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(54) LIQUID CRYSTAL DISPLAY DEVICE

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(57) **ABSTRACT**

A liquid crystal display device includes: a liquid crystal panel which includes a liquid crystal layer and a pair of resilient substrates which sandwiches the liquid crystal layer therebetween; and a curving holding means (a lower frame, an upper frame, a plurality of bolts, and a plurality of nuts) which clamps an outer peripheral portion of the liquid crystal panel from a front surface and a back surface of the liquid crystal panel so as to hold the liquid crystal panel in a state that the liquid crystal panel is curved in one direction, wherein a clamping force applied to a non-curved outer peripheral portion of the liquid crystal panel by the curving holding means is set larger than a clamping force applied to a curved outer peripheral portion of the liquid crystal panel by the curving holding means.

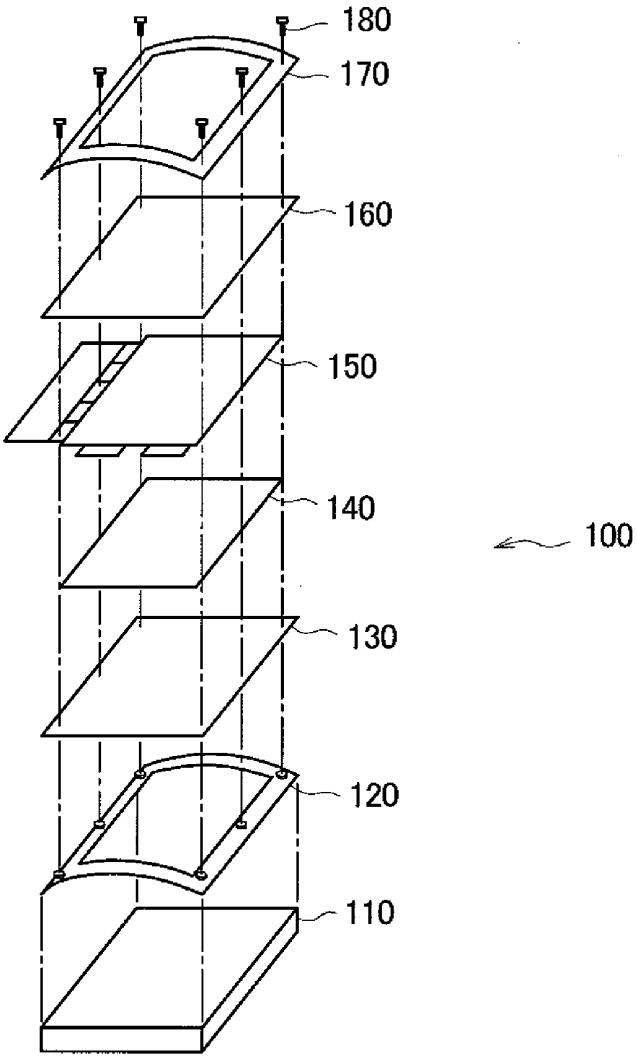
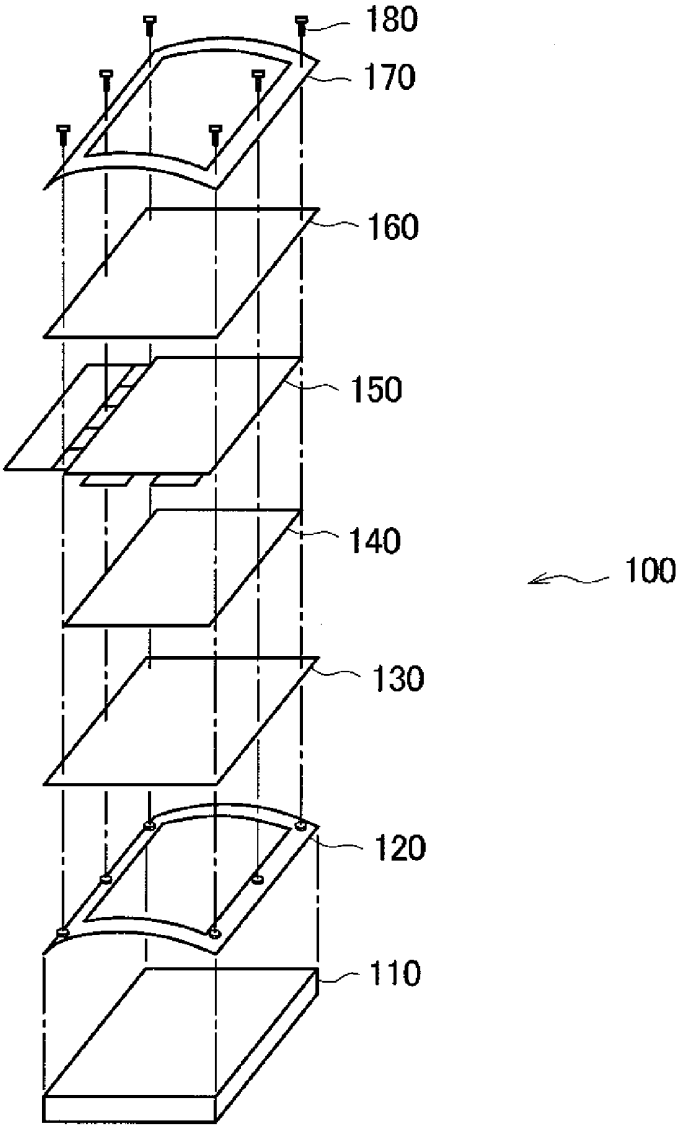


FIG. 1A


180
170
160
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130
120
110
100

FIG. 1B

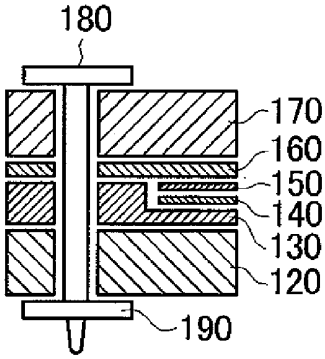
180
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FIG. 2

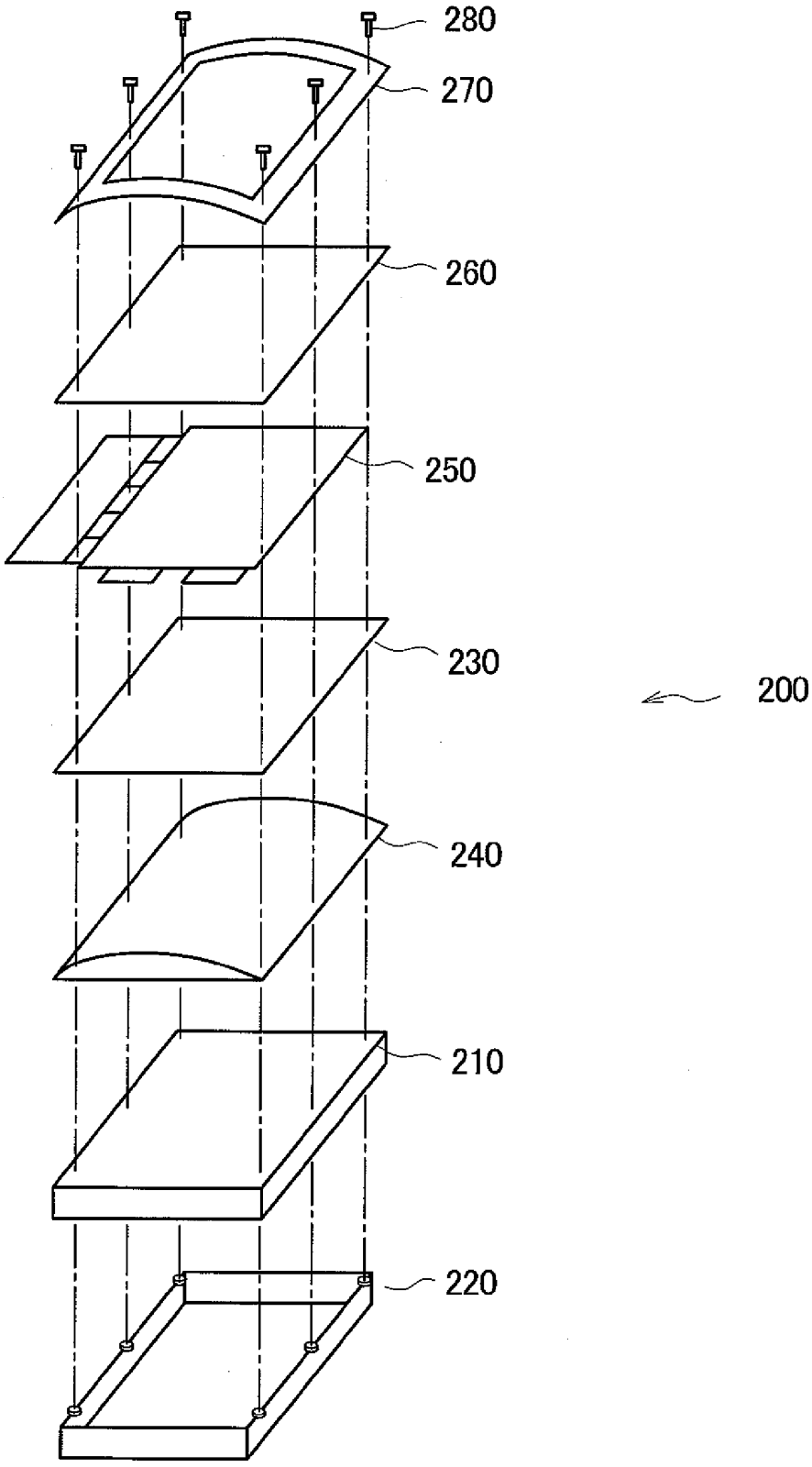


FIG. 3

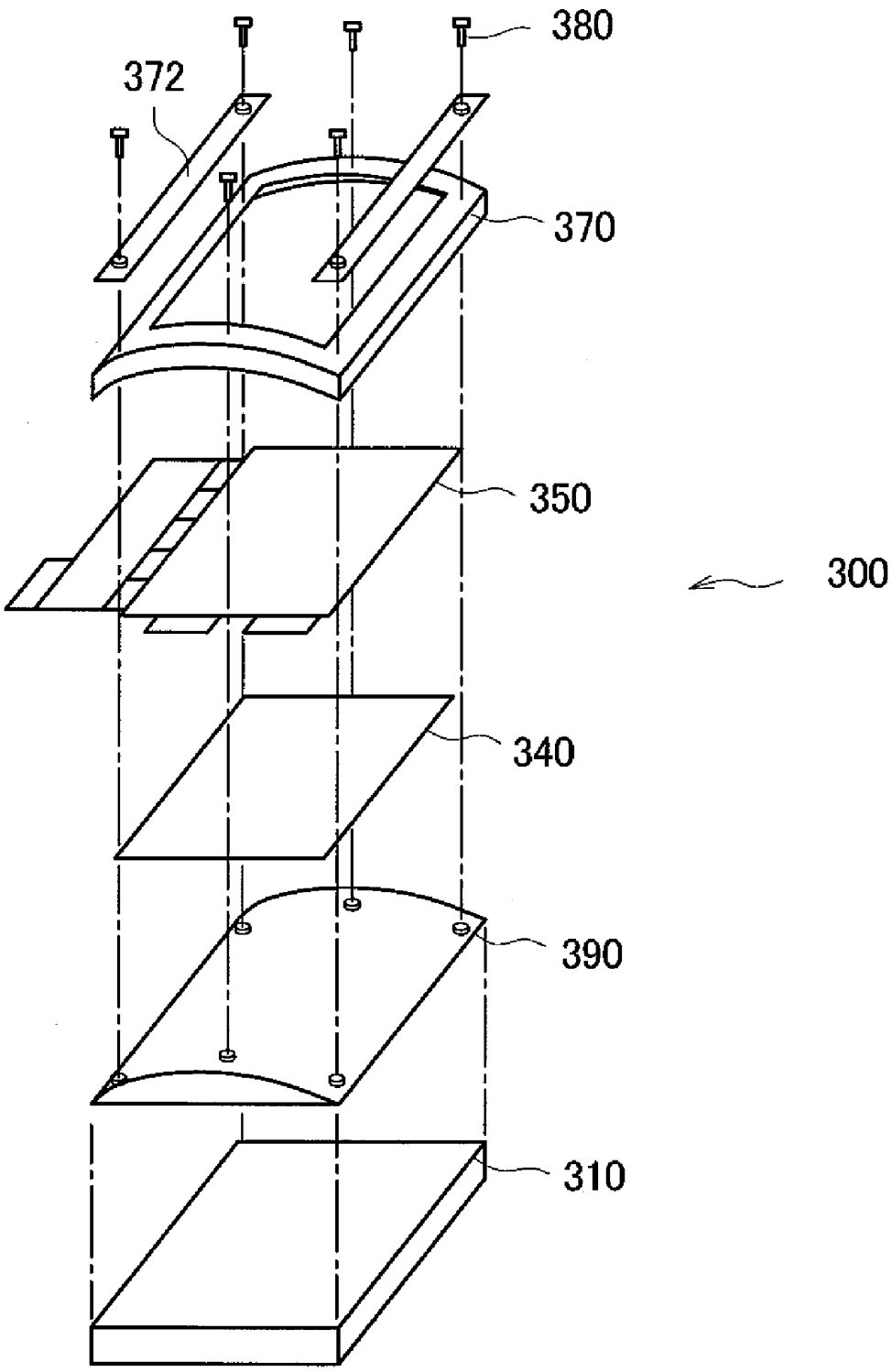


FIG. 4

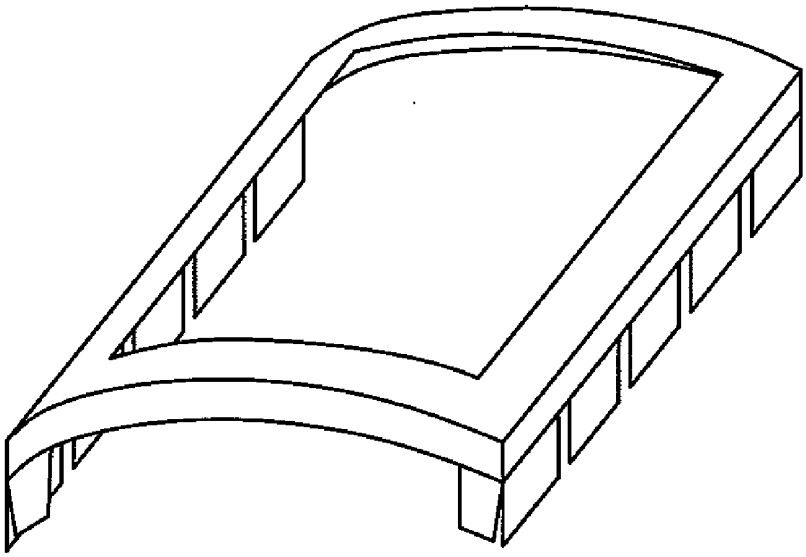


FIG. 5

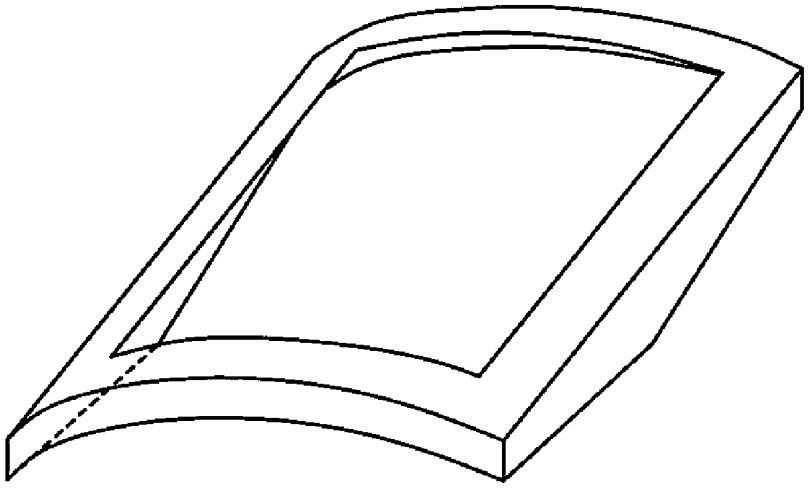


FIG. 6A

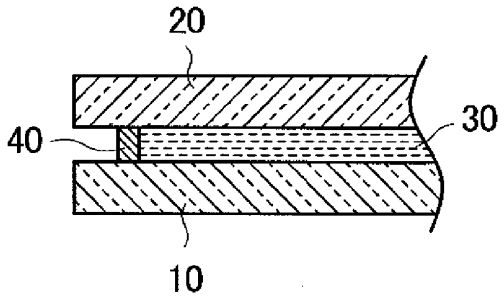


FIG. 6B

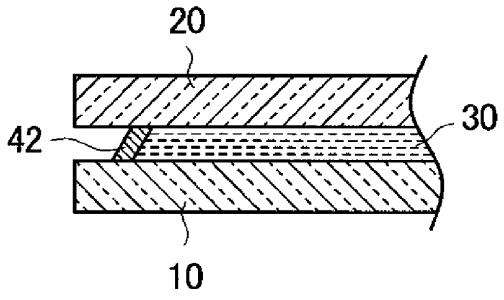
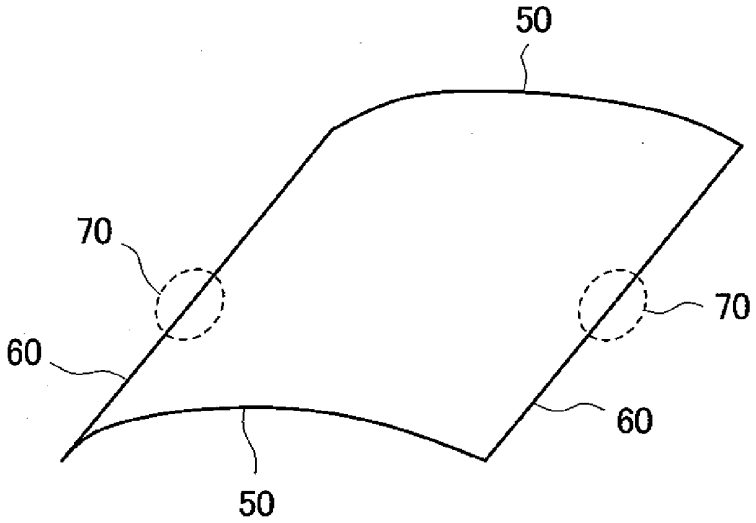


FIG. 7

PRIOR ART



LIQUID CRYSTAL DISPLAY DEVICE

[0001] The present application claims priority from Japanese applications JP 2008-205790 filed on Aug. 8, 2008, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid crystal display device, and more particularly to a liquid crystal display device which includes a curved liquid crystal panel.

[0004] 2. Description of the Related Art

[0005] In the manufacture of a curved-face display using a liquid crystal panel, it is advantageous to adopt the following method for relatively easily manufacturing the curved-face display. That is, a liquid crystal panel having resiliency by making thicknesses of a pair of transparent substrates (for example, glass substrates) which sandwiches a liquid crystal layer therebetween small is prepared. Then, the liquid crystal panel is curved in one direction along a suitable curved member and, at the same time, sides of the liquid crystal panel which are not curved (non-curved sides) and are arranged orthogonal to sides of the liquid crystal panel which are curved (curved sides) are held by a holding member. For example, JP-A-8-286174 (patent document 1) and JP-A-2006-106079 (patent document 2) disclose a technique for curving the liquid crystal panel.

SUMMARY OF THE INVENTION

[0006] However, when a liquid crystal panel is curved in one direction by the above-mentioned method, as shown in FIG. **7**, due to elasticity of a transparent substrate (a force which acts to return the transparent substrate to an original shape), a gap between the substrates is increased in a zone **70** in the vicinity of the center of a non-curved side **60** which is not directly held by a curving member not shown in the drawing thus giving rise to a drawback that display irregularities (so-called gap irregularities) occur in the zone **70** in the vicinity of the center of the non-curved side **60**.

[0007] The invention has been made under such circumstances, and it is an object of the invention to provide a liquid crystal display device which can decrease display irregularities attributed to curving of a liquid crystal panel.

[0008] To overcome the above-mentioned drawbacks, according to one aspect of the invention, there is provided a liquid crystal display device which includes a liquid crystal panel which includes a liquid crystal layer and a pair of resilient substrates which sandwiches the liquid crystal layer therebetween, and a curving holding means which clamps an outer peripheral portion of the liquid crystal panel from a front surface and a back surface of the liquid crystal panel so as to hold the liquid crystal panel in a state that the liquid crystal panel is curved in one direction, wherein a clamping force applied to a non-curved outer peripheral portion of the liquid crystal panel by the curving holding means is set larger than a clamping force applied to a curved outer peripheral portion of the liquid crystal panel by the curving holding means.

[0009] According to the invention, it is possible to suppress the increase of a gap between the substrates at the non-curved outer peripheral portions of the liquid crystal panel curved in one direction. Since the increase of the gap between the substrates can be suppressed in this manner, it is possible to decrease display irregularities attributed to curving of the liquid crystal panel.

[0010] Further, according to one mode of the invention, the clamping force applied to the non-curved outer peripheral portion of the liquid crystal panel by the curving holding means differs corresponding to a distance from the curved outer peripheral portion of the liquid crystal panel.

[0011] Further, according to one mode of the invention, the clamping force applied to the non-curved outer peripheral portion of the liquid crystal panel by the curving holding means is increased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel. According to the mode, it is possible to preferably suppress the increase of the gap between the substrates in the vicinity of the center of the non-curved outer peripheral portion of the liquid crystal panel curved in one direction.

[0012] Further, according to one mode of the invention, the curving holding means includes a front-surface-side curved frame which pushes an outer peripheral portion of the liquid crystal panel from a front surface side of the liquid crystal panel and a back-surface-side curved structural body which pushes at least the outer peripheral portion of the liquid crystal panel from a back surface side of the liquid crystal panel.

[0013] Further, according to one mode of the invention, the curving holding means further includes a plurality of fixing jigs which fixes a portion of the front-surface-side curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner and a portion of the back-surface-side curved structural body which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner in a state that both the portion of the front-surface-side curved frame and the portion of the back-surface-side curved structural body face each other.

[0014] Further, according to one mode of the invention, an interval between the fixing jigs is decreased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel.

[0015] Further, according to one mode of the invention, the fixing jig is a bolt and a nut which forms a pair.

[0016] In the mode, the bolts and the nuts may fix the front-surface-side curved frame and the back-surface-side curved structural body to each other in an opposed manner by way of a push plate having a predetermined thickness.

[0017] Further, according to one mode of the invention, the fixing jig is a removal preventing pawl which is joined to or integrally formed with one of the front-surface-side curved frame and the back-surface-side curved structural body, and is fitted into a predetermined portion of another of the front-surface-side curved frame and the back-surface-side curved structural body.

[0018] In the mode, a length of the removal preventing pawl may be increased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel.

[0019] Further, according to one mode of the invention, a portion of the front-surface-side curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner includes a raised portion which is raised corresponding to the distance from the curved outer peripheral portion of the liquid crystal panel.

[0020] Further, according to one mode of the invention, the back-surface-side curved structural body is a back-surface

curved frame which pushes the outer peripheral portion of the liquid crystal panel from a back surface side of the liquid crystal panel.

[0021] In the mode, a portion of the back-surface curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner may include a raised portion which is raised corresponding to the distance from the curved outer peripheral portion of the liquid crystal panel.

[0022] Further, according to one mode of the invention, the back-surface-side curved structural body is arranged between the liquid crystal panel and a backlight which is arranged on a back surface side of the liquid crystal panel, and diffuses light emitted toward the liquid crystal panel from the backlight.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1**A and FIG. **1**B are views showing constitutional parts of a liquid crystal display device according to an embodiment 1 of the invention;

[0024] FIG. **2** is a view showing constitutional parts of a liquid crystal display device according to an embodiment 2 of the invention;

[0025] FIG. **3** is a view showing constitutional parts of a liquid crystal display device according to an embodiment 3 of the invention;

[0026] FIG. **4** is a view showing an upper frame in which a plurality of removal preventing pawls is joined to or integrally formed with a non-curved edge portion;

[0027] FIG. **5** is a view showing the upper frame in which the vicinity of the center of the non-curved edge portion is raised;

[0028] FIG. **6**A and FIG. **6**B are cross-sectional views of a portion in the vicinity of a non-curved outer peripheral portion of a liquid crystal panel; and

[0029] FIG. **7** is a view showing a liquid crystal panel curved in one direction.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Hereinafter, embodiments of the invention are explained in detail in conjunction with drawings. Here, the repeated explanation of identical or similar constitutional parts is omitted.

Embodiment 1

[0031] FIG. **1**A and FIG. **1**B are views showing constitutional parts of a liquid crystal display device **100** according to an embodiment 1 of the invention.

[0032] As shown in the drawing, the liquid crystal display device **100** includes a backlight **110**, a lower frame **120**, PC sheets (polycarbonate sheets) **130**, **160**, a diffusion sheet **140**, a liquid crystal panel **150**, an upper frame **170**, bolts **180** and nuts **190**.

[0033] The liquid crystal panel **150** includes a liquid crystal layer and a pair of quadrangular glass substrates having resiliency which sandwiches the liquid crystal layer therebetween. To the liquid crystal panel **150**, a drive circuit for controlling voltages applied between pixel electrodes formed on one of the pair of glass substrates and counter electrodes formed on another of the pair of glass substrates, a flexible printed circuit board for transmitting electrical signals and the like to the drive circuit and the like are connected.

[0034] The backlight **110** is a light source which is arranged on a back surface side of the liquid crystal panel **150**.

[0035] The diffusion sheet **140** is formed of a transparent or a semi-transparent sheet having resiliency and is arranged between the backlight **110** and the liquid crystal panel **150**. The diffusion sheet **140** diffuses light emitted toward the liquid crystal panel **150** from the backlight **110**.

[0036] The PC sheets **130**, **160** are formed of a transparent sheet made of polycarbonate which has resiliency. The PC sheet **130** is arranged between the backlight **110** and the diffusion sheet **140**, while the PC sheet **160** is arranged on a front surface side of the liquid crystal panel **150**.

[0037] The lower frame **120**, the upper frame **170**, a plurality of bolts **180** and a plurality of nuts **190** constitute a curving holding means. That is, the curving holding means clamps an outer peripheral portion (a peripheral portion excluding a pixel region) of the quadrangular liquid crystal panel **150** from a front surface and a back surface of the liquid crystal panel **150** in such a manner that the liquid crystal panel **150** is held in a curved state (in an arcuate shape in this embodiment) in one direction.

[0038] The lower frame **120** is a metal-made frame which is arranged on aback surface side of the liquid crystal panel **150** and between the backlight **110** and the diffusion sheet **140**. The lower frame **120** is constituted of a pair of opposedly-arranged edge portions which is curved in an arcuate shape so as to project toward the liquid crystal panel **150** side (hereinafter referred to as "curved edge portions") and a pair of opposedly-arranged edge portions which is not curved (hereinafter referred to as "non-curved edge portions"). The lower frame **120** pushes the outer peripheral portion of the liquid crystal panel **150** from a back surface side of the liquid crystal panel **150** by way of the PC sheet **130** and the diffusion sheet **140**. An opening region surrounded by the curved edge portions and the non-curved edge portions of the lower frame **120** corresponds to the pixel region of the liquid crystal panel **150** so that light emitted toward the liquid crystal panel **150** from the backlight **110** is not interrupted by the lower frame **120**.

[0039] The upper frame **170** is a metal-made frame which is arranged on a front surface side of the liquid crystal panel **150**. The upper frame **170** is constituted of a pair of opposedly-arranged curved edge portions which is curved in an arcuate shape so as to be recessed on the liquid crystal panel **150** side and a pair of opposedly-arranged non-curved edge portions which is not curved. The upper frame **170** pushes the outer peripheral portion of the liquid crystal panel **150** from a front surface side of the liquid crystal panel **150** by way of the PC sheet **160**. An opening region surrounded by the curved edge portions and the non-curved edge portions of the upper frame **170** corresponds to the pixel region of the liquid crystal panel **150** so that light emitted toward the front surface side of the liquid crystal panel **150** from the liquid crystal panel **150** is not interrupted by the upper frame **170**. Here, a curved shape of the curved edge portion of the upper frame **170** corresponds to a curved shape of the curved edge portion of the lower frame **120**.

[0040] In the liquid crystal display device **100**, as shown in FIG. **1**A, the PC sheet **130**, the diffusion sheet **140**, the liquid crystal panel **150** and the PC sheet **160** are stacked in this order. Then, these constitutional parts are clamped between the lower frame **120** and the upper frame **170** from both upper and lower sides so that these constitutional parts are held in an

arcuately curved state along the curved edge portions of the lower frame **120** and the curved edge portions of the upper frame **170**.

[0041] Particularly, in this embodiment, a plurality of bolt insertion holes are formed in the non-curved edge portions of the upper frame **170**, the non-curved edge portions of the lower frame **120**, and the PC sheets **130**, **160** which are clamped between the upper frame **170** and the lower frame **120** at predetermined intervals. As shown in FIG. **1**B, the non-curved edge portions of the upper frame **170** and the non-curved edge portions of the lower frame **120** are fixed to each other in an opposedly facing manner by means of the bolts **180** which penetrate the bolt insertion holes and the nuts **190**.

[0042] Due to such a constitution, a clamping force applied to the non-curved portions of the outer peripheral portion of the liquid crystal panel **150** (herein after referred to as "non-curved outer peripheral portions) by the curving holding means (the lower frame **120**, the upper frame **170**, the plurality of bolts **180** and the plurality of nuts **190**) becomes larger than a clamping force applied to the curved portions of the outer peripheral portion of the liquid crystal panel **150** (hereinafter referred to as "curved outer peripheral portions). Accordingly, it is possible to suppress the increase of a gap between the substrates at the non-curved outer peripheral portions of the liquid crystal panel **150** having an arcuately curved shape. Since the increase of the gap between the substrates can be suppressed in this manner, it is possible to decrease display irregularities attributed to curving of the liquid crystal panel **150**.

[0043] Here, the interval between the bolts **180** which fix the non-curved edge portions of the upper frame **170** and the non-curved edge portions of the lower frame **120** in an oppos-edly facing manner may be decreased corresponding to a distance from the curved outer peripheral portion of the liquid crystal panel **150**. That is, the bolts **180** may be arranged more densely in the vicinity of the center of the non-curved edge portion of the upper frame **170** and in the vicinity of the center of the non-curved edge portion of the lower frame **120**. Due to such a constitution, a portion of the non-curved edge portion of the arcuately curved liquid crystal panel **150** in the vicinity of the center of the non-curved edge portion is more firmly clamped than end portions of the non-curved edge portion of the arcuately curved liquid crystal panel **150** and hence, the increase of the gap between the substrates in the vicinity of the center of the non-curved edge portion of the liquid crystal panel **150** can be preferably suppressed.

[0044] Further, as shown in FIG. **4**, the non-curved edge portions of the upper frame **170** and the non-curved edge portions of the lower frame **120** maybe fixed to each other in an opposedly facing manner such that a plurality of removal preventing pawls is joined to or integrally formed with the non-curved edge portions of the upper frame **170**, and these removal preventing pawls may be fitted into predetermined portions of the lower frame **120**. Due to such a constitution, it is possible to clamp the non-curved edge portions of the liquid crystal panel **150** more firmly than the curved outer peripheral portions of the liquid crystal panel **150** without using the bolts **180** and the nuts **190**. It is needless to say that these removal preventing pawls may be formed on a lower frame **120** side.

[0045] In this case, corresponding to a distance from the curved outer peripheral portion of the liquid crystal panel **150**, the interval between the removal preventing pawls which fix the non-curved edge portion of the upper frame **170** and the non-curved edge portion of the lower frame **120** in an opposed facing manner may be decreased. Alternatively, corresponding to a distance from the curved outer peripheral portion of the liquid crystal panel **150**, a length of the removal preventing pawl may be increased. Due to such a constitution, the increase of the gap between the substrates in the vicinity of the center of the non-curved edge portion of the arcuately curved liquid crystal panel **150** can be preferably suppressed.

[0046] Further, as shown in FIG. **5**, a raised portion may be formed on the non-curved edge portion of the upper frame **170** in such a manner that the raised portion is raised corresponding to a distance from the curved outer peripheral potion of the liquid crystal panel **150**. Also due to such a constitution, the increase of the gap between the substrates in the vicinity of the center of the non-curved edge portion of the arcuately curved liquid crystal panel **150** can be preferably suppressed.

Embodiment 2

[0047] FIG. **2** is a view showing constitutional parts of a liquid crystal display device **200** according to an embodiment 2 of the invention.

[0048] As shown in the drawing, the liquid crystal display device **200** includes a lower frame **220**, a backlight **210**, a diffusion plate **240**, a PC sheet **230**, a liquid crystal panel **250**, a PC sheet **260**, an upper frame **270**, bolts **280** and nuts (not shown in the drawing).

[0049] The liquid crystal panel **250** includes a liquid crystal layer and a pair of quadrangular glass substrates having resiliency which sandwiches the liquid crystal layer therebetween.

[0050] The backlight **210** is a light source which is arranged on a back surface side of the liquid crystal panel **250**. The backlight **210** has a back surface side thereof supported by the lower frame **220**.

[0051] The PC sheets **230**, **260** are formed of a transparent sheet made of polycarbonate which has resiliency. The PC sheet **230** is arranged on a back surface side of the liquid crystal panel **250**, while the PC sheet **260** is arranged on a front surface side of the liquid crystal panel **250**.

[0052] The diffusion plate **240**, the upper frame **270** and a plurality of bolts **280** and nuts constitute a curving holding means. That is, the curving holding means clamps an outer peripheral portion (a peripheral portion excluding a pixel region) of the quadrangular liquid crystal panel **250** from a front surface side and a back surface side in such a manner that the liquid crystal panel **250** is held in a curved state (in an arcuate shape in this embodiment) in one direction.

[0053] The diffusion plate **240** is formed of a transparent or a semi-transparent member which is arranged on a back surface side of the liquid crystal panel **250** and between the backlight **210** and the liquid crystal panel **250**. The diffusion plate **240** diffuses light emitted toward the liquid crystal panel **250** from the backlight **210**. Further, an upper surface of the diffusion plate **240** is formed into an arcuately curved surface which projects toward a liquid crystal panel **250** side. The upper surface of the diffusion plate **240** pushes the liquid crystal panel **250** from a back surface side of the liquid crystal display panel **250** by way of the PC sheet **230**.

[0054] The upper frame **270** is a metal-made frame which is arranged on a front surface side of the liquid crystal panel **250**. The upper frame **270** is constituted of a pair of opposedly-arranged curved edge portions which is curved in an arcuate shape so as to be recessed on the liquid crystal panel **250** side

and a pair of opposedly-arranged non-curved edge portions which is not curved. The upper frame **270** pushes the outer peripheral portion of the liquid crystal panel **250** from a front surface side of the liquid crystal panel **250** by way of the PC sheet **260**. An opening region surrounded by the curved edge portions and the non-curved edge portions of the upper frame **270** corresponds to the pixel region of the liquid crystal panel **250** so that light emitted toward the front surface side of the liquid crystal panel **250** from the liquid crystal panel **250** is not interrupted by the upper frame **270**. Here, a curved shape of the curved edge portion of the upper frame **270** corresponds to a curved shape of the curved surface of the diffusion plate **240**.

[0055] In the liquid crystal display device **200**, as shown in FIG. **2**, the backlight **210**, the diffusion plate **240**, the PC sheet **230**, the liquid crystal panel **250** and the PC sheet **260** are stacked in this order. Then, these constitutional parts are clamped between the lower frame **220** and the upper frame **270** from both upper and lower sides. Out of these constitutional parts, the PC sheet **230**, the liquid crystal panel **250** and the PC sheet **260** are held in an arcuately curved state along the curved surface of the diffusion plate **240** and the curved edge portions of the upper frame **270**.

[0056] Particularly, in this embodiment, a plurality of bolt insertion holes is formed in the non-curved edge portions of the upper frame **270**, and portions of the lower frame **220** which face the non-curved edge portions of the upper frame **270** (hereinafter referred to as "opposedly-facing fixing edge portions") at predetermined intervals. The non-curved edge portions of the upper frame **270** and the opposedly-facing fixing edge portions of the lower frame **220** are fixed to each other in an opposedly facing manner by means of the bolts **280** which penetrate the bolt insertion holes and nuts. As a result, the non-curved edge portions of the upper frame **270** are also fixed to the diffusion plate **240** in an opposedly facing manner.

[0057] Due to such a constitution, a clamping force applied to the non-curved outer peripheral portions of the liquid crystal panel **250** by the curving holding means (the diffusion plate **240**, the upper frame **270** and the plurality of bolts **280** and the plurality of nuts) becomes larger than a clamping force applied to the curved outer peripheral portions of the liquid crystal panel **250**. Accordingly, it is possible to suppress the increase of a gap between the substrates at the non-curved outer peripheral portions of the liquid crystal panel **250** having an arcuately curved shape. Since the increase of the gap between the substrates can be suppressed in this manner, it is possible to decrease display irregularities attributed to curving of the liquid crystal panel **250**.

[0058] Here, an interval between the bolts **280** which fix the non-curved edge portions of the upper frame **270** and the opposedly-facing fixing edge portions of the lower frame **220** in an opposedly facing manner may be decreased corresponding to the increased of a distance from the curved outer peripheral portion of the liquid crystal panel **250**. That is, the bolts **280** may be arranged more densely in the vicinity of the center of the non-curved edge portion of the upper frame **270** and in the vicinity of the center of the non-curved edge portion of the lower frame **220**. Due to such a constitution, the increase of the gap between the substrates in the vicinity of the center of the non-curved outer peripheral portion of the liquid crystal panel **250** having an arcuately curved shape can be preferably suppressed.

[0059] Further, in the same manner as the above-mentioned embodiment 1, a plurality of removal preventing pawls shown in FIG. **4** may be formed on the non-curved edge portions of the upper frame **270** or the raised portion shown in FIG. **5** may be formed on the non-curved edge portions of the upper frame **270** or portions of an upper surface of the diffusion plate **240** which face the non-curved edge portions of the upper frame **270** in an opposed manner.

Embodiment 3

[0060] FIG. **3** is a view showing constitutional parts of a liquid crystal display device **300** according to an embodiment 3 of the invention.

[0061] As shown in the drawing, the liquid crystal display device **300** includes a backlight **310**, a pipe **390**, a diffusion sheet **340**, a liquid crystal panel **350**, an upper frame **370**, push plates **372**, bolts **380** and nuts (not shown in the drawing).

[0062] The liquid crystal panel **350** includes a liquid crystal layer and a pair of quadrangular glass substrates having resiliency which sandwiches the liquid crystal layer therebetween.

[0063] The backlight **310** is a light source which is arranged on a back surface side of the liquid crystal panel **350**.

[0064] The diffusion sheet **340** is formed of a transparent or a semi-transparent sheet having resiliency and is arranged between the backlight **310** and the liquid crystal panel **350**. The diffusion sheet **340** diffuses light emitted toward the liquid crystal panel **350** from the backlight **310**.

[0065] The pipe **390**, the upper frame **370**, the push plates **372** and a plurality of bolts **380** and nuts constitute a curving holding means. That is, the curving holding means clamps an outer peripheral portion (a peripheral portion excluding a pixel region) of the quadrangular liquid crystal panel **350** from a front surface side and a back surface side in such a manner that the liquid crystal panel **350** is held in a curved state (in an arcuate shape in this embodiment) in one direction.

[0066] The pipe **390** is formed of a transparent member made of an acrylic resin, for example, which is arranged on a back surface side of the liquid crystal panel **350** and between the backlight **310** and the diffusion sheet **340**. Further, an upper surface of the pipe **390** is formed into an arcuately curved surface which projects toward a liquid crystal panel **350** side. The upper surface of the pipe **390** pushes the liquid crystal panel **350** from a back surface side of the liquid crystal panel **350** by way of the diffusion sheet **340**.

[0067] The upper frame **370** is a metal-made frame which is arranged on a front surface side of the liquid crystal panel **350**. The upper frame **370** is constituted of a pair of opposedly-arranged curved edge portions which is curved in an arcuate shape so as to be recessed on the liquid crystal panel **350** side and a pair of opposedly-arranged non-curved edge portions which is not curved. The upper frame **370** pushes the outer peripheral portion of the liquid crystal panel **350** from a front surface side of the liquid crystal panel **350**. An opening region surrounded by the curved edge portions and the non-curved edge portions of the upper frame **370** corresponds to the pixel region of the liquid crystal panel **350** so that light emitted toward the front surface side of the liquid crystal panel **350** from the liquid crystal panel **350** is not interrupted by the upper frame **370**. Here, a curved shape of the curved edge portion of the upper frame **370** corresponds to a curved shape of the curved surface of the pipe **390**.

[0068] In the liquid crystal display device **300**, as shown in FIG. **3**, the diffusion sheet **340** and the liquid crystal panel **350** are clamped by the pipe **390** and the upper frame **370** from both upper and lower sides so that the diffusion sheet **340** and the liquid crystal panel **350** are held in an arcuately curved state along the curved surface of the pipe **390** and the curved edge portions of the upper frame **370**.

[0069] Particularly, in this embodiment, a plurality of bolt insertion holes is formed in the non-curved edge portions of the upper frame **370**, and portions of the pipe **390** which face the non-curved edge portions of the upper frame **370** in an opposed manner (opposedly-facing fixing edge portions) at predetermined intervals. The non-curved edge portions of the upper frame **370** and the opposedly-facing fixing edge portions of the pipe **390** are fixed to each other in an opposedly facing manner by means of the bolts **380** which penetrate the bolt insertion holes and the nuts. Here, the bolts **380** and the nuts fix the upper frame **370** and the pipe **390** to each other in an opposedly facing manner by way of the push plates **372** having a predetermined thickness and in which bolt insertion holes are formed.

[0070] Due to such a constitution, a clamping force applied to the non-curved outer peripheral portions of the liquid crystal panel **350** by the curving holding means (the pipe **390**, the upper frame **370**, the push plates **372** and the plurality of bolts **380** and the plurality of nuts) becomes larger than a clamping force applied to the curved outer peripheral portions of the liquid crystal panel **350**. Accordingly, it is possible to suppress the increase of a gap between the substrates at the non-curved outer peripheral portions of the liquid crystal panel **350** having an arcuately curved shape. Since the increase of the gap between the substrates can be suppressed in this manner, it is possible to decrease display irregularities attributed to curving of the liquid crystal panel **350**.

[0071] According to the liquid crystal display devices **100**, **200**, **300** according to the embodiments 1, 2, 3 explained above, the increase of the gap between the substrates at the non-curved outer peripheral portion of the liquid crystal panel curved in one direction can be suppressed. Since the increase of the gap between the substrates can be suppressed in this manner, it is possible to decrease display irregularities attributed to curving of the liquid crystal panel.

[0072] The invention is not limited to the above-mentioned embodiments.

[0073] For example, in the above-mentioned embodiments, the example in which the quadrangular liquid crystal panel is curved is exemplified. However, the invention is also applicable to a liquid crystal panel having other shape such as a polygonal shape, a corner-rounded polygonal shape, or an elliptical shape. Further, the invention is not limited to the liquid crystal panel which is curved in an arcuate shape such that the liquid crystal panel projects toward a front surface side or is recessed on the front surface side, and is also broadly applicable to a liquid crystal panel which is curved in one direction (for example, a liquid crystal panel which is curved in a wave shape)

[0074] Further, kinds, the structures, the order of arrangement or the like of parts which constitute the liquid crystal display device may be suitably changed provided that it is possible to ensure the curving holding means which clamps the outer peripheral portion of the liquid crystal panel from the front surface and the back surface of the liquid crystal panel such that a state where the liquid crystal panel is curved in one direction is held.

[0075] Further, the curving holding means may be formed such that the upper frame, the lower frame and the like are integrally formed. In this case, the liquid crystal panel is slidably inserted into the curving holding means from a lateral side, for example.

[0076] Here, to decrease display irregularities attributed to curving of the liquid crystal panel, the conventional structure for sealing the liquid crystal layer may be improved. FIG. **6**A and FIG. **6**B are partial cross-sectional views of a portion in the vicinity of the non-curved outer peripheral portion of the liquid crystal panel. Conventionally, as shown in FIG. **6**A, a liquid crystal layer **30** is sealed in a space defined between a pair of opposedly-facing glass substrates **10**, **20** by a sealing surface **40** which is arranged on edges of the glass substrate **10** and the glass substrate **20** perpendicular to a substrate surface. To the contrary, in the improved structure for sealing the liquid crystal layer, as shown in FIG. **6**B, a sealing surface **42** which is inclined obliquely with respect to the substrate surface is formed on the edges of the glass substrates **10**, **20**. To be more specific, the sealing surface **42** is inclined such that an adhesion position between a glass substrate on a side where the glass substrate is elongated attributed to curving of the liquid crystal panel (here, glass substrate **10**) and the sealing surface **42** is displaced from an adhesion position between a glass substrate on a side where the glass substrate is compressed (here, glass substrate **20**) and the sealing surface **42** by a predetermined length in the direction toward the periphery of the substrate. Due to such a constitution, when the liquid crystal panel is curved, "a force which increases a gap between the substrates" generated on the glass substrate on the side where the glass substrate is elongated is decreased so that the display irregularities attributed to curving of the liquid crystal panel can be decreased.

What is claimed is:

1. A liquid crystal display device comprising:

a liquid crystal panel which includes a liquid crystal layer and a pair of resilient substrates which sandwiches the liquid crystal layer therebetween; and

a curving holding means which clamps an outer peripheral portion of the liquid crystal panel from a front surface and a back surface of the liquid crystal panel so as to hold the liquid crystal panel in a state that the liquid crystal panel is curved in one direction, wherein

a clamping force applied to a non-curved outer peripheral portion of the liquid crystal panel by the curving holding means is set larger than a clamping force applied to a curved outer peripheral portion of the liquid crystal panel by the curving holding means.

2. A liquid crystal display device according to claim **1**, wherein the clamping force applied to the non-curved outer peripheral portion of the liquid crystal panel by the curving holding means differs corresponding to a distance from the curved outer peripheral portion of the liquid crystal panel.

3. A liquid crystal display device according to claim **2**, wherein the clamping force applied to the non-curved outer peripheral portion of the liquid crystal panel by the curving holding means is increased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel.

4. A liquid crystal display device according to claim **1**, wherein the curving holding means includes: a front-surface-side curved frame which pushes an outer peripheral portion of the liquid crystal panel from a front surface side of the liquid crystal panel; and a back-surface-side curved structural body

which pushes at least the outer peripheral portion of the liquid crystal panel from a back surface side of the liquid crystal panel.

5. A liquid crystal display device according to claim **4**, wherein the curving holding means further includes a plurality of fixing jigs which fixes a portion of the front-surface-side curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner and a portion of the back-surface-side curved structural body which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner in a state that both the portion of the front-surface-side curved frame and the portion of the back-surface-side curved structural body face each other.

6. A liquid crystal display device according to claim **5**, wherein an interval between the fixing jigs is decreased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel.

7. A liquid crystal display device according to claim **5**, wherein the fixing jig is a bolt and a nut which forms a pair.

8. A liquid crystal display device according to claim **7**, wherein the bolt and the nut fix the front-surface-side curved frame and the back-surface-side curved structural body in an opposedly facing manner by way of a push plate having a predetermined thickness.

9. A liquid crystal display device according to claim **5**, wherein the fixing jig is a removal preventing pawl which is joined to or integrally formed with one of the front-surface-side curved frame and the back-surface-side curved structural body, and is fitted into a predetermined portion of another of the front-surface-side curved frame and the back-surface-side curved structural body.

10. A liquid crystal display device according to claim **9**, wherein a length of the removal preventing pawl is increased corresponding to the increase of the distance from the curved outer peripheral portion of the liquid crystal panel.

11. A liquid crystal display device according to claim **4**, wherein a portion of the front-surface-side curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner includes a raised portion which is raised corresponding to the distance from the curved outer peripheral portion of the liquid crystal panel.

12. A liquid crystal display device according to claim **4**, wherein the back-surface-side curved structural body is a back-surface curved frame which pushes the outer peripheral portion of the liquid crystal panel from a back surface side of the liquid crystal panel.

13. A liquid crystal display device according to claim **11**, wherein a portion of the back-surface curved frame which faces the non-curved outer peripheral portion of the liquid crystal panel in an opposed manner includes a raised portion which is raised corresponding to the distance from the curved outer peripheral portion of the liquid crystal panel.

14. A liquid crystal display device according to claim **4**, wherein the back-surface-side curved structural body is arranged between the liquid crystal panel and a backlight which is arranged on a back surface side of the liquid crystal panel, and diffuses light emitted toward the liquid crystal panel from the backlight.

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专利名称(译)	液晶显示装置		
公开(公告)号	US20100033648A1	公开(公告)日	2010-02-11
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[标]申请(专利权)人(译)	株式会社日立显示器		
申请(专利权)人(译)	日立显示器有限公司.		
当前申请(专利权)人(译)	松下液晶显示CO.，LTD.		
[标]发明人	KAGANEZAWA NOBUYUKI		
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摘要(译)

一种液晶显示装置，包括：液晶面板，包括液晶层和一对弹性基板，所述弹性基板将液晶层夹在其间;弯曲保持装置（下框架，上框架，多个螺栓和多个螺母），其从液晶面板的前表面和后表面夹紧液晶面板的外周部分。在液晶面板沿一个方向弯曲的状态下保持液晶面板，其中通过弯曲保持装置施加到液晶面板的非弯曲外周部分的夹紧力设定得大于夹紧通过弯曲保持装置将力施加到液晶面板的弯曲外周部分。