e* and the second clamping unit **552***e* as described above.

[0560] Once the display panel **330***e*, the second adhesive layer **350***e*, the TSP **340***e*, and the first adhesive layer **320***e* are fixed in this manner, portions of the display panel **330***e*, the second adhesive layer **350***e*, the TSP **340***e*, and the first adhesive layer **320***e* may protrude toward the first jig **510***e* or the second jig **520***e*. In further detail, since the distance S**7** between the first clamping unit **551***e* and the second clamping unit **552***e* is less than a width or a length of at least one of the display panel **330***e* or the TSP **340***e*, the portions may protrude toward the second jig **520***e* or protrude toward the first jig **510***e*. However, for convenience of description, it will be assumed that one portion of the panel member **390***e* protrudes toward the second jig **520***e*.

[0561] When the display panel **330***e*, the second adhesive layer **350***e*, the TSP **340***e*, and the first adhesive layer **320***e* are fixed, the first adhesive layer **320***e* and the cover window **310***e* may be compressed against each other by moving at least one of the first jig **510***e* or the second jig **520***e*. For convenience of description, it will be assumed that the first adhesive layer **320***e* and the cover window **310***e* are compressed by moving both the first jig **510***e* and the second jig **520***e*.

[0562] When the first jig **510***e* and the second jig **520***e* move, the first driving unit **515***e* and the second driving unit **525***e* may operate to move the first jig **510***e* and the second jig **520***e* closer to each other.

[0563] A protruding portion of the cover window **310***e* first contacts the first adhesive layer **320***e*. When the first jig **510***e* and the second jig **520***e* continuously move, the cover window **310***e* and the first adhesive layer **320***e* may be laminated beginning from a contact portion between the cover window **310***e* and the first adhesive layer **320***e* toward both end portions.

[0564] In particular, when the cover window **310***e* and the panel member **390***e* contact each other, a load range applied when the first jig **510***e* and the second jig **520***e* compress the cover window **310***e* and the panel member **390***e* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***e* and the panel member **390***e* may be reduced, and the cover window **310***e* and the panel member **390***e* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***e* and the panel member **390***e* are attached to each other, the cover window **310***e* and the panel member **390***e* may be damaged, thereby reducing quality and reliability.

[0565] A first cushion unit **593***e* and a second cushion unit **591***e* may uniformly distribute a force applied to the panel member **390***e* and the cover window **310***e* when the panel member **390***e* and the cover window **310***e* are compressed and laminated.

[0566] Accordingly, the apparatus **500***e* may rapidly and accurately manufacture the display device **300***e* having a curved surface. In particular, the apparatus **500***e* may reduce or minimize a product

defect rate by accurately attaching the panel member **390***e* and the cover window **310***e* having a curved surface.

[0567] In addition, the apparatus **500***e* may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) when the panel member **390***e* and the cover window **310***e* are compressed.

[0568] FIG. **37** is a cross-sectional view illustrating an apparatus **600***e* for manufacturing the display device **300***e* of FIG. **34**, according to yet another embodiment of the present invention.

[0569] Referring to FIG. **37**, the apparatus **600***e* includes a first jig **610***e*, a second jig **620***e*, a driving unit M, a clamping unit **650***e*, a fixing unit (for example, first fixing unit **630***e*), a cushion unit **690***e*, and a linear moving unit L. The first jig **610***e*, the second jig **620***e*, the driving unit, the clamping unit **650***e*, the fixing unit, and the cushion unit **690***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0570] The driving unit M may include a first driving unit **615***e* and a second driving unit **625***e*, and the fixing unit may include a first fixing unit **630***e*. The first driving unit **615***e*, the second driving unit **625***e*, and the first fixing unit **630***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0571] The clamping unit **650***e* may include a first clamping unit **651***e* and a second clamping unit **652***e*. The first clamping unit **651***e* and the second clamping unit **652***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.

[0572] The linear moving unit L may include a first linear driving unit **660***e* and a second linear driving unit **670***e* that respectively vertically move the first clamping unit **651***e* and the second clamping unit **652***e*. In this case, the first linear driving unit **660***e* and the second linear driving unit **670***e* are formed similarly, and thus the following description will focus on the first linear driving unit **660***e*.

[0573] The first linear driving unit **660***e* may include a first shaft **661***e* that is connected to the first clamping unit **651***e* and linearly moves the first clamping unit **651***e*. In addition, the first linear driving unit **660***e* may include a first driving module **665***e* that drives the first shaft **661***e*. The first driving module **665***e* may be formed to include a cylinder or a motor. However, for convenience of description, it will be assumed that the first driving module **665***e* includes a motor. In addition, it will be assumed that the first shaft **661***e* includes a ball screw that is raised and lowered as the first driving module **665***e* rotates.

[0574] The first linear driving unit **660***e* may include a first elastic unit **663***e* that surrounds the first shaft **661***e*. The first elastic unit **663***e* may include a compression spring, or may be formed of an elastic material such as rubber. However, for convenience of description, it will be assumed that the first elastic unit **663***e* includes a compression spring.

[0575] The first elastic unit **663***e* may be disposed to surround an outer surface of the first shaft **661***e* as described above, and thus may provide a restoring force to the first clamping unit **651***e* when the first clamping unit **651***e* moves.

[0576] A method of manufacturing the display device **300***e* by using the apparatus **600***e* will now be described. First, the cover window **310***e* and the panel member **390***e* may be manufactured and prepared. The panel member **390***e* may include at least one of the display panel **330***e* or the TSP **340***e*. However, for convenience of description, it will be assumed that the panel member **390***e* includes the display panel **330***e* and the TSP **340***e*.

[0577] The display panel **330***e* and the TSP **340***e* prepared as described above may be attached by using the second adhesive layer **350***e*, and then the first adhesive layer **320***e* may be formed on the TSP **340***e*. In this case, both ends of the display panel **330***e* and the TSP **340***e* on which the first adhesive layer **320***e* is formed may be fixed to the first clamping unit **651***e* and the second clamping unit **652***e*.

[0578] When the panel member **390***e* is fixed to the first clamping unit **651***e* and the second clamping unit **652***e* as described above, a portion of the panel member **390***e* may protrude toward

the second jig **620***e* or may protrude toward the first jig **610***e*. In further detail, since a distance S**8** between the first clamping unit **651***e* and the second clamping unit **652***e* is less than a width or a length of the panel member **390***e*, a portion of the panel member **390***e* may protrude toward the second jig **620***e* or protrude toward the first jig **610***e*. In this case, for convenience of description, it will be assumed that the distance S**8** between the first clamping unit **651***e* and the second clamping unit **652***e* is less than a width of the panel member **390***e* and a portion of the panel member **390***e* protrudes toward the second jig **620***e*.

[0579] When the panel member **390***e* is disposed as described above, the panel member **390***e* and the cover window **310***e* may be compressed against each other by moving at least one of the first jig **610***e* or the second jig **620***e*. However, for convenience of description, it will be assumed that the panel member **390***e* and the cover window **310***e* are compressed against each other by moving both the first jig **610***e* and the second jig **620***e*.

[0580] When the first jig **610***e* and the second jig **620***e* move as described above, the first linear driving unit **660***e* and the second linear driving unit **670***e* may operate to vertically move the first clamping unit **651***e* and the second clamping unit **652***e*. In particular, the first clamping unit **651***e* and the second clamping unit **652***e* may move at a speed similar to a speed at which the second jig **620***e* moves.

[0581] When the first clamping unit **651***e* and the second clamping unit **652***e* are raised as described above, the panel member **390***e* may be raised while maintaining its curved state. When a distance between the first jig **610***e* and the second jig **620***e* reaches a set or predetermined distance, the first clamping unit **651***e* and the second clamping unit **652***e* may release the panel member **390***e*.

[0582] In particular, after the first clamping unit **651***e* and the second clamping unit **652***e* operate as described above, the first linear driving unit **660***e* and the second linear driving unit **670***e* may operate to lower the first clamping unit **651***e* and the second clamping unit **652***e*.

[0583] After that, the first driving unit **615***e* and the second driving unit **625***e* may continuously operate to make the first jig **610***e* and the second jig **620***e* get closer to each other. In particular, as the first jig **610***e* and the second jig **620***e* get closer to each other, the panel member **390***e* and the cover window **310***e* may be compressed. In this case, a method of compressing the panel member **390***e* and the cover window **310***e* is performed in the same manner as that described above, and thus a detailed description thereof will not be repeated.

[0584] In particular, when the cover window **310***e* and the panel member **390***e* contact each other, a load range applied when the first jig **610***e* and the second jig **620***e* compress the cover window **310***e* and the panel member **390***e* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***e* and the panel member **390***e* may be reduced, and the cover window **310***e* and the panel member **390***e* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***e* and the panel member **390***e* are attached to each other, the cover window **310***e* and the panel member **390***e* may be damaged, thereby reducing quality and reliability.

[0585] A first cushion unit **693***e* and a second cushion unit **691***e* may uniformly distribute a force applied to the cover window **310***e* and the panel member **390***e* when the cover window **310***e* and the panel member **390***e* are compressed and laminated.

[0586] Accordingly, the apparatus **600***e* may rapidly and accurately manufacture the display device **300***e* having a curved surface. In particular, the apparatus **600***e* may reduce or minimize a product defect rate by accurately attaching the panel member **390***e* and the cover window **310***e* having a curved surface.

[0587] In addition, the apparatus **600***e* may improve product quality by removing air bubbles that may be generated (or preventing air bubbles from being generated) when the panel member **390***e* and the cover window **310***e* are compressed.

[0588] FIG. **38** is a cross-sectional view illustrating an apparatus **700***e* for manufacturing the display device **300***e* of FIG. **34**, according to still yet another embodiment of the present invention.
[0589] Referring to FIG. **38**, the apparatus **700***e* may include a first jig **710***e*, a second jig **720***e*, a driving unit M, a clamping unit **750***e*, a fixing unit (for example, first fixing unit **730***e*), a linear driving unit L, and a cushion unit **790***e* (including a first cushion unit **793***e* and a second cushion unit **791***e*). The first jig **710***e* and the second jig **720***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0590] The driving unit M may include a first driving unit **715***e* and a second driving unit **725***e*, and the fixing unit may include a first fixing unit **730***e*. The first driving unit **715***e*, the second driving unit **725***e*, and the first fixing unit **730***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0591] In addition, the clamping unit **750***e* may include a first clamping unit **751***e* and a second clamping unit **752***e*. The first clamping unit **751***e* and the second clamping unit **752***e* may be substantially the same as those described above, and thus a detailed description thereof will not be repeated.
[0592] The linear driving unit L may include a first linear driving unit **760***e* and a second linear driving unit **770***e*, and the first linear driving unit **760***e* and the second linear driving unit **770***e* may linearly move the first clamping unit **751***e* and the second clamping unit **752***e*, respectively. In particular, the first linear driving unit **760***e* and the second linear driving unit **770***e* may linearly move the first clamping unit **751***e* and the second clamping unit **752***e* in a diagonal direction. Since the second linear driving unit **770***e* may be formed similarly to the first linear driving unit **760***e*, the following description will focus on the first linear driving unit **760***e*.
[0593] In further detail, the first linear driving unit **760***e* may include a first shaft **761***e*, a first driving module **765***e*, and a first elastic unit **763***e*. The first shaft **761***e*, the first driving module **765***e*, and the first elastic unit **763***e* may be formed in a similar manner to those described above except that the first shaft **761***e* is disposed in a diagonal direction to diagonally move the first clamping unit **751***e*.
[0594] In particular, when the first linear driving unit **760***e* operates, the first driving module **765***e* may vary a length of the first shaft **761***e*. Since the first driving module **765***e* and the first shaft **761***e* are diagonally disposed with respect to the second jig **720***e* as described above, the first clamping unit **751***e* may be diagonally moved by varying the movement of the first shaft **761***e*.
[0595] For example, when the first driving module **765***e* operates to diagonally move the first shaft **761***e* downward with respect to the second jig **720***e*, the first clamping unit **751***e* may diagonally move downward with respect to the second jig **720***e* as the first shaft **761***e* moves.
[0596] When the first driving module **765***e* operates in an opposite direction to diagonally move the first shaft **761***e* upward with respect to the second jig **720***e*, the first clamping unit **751***e* may diagonally move upward with respect to the second jig **720***e* as the first shaft **761***e* moves.
[0597] The first shaft **761***e* may include a ball screw as described above and thus may rotate as the first driving module **765***e* operates. In particular, the first shaft **761***e* may diagonally move downward or upward with respect to the second jig **720***e* as the first driving module **765***e* rotates.
[0598] A method of manufacturing the display device **300***e* may be similar to that described above. In further detail, the panel member **390***e* and the cover window **310***e* may be manufactured and prepared. The panel member **390***e* may include the display panel **330***e* and the TSP **340***e* as described above. However, for convenience of description, it will be assumed that the panel member **390***e* includes both the display panel **330***e* and the TSP **340***e*.
[0599] When the display panel **330***e* and the TSP **340***e* are completely manufactured as described above, the display panel **330***e* and the TSP **340***e* may be adhered by using the second adhesive layer **350***e*, and the first adhesive layer **320***e* may be coated on the TSP **340***e*.
[0600] The panel member **390***e* manufactured as described above may be fixed by the first clamping unit **751***e* and the second clamping unit **752***e*. When the fixing is completed, the panel

member **390***e* and the cover window **310***e* may be compressed against each other by moving at least one of the first jig **710***e* or the second jig **720***e*.
[0601] A method of compressing the panel member **390***e* and the cover window **310***e* may be similar to that described above, and thus a detailed description thereof will not be repeated.
[0602] When the first jig **710***e* and the second jig **720***e* move in this manner, the first clamping unit **751***e* and the second clamping unit **752***e* may also move. In particular, the first clamping unit **751***e* and the second clamping unit **752***e* may be diagonally moved by the first linear driving unit **760***e* and the second linear driving unit **770***e*, respectively. The first clamping unit **751***e* and the second clamping unit **752***e* may be raised diagonally.
[0603] When the first clamping unit **751***e* and the second clamping unit **752***e* are raised and then an interval between the first jig **710***e* and the second jig **720***e* reaches a preset interval, both ends of the panel member **390***e* may be released.
[0604] After the releasing of the first clamping unit **751***e* and the second clamping unit **752***e* as described above, the first linear driving unit **760***e* and the second linear driving unit **770***e* may operate to lower the first clamping unit **751***e* and the second clamping unit **752***e*. The first clamping unit **751***e* and the second clamping unit **752***e* may be lowered diagonally.
[0605] While the first clamping unit **751***e* and the second clamping unit **752***e* are lowered, the first jig **710***e* and the second jig **720***e* may get closer to each other to compress the panel member **390***e* and the cover window **310***e*. In this case, a method of adhering the panel member **390***e* and the cover window **310***e* through compression may be similar to that described above.
[0606] When the panel member **390***e* and the cover window **310***e* are compressed by moving the first jig **710***e* and the second jig **720***e* as described above, the first cushion unit **793***e* and the second cushion unit **791***e* may distribute a force applied to the panel member **390***e* and the cover window **310***e*. In addition, the first cushion unit **793***e* and the second cushion unit **791***e* may help prevent the panel member **390***e* or the cover window **310***e* from being damaged by absorbing part of a force applied to the panel member **390***e* and the cover window **310***e*.
[0607] In particular, when the cover window **310***e* and the panel member **390***e* contact each other, a load range applied when the first jig **710***e* and the second jig **720***e* compress the cover window **310***e* and the panel member **390***e* may be greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa. When the load range is less than 0.3 MPa, an adhesive force between the cover window **310***e* and the panel member **390***e* may be reduced, and the cover window **310***e* and the panel member **390***e* may be delaminated and separated from each other. In addition, when the load range exceeds 0.5 MPa and the cover window **310***e* and the panel member **390***e* are attached to each other, the cover window **310***e* and the panel member **390***e* may be damaged, thereby reducing quality and reliability.
[0608] Accordingly, the apparatus **700***e* may rapidly and accurately manufacture the display device **300***e* having a curved surface. In particular, the apparatus **700***e* may reduce or minimize a product defect rate by accurately attaching the panel member **390***e* and the cover window **310***e* having a curved surface.
[0609] In addition, the apparatus **700***e* may improve quality by removing air bubbles or preventing air bubbles from being generated when the display panel **330***e* and the panel member **390***e* are compressed. This application relates in general to a display device and more particularly, to a display device and a corresponding method and apparatus for manufacturing the display device that may rapidly, accurately, and cleanly manufacture the display device having a curved shape. Small electronic devices having curved display devices have presented challenges in accurately forming and aligning their corresponding cover windows (for example, transparent protective covers) and display panels (such as OLED display panels or flexible OLED display panels), and adhering the cover windows to the display panels via transparent adhesive without quality defects such as air bubbles between the cover windows and the display panels.
[0610] Embodiments of the present invention address these problems by providing a display device

having a curved cover window, a display panel and/or touch screen panel (TSP) that fits in the cover window, and an adhesive layer between the display device and the cover window, together with an apparatus and method for manufacturing the display device. The cover window is fabricated with a curved shape (such as rounded edges, inward or outward) and mounted on a first jig having a mount surface that conforms to the cover window. For example, the cover window may sit in the first jig (through gravity) or attach to the first jig via a fixing unit, such as a vacuum suction device. Meanwhile, the display panel (to which the adhesive layer is attached), is attached to a second jig by similar means. The distance between the jigs is then closed (by moving one or both jigs towards the other using, for example, driving units), allowing the display panel to press up to the cover window and adhere via the adhesive layer, and without forming air bubbles between the cover window and the display panel.

[0611] In another embodiment, the display panel may be attached to a clamp unit, such as a pair of clamps, and bent through a clamping force to mate cleanly with the cover window when the jigs are moved towards each other. The clamps may be moved via dedicated driving units (for example, which drive ball screws through rotational movement to move the clamps) independently of the jigs, and may move, for example vertically or diagonally with respect to the jigs (and with respect to a gravity direction).

[0612] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims, and equivalents thereof.

Claims

1. A method of manufacturing a display device, the method comprising: mounting a cover window comprising a curved portion on a first jig comprising a curved portion; mounting a panel member comprising a display panel on a second jig that conforms to a surface of the first jig; laminating the cover window to the panel member by moving a first one of the first jig or the second jig to a first other one of the first jig or the second jig; and compressing the cover window and the panel member together with a load of greater than or equal to 0.3 MPa and less than or equal to 0.5 MPa.

2. The method of claim 1, wherein at least a portion of the panel member contacts a surface of the second jig.

3. The method of claim 1, wherein the panel member is bent along an outer surface of the second jig during the mounting of the panel member on the second jig.

4. The method of claim 1, wherein the panel member is smaller in at least one of a length or a width than the cover window.

5. The method of claim 1, wherein the panel member is flat during the mounting of the panel member on the second jig, and the laminating of the cover window to the panel member comprises partially curving the panel member by the moving of the first one of the first jig or the second jig.

6. The method of claim 1, wherein the first one of the first jig or the second jig is above the first other one of the first jig or the second jig, or the first other one of the first jig or the second jig is above the first one of the first jig or the second jig.

7. The method of claim 1, wherein a second one of the first jig or the second jig is formed by protruding toward or recessing away from a second other one of the first jig or the second jig.

8. The method of claim 7, wherein the second other one of the first jig or the second jig is formed by recessing away from or protruding toward the second one of the first jig or the second jig.

9. The method of claim 1, wherein the mounting of the panel member comprises fixing the panel member to the second jig.

10. The method of claim 1, wherein the panel member is flexible.

11. The method of claim 1, wherein the panel member is attached to a recessed outer surface of the

cover window or a protruding outer surface of the cover window.

12. The method of claim 1, wherein the panel member further comprises a touch screen panel (TSP).

13. The method of claim 1, wherein the cover window comprises a flat portion and the curved portion extended from the flat portion.

14. The method of claim 1, wherein at least one of the first jig or the second jig comprises at least one of a cushion unit.