US007148943B2

(12) **United States Patent**
Suzuki

(10) **Patent No.: US 7,148,943 B2**
(45) **Date of Patent: Dec. 12, 2006**

(54) **LIQUID CRYSTAL DISPLAY DEVICE**

(75) Inventor: **Hidehiko Suzuki**, Kawasaki (JP)

(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 12 days.

(21) Appl. No.: **10/802,006**

(22) Filed: **Mar. 16, 2004**

(65) **Prior Publication Data**

US 2004/0183987 A1 Sep. 23, 2004

(30) **Foreign Application Priority Data**

Mar. 20, 2003 (JP) 2003-077816

(51) **Int. Cl.**
G02F 1/1339 (2006.01)
G02F 1/1341 (2006.01)

(52) **U.S. Cl.** **349/153**; 349/190

(58) **Field of Classification Search** 349/153, 349/189–190

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,037,185	A *	8/1991	Grupp	349/195
5,459,598	A	10/1995	Carrington	359/81
5,517,344	A *	5/1996	Hu et al.	349/153
6,219,126	B1 *	4/2001	Von Gutfeld	349/153
6,222,603	B1 *	4/2001	Sakai et al.	349/153
6,791,660	B1 *	9/2004	Hayashi et al.	349/190
6,836,311	B1 *	12/2004	Hong	349/153
2003/0086050	A1 *	5/2003	Lee et al.	349/153
2004/0041972	A1 *	3/2004	Yanagawa	349/153
2004/0160566	A1 *	8/2004	Kawabe et al.	349/153
2005/0073637	A1 *	4/2005	Liao	349/153
2005/0088603	A1 *	4/2005	Hong	349/153
2005/0094086	A1 *	5/2005	Lee et al.	349/153

FOREIGN PATENT DOCUMENTS

JP	54-107752	8/1979
JP	5-5890	1/1993
JP	2001-133795	5/2001

* cited by examiner

Primary Examiner—James A. Dudek
(74) *Attorney, Agent, or Firm*—Greer, Burns & Crain, Ltd.

(57) **ABSTRACT**

A liquid crystal display device has a pair of substrates, a liquid crystal inserted in an annular seal between the substrates, and a threshold pattern provided in a frame portion between the annular seal and a pixel display area. The threshold pattern has an opening connecting the pixel display area with an area between the annular seal and the threshold pattern. The liquid crystal can move between the space in the threshold pattern and the area between the annular seal and the threshold pattern in response to the expansion and the contraction of the liquid crystal.

7 Claims, 4 Drawing Sheets

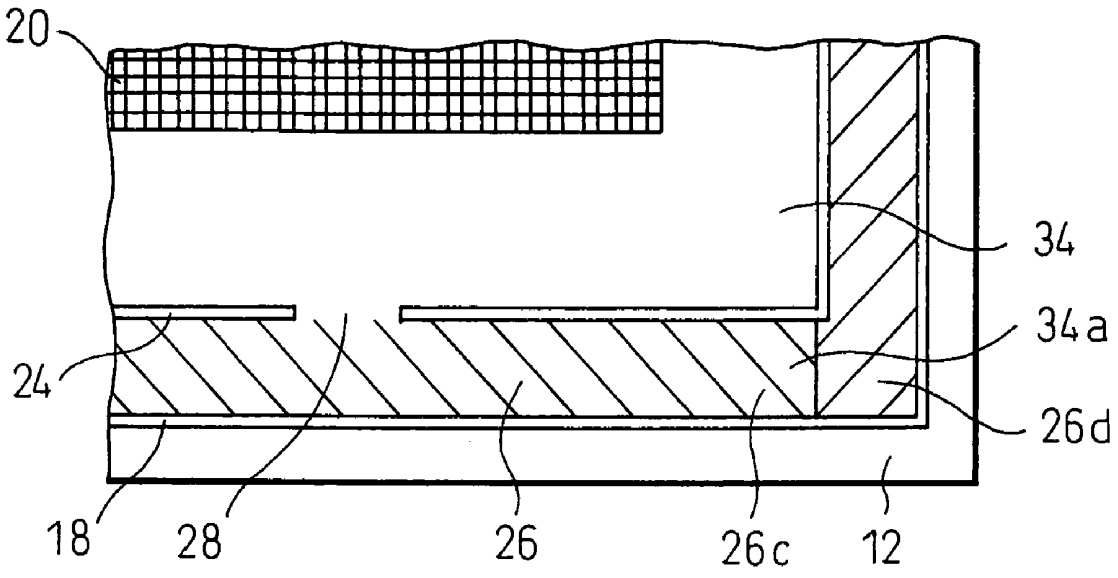


Fig.1

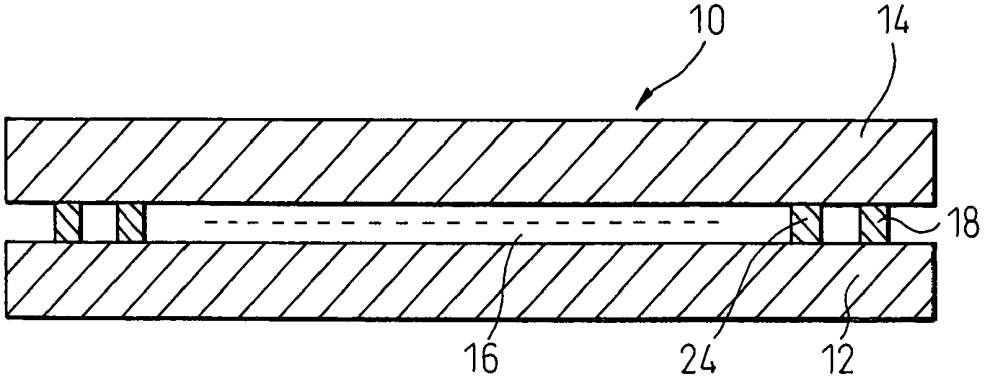


Fig.2

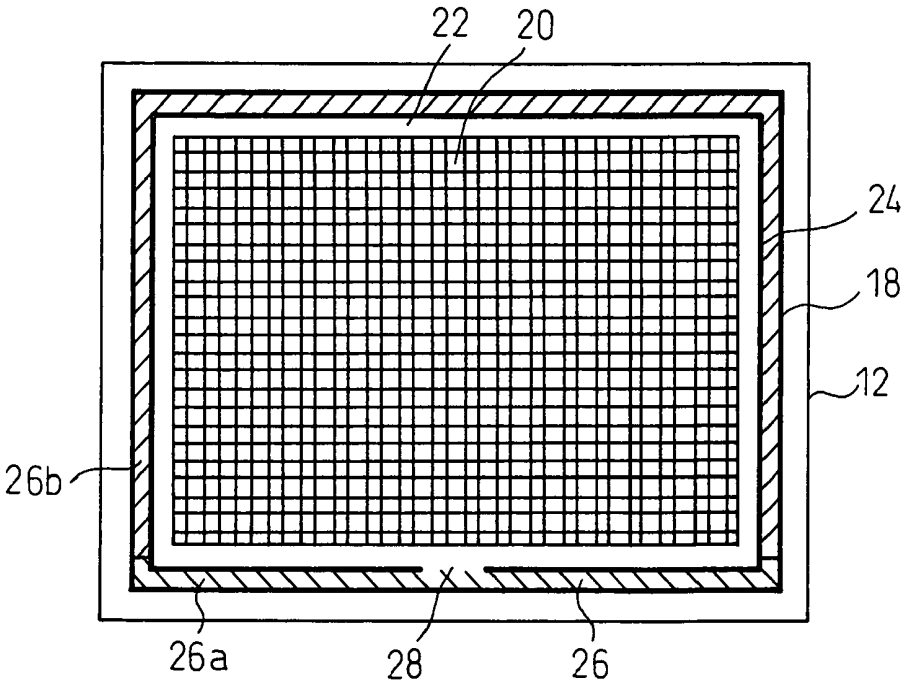


Fig.3

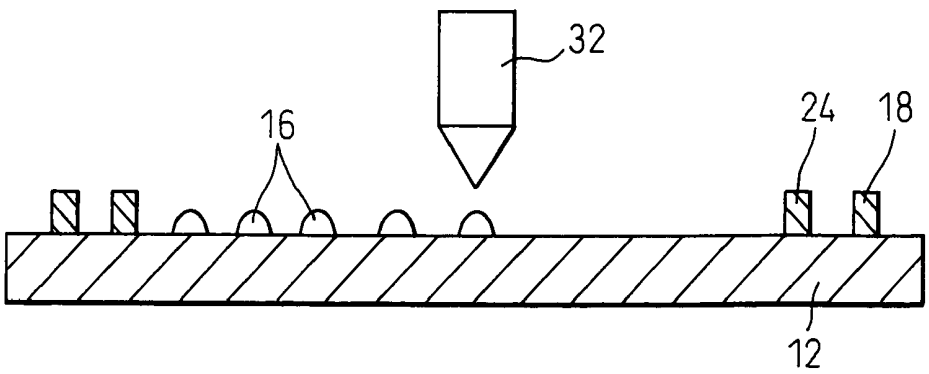


Fig.4A

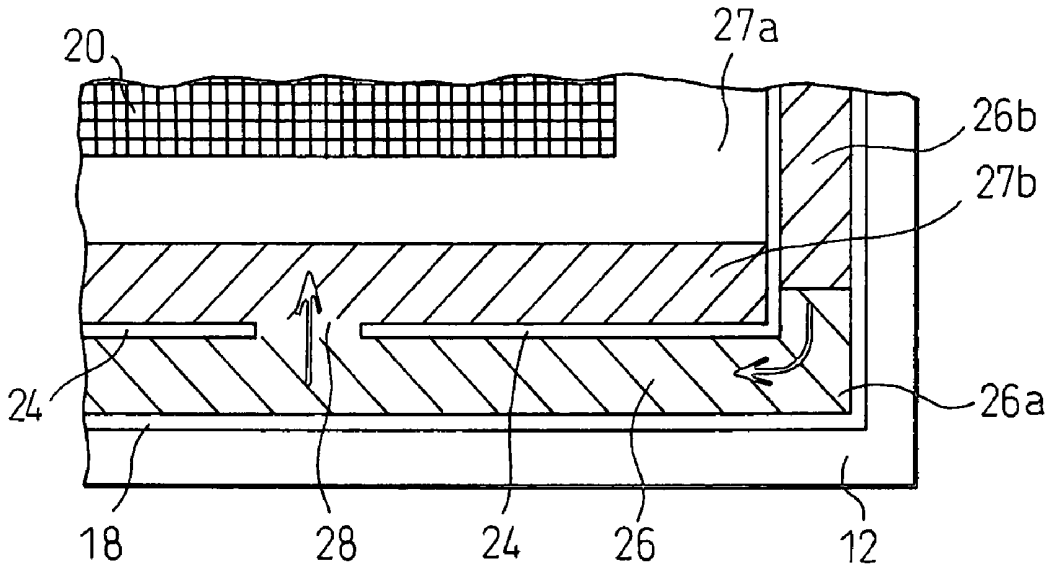


Fig.4B

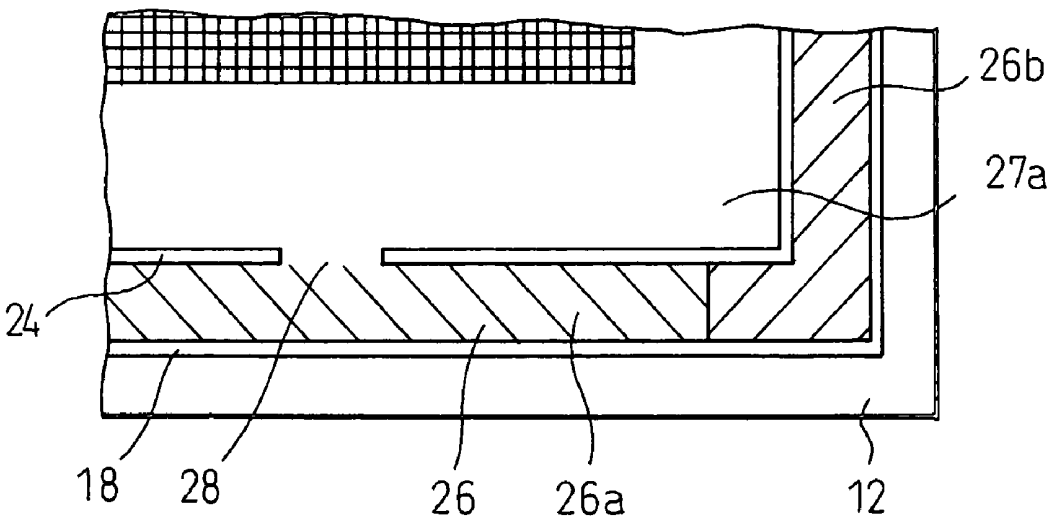


Fig.5A

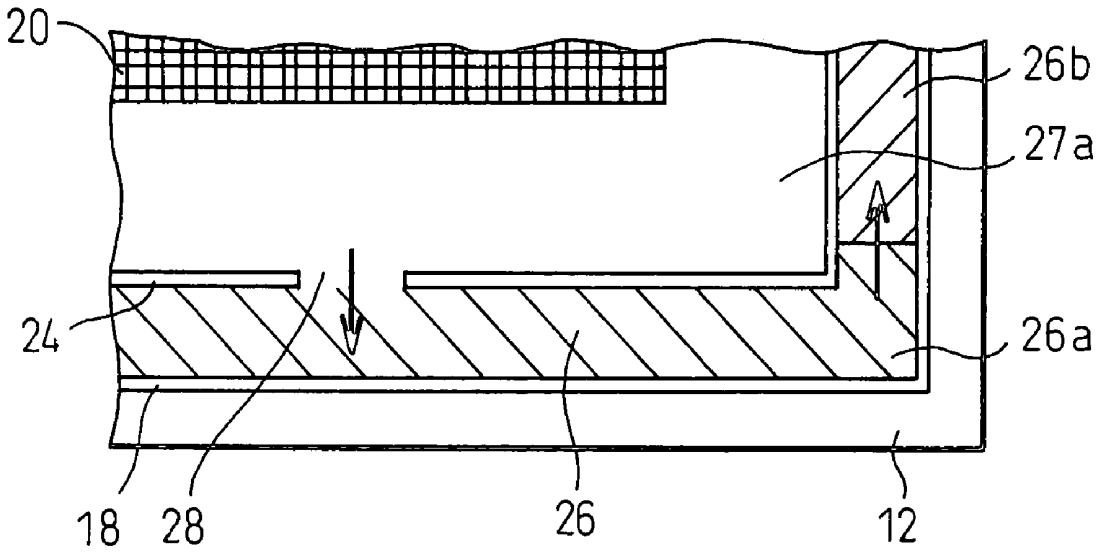


Fig.5B

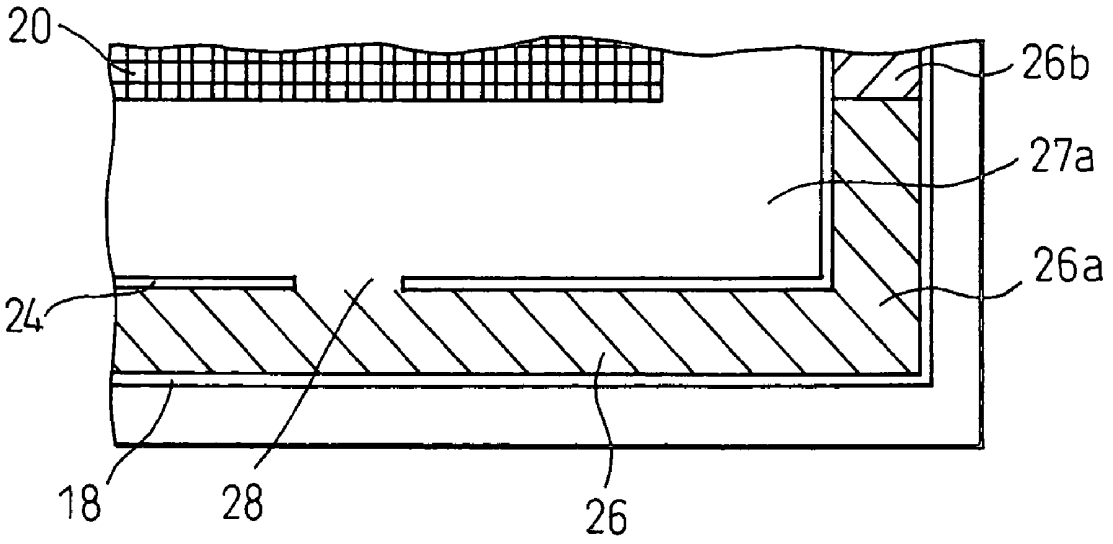


Fig.6

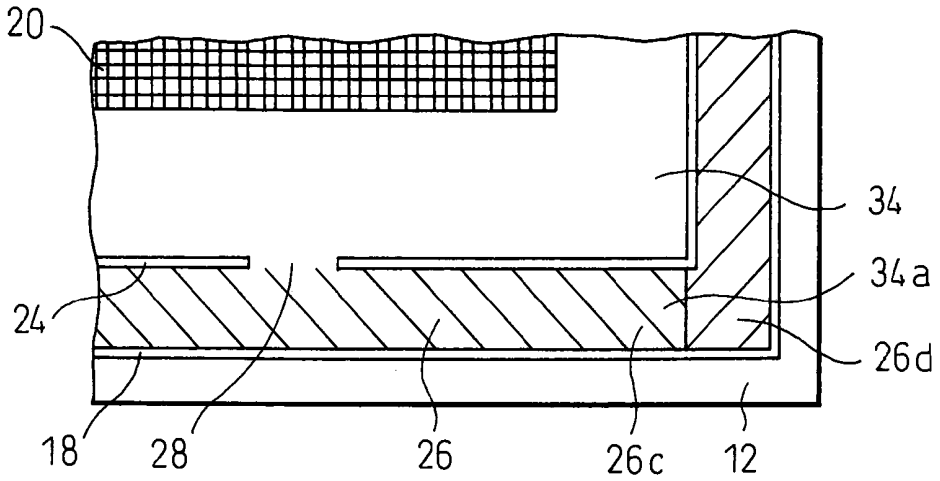


Fig.7

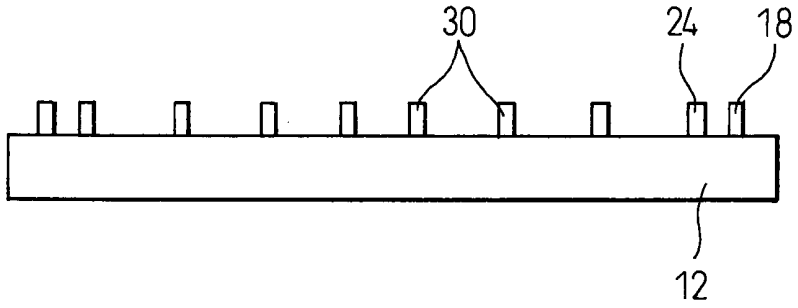
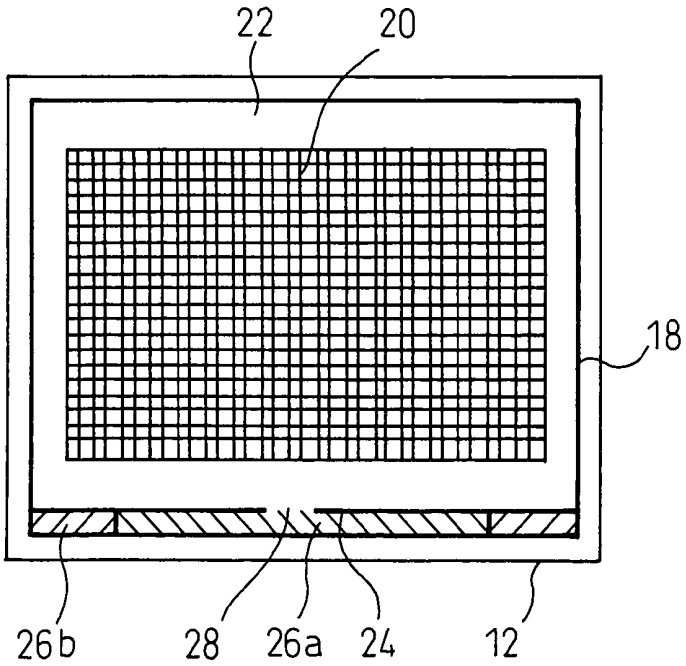


Fig.8



LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the production of a liquid crystal display device.

2. Description of the Related Art

A liquid crystal display device comprises a pair of substrates and a liquid crystal inserted between the substrates. One substrate is a TFT substrate forming TFTs, and the other one is a color filter substrate forming color filters. An annular seal comprising a photo-curable sealing agent is formed on one substrate. After the pair of substrates are bonded together, the annular seal is irradiated with ultraviolet rays so as to be cured. The liquid crystal is inserted into a region surrounded by the annular seal.

In a conventional method of producing a liquid crystal display device, an injection hole is formed in the annular seal, the liquid crystal is injected through the injection hole formed in the annular seal in a vacuum chamber after the substrates are bonded together. Thereafter, the injection hole in the annular seal is closed, and a liquid crystal panel comprising the pair of substrates is taken out from the vacuum chamber.

In producing the liquid crystal display device in recent years, there has been proposed a drip injection method (see, for example, Japanese Unexamined Patent Publication (Kokai) No. 2001-133795). In the drip injection method, an annular seal is formed on one substrate, and droplets of liquid crystal is dripped into the annular seal of one substrate. Then, the pair of substrates are bonded together in the vacuum chamber. According to the drip injection method, the injection of liquid crystal is completed at the same time as the substrates are bonded together, reducing the steps of production and lowering the cost of producing the liquid crystal display device.

In Japanese Unexamined Patent Publication (Kokai) No. 2001-133795, a rectangular seal having openings at four corners is provided, instead of a rectangular annular seal, the liquid crystal is dripped onto the area surrounded by the seal, and thereafter, the liquid crystal leaking from the openings are wiped and the openings are then sealed with a sealing member. Further, polar spacers are provided between the pair of substrates.

When the temperature of an environment in which the user is using the liquid crystal display device rises or drops, however, the volume of the liquid crystal filled in the liquid crystal display device expands or contracts, and the cell space of the liquid crystal display device becomes no longer capable of tolerating or absorbing a change in the volume of the liquid crystal. In the liquid crystal display device, for example, vacuum bubbles tend to be contained in the liquid crystal in the frame portion between the pixel display area and the annular seal. In an environment in which the user uses the liquid crystal display device, it is possible that the bubbles flow into the pixel display area from the frame portion due to a drop in the temperature of the environment causing a shading in the display. In producing the liquid crystal display device, therefore, the liquid crystal is used in slightly larger amounts so that the bubbles will not remain in the frame portion. When the temperature of the environment rises, however, expansion of the liquid crystal cell becomes no longer capable of dealing with the amount of expansion of the liquid crystal. When the liquid crystal display device is used in a nearly upright position, therefore, the excess of liquid crystal stays in a lower position of the liquid crystal display device due to the weight, and the thickness of the cell of this portion becomes irregular.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a liquid crystal display device of which the display quality is not affected even by a change in the volume of the liquid crystal.

A liquid crystal display device, according to the present invention, comprises a pair of substrates, a liquid crystal inserted in an annular seal between the pair of substrates, and a threshold pattern provided in a frame portion between the annular seal and a pixel display area, the threshold pattern having an opening connecting the pixel display area with an area between the annular seal and the threshold pattern.

According to this constitution, the frame portion outside the pixel display area of the liquid crystal display device is effectively utilized to absorb and deal with a change in the volume of the liquid crystal caused by a change in the environment. It further becomes possible to increase an environmental margin for the amount of the liquid crystal in the liquid crystal display device produced by the drip injection method.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more apparent from the following description of the preferred embodiments, with reference to the accompanying drawings, in which:

FIG. **1** is a schematical sectional view illustrating a liquid crystal display device according to an embodiment of the present invention;

FIG. **2** is a plan view illustrating one substrate of FIG. **1**;

FIG. **3** is a view illustrating a drip injection method;

FIGS. **4**A and **4**B are views illustrating the liquid crystal display device when the volume of the liquid crystal decreases due to a drop in the environmental temperature, wherein FIG. **4**A illustrates the migration of the liquid crystals from the area between the annular seal and the threshold pattern to the inside of the threshold pattern through the opening, and FIG. **4**B illustrates a state where the inside of the threshold pattern is filled with the liquid crystals;

FIGS. **5**A and **5**B are views illustrating the liquid crystal display device when the volume of the liquid crystal increases due to a rise in the environmental temperature, wherein FIG. **5**A illustrates the migration of the liquid crystal from the inside of the threshold pattern to the area between the annular seal and the threshold pattern through the opening, and FIG. **5**B illustrates the migration of the liquid crystal in the area between the annular seal and the threshold pattern;

FIG. **6** is a view illustrating a modified example of the present invention;

FIG. **7** is a view illustrating a substrate having a threshold pattern and polar spacers; and

FIG. **8** is a view illustrating a modified example of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described with reference to the drawings.

FIG. **1** is a schematical sectional view illustrating a liquid crystal display device according to an embodiment of the present invention, and FIG. **2** is a plan view illustrating one substrate of FIG. **1**.

In FIGS. **1** and **2**, the liquid crystal display device **10** includes first and second substrates **12** and **14**, a liquid crystal **16** inserted between the first and second substrates **12** and **14**, and an annular seal **18** provided between the first and second substrates **12** and **14** so as to surround the liquid crystal **16**. The liquid crystal display device **10** includes a pixel display area **20** and a frame portion **22** inside the annular seal **18**.

A threshold pattern **24** is provided in the frame portion **22** between the annular seal **18** and the pixel display area **20**. The threshold pattern **24** has an opening **28** connecting the pixel display area **20** (the inside of the threshold pattern **24**) with the area **26** between the annular seal **18** and the threshold pattern **24**. In FIG. **2**, the annular seal **18** is formed in a continuous rectangular shape without an injection hole. A closed space is formed between the threshold pattern **24** and the annular seal **18** except for the opening **28**.

The threshold pattern **24** annularly extends substantially in parallel with the annular seal **18** with a gap from the annular seal **18**. Desirably, the opening **28** is provided at a lower position of the liquid crystal display device in an environment in which it is used (at a lower position when the liquid crystal display device **10** is used in a nearly upright position).

The liquid crystal display device **10** is an active matrix-type color liquid crystal display device, and one substrate is a TFT substrate forming TFTs and the other substrate is a color filter substrate forming color filters. The color filters, TFTs and pixel electrodes can be constructed in known manners and are not, therefore, described here in detail. There is, further, provided a known alignment film. The pixel display area **20** is the one where the TFTs and pixel electrodes are provided, and the frame portion **22** is an area covered with a black matrix surrounding the pixel display area **20**.

The threshold pattern **24** can be made of a material forming the annular seal **18**. The threshold pattern **24** is applied together with the annular seal **18** when the annular seal **18** is to be applied onto the substrate **12**. The threshold pattern **24** has substantially the same height as the annular seal **18**. The threshold pattern **24** can be made of a material that forms the color filters. The threshold pattern **24** can be made of an organic film material (insulating film material) at the time of forming the films of the TFT substrate. The threshold pattern **24** can be made of a material forming the polar spacers. FIG. **7** illustrates an example of the polar spacers **30**.

The liquid crystal display device **10** is produced by a drip injection method. FIG. **3** is a view illustrating the drip injection method. The liquid crystal **16** is dripped as droplets from a dispenser **32** onto the first substrate **12** (or the second substrate **14**). The dispenser **32** drips the liquid crystal **16** in the form of droplets onto the region surrounded by the annular seal **18** while the dispenser **32** moves in the XY-directions. The liquid crystal **16** in the form of liquid droplets spread over the substrate **12**.

The liquid crystal **16** fills the inside of the threshold pattern **24** and flows into the area **26** between the annular seal **18** and the threshold pattern **24** through the opening **28** of the threshold pattern **24**. It is desired that the liquid crystal **16** flows in sufficient amount into the area **26** up to a predetermined position from the opening **28**. As shown in FIG. **2**, therefore, the area **26** includes a portion **26***a* where the liquid crystal **16** exists in sufficient amount and a portion **26***b* where the amount of the liquid crystal **16** is small and vacuum bubbles are contained. Basically, the bubbles in the area **26** tend to be collected in the upper portion of the liquid crystal display unit in a state where the liquid crystal display device is being used. By forming the opening **28** in the lower portion, therefore, the portion **26***a* where the liquid crystal **16** exists in a sufficient amount is located near the opening **28**.

After the liquid crystal **16** is dripped onto the first substrate **12** (or the second substrate **14**), the first substrate **12** and the second substrate **14** are bonded together with the annular seal **18** in a vacuum chamber. The annular seal **18** is then cured. The liquid crystal panel is thus completed.

FIGS. **4**A and **4**B are views illustrating the liquid crystal display device when the volume of the liquid crystal decreases due to a drop in the environmental temperature and the like. As the volume of liquid crystal decreases inside the threshold pattern **24**, the interior in the threshold pattern **24** includes a portion **27***a* where the liquid crystal **16** exists in sufficient amount and a portion **27***b* mixed in the portion **27***a* where vacuum bubbles are contained. As illustrated in FIG. **4**A, therefore, the liquid crystal **16** migrates from the area **26** between the annular seal **18** and the threshold pattern **24** to the inside of the threshold pattern **24** through the opening **28**. As illustrated in FIG. **4**B, therefore, the interior of the threshold pattern **24** is filled with the liquid crystal **16**, and there exists no portion **27***b* containing vacuum bubbles. In the area **26** between the annular seal **18** and the threshold pattern **24**, a boundary between a portion **26***a* where the liquid crystal **16** sufficiently exists and a portion **26***b* where the amount of the liquid crystal **16** is small and vacuum bubbles are contained moves toward the opening **28**.

In this way, when the volume of the liquid crystals decreases due to a drop in the environmental temperature, the liquid crystal in the area **26** near the opening **28** is supplemented into the pixel display area **20** where the liquid crystal is deficient, and no vacuum bubbles evolve in the pixel display area **20**.

Here, if there exists the annular seal **18** only and there is no threshold pattern **24**, a rise or a drop of the temperature of an environment in which the user is using the liquid crystal display device is accompanied by an expansion or a contraction of the volume of the liquid crystal filling the liquid crystal display device, and the cell space of the liquid crystal display device becomes no longer capable of tolerating or absorbing changes in the volume of the liquid crystal. In the liquid crystal display device, for example, vacuum bubbles tend to be made present and are contained in the liquid crystal in the frame portion between the pixel display area and the annular seal. In an environment in which the user uses the liquid crystal display device, it is possible that the bubbles flow into the pixel display area from the frame portion due to a drop in the environmental temperature, causing a shade in the display.

According to the present invention, the interior of the threshold pattern **24** including the pixel display area **20** is filled with the liquid crystal **16**, and the portion **27***b* containing vacuum bubbles exists in the area **26** between the annular seal **18** and the threshold pattern **24**, at a position remote from the port **28**, so vacuum bubbles do not flow into the pixel display area **20** and become a cause of shading on the display is eliminated.

FIGS. **5**A and **5**B are views illustrating the liquid crystal display device when the volume of the liquid crystal increases due to a rise in the environmental temperature and the like. As the volume of liquid crystal increases inside the

threshold pattern **24**, the interior of the threshold pattern **24** is occupied by only the portion **27***a* where the liquid crystal **16** sufficiently exists, and the amount of the liquid crystal **16** becomes excessive. As illustrated in FIG. **5**A, therefore, the liquid crystal **16** migrates from the interior of the threshold pattern **24** to the area **26** between the annular seal **18** and the threshold pattern **24** through the opening **28**. As illustrated in FIG. **5**B, therefore, the excess of liquid crystal **16** is expelled to the outer side of the threshold pattern **24**. In the area **26** between the annular seal **18** and the threshold pattern **24**, therefore, the boundary between the portion **26***a* where the liquid crystal **16** sufficiently exists and the portion **26***b* where the amount of the liquid crystal **16** is small and vacuum bubbles are contained, moves away from the opening **28**.

In producing the liquid crystal display devices, so far, the liquid crystal is used in slightly large amounts. When the temperature of the environment rises, therefore, expansion of the liquid crystal cell becomes no longer capable of dealing with the amount of expansion of the liquid crystal. When the liquid crystal display device is used in a nearly upright position, therefore, the excess of liquid crystal stays at the lower position of the liquid crystal display device due to the weight, and the thickness of the cell of this portion becomes irregular.

According to the present invention, when the volume of the liquid crystal expands due to a rise in the environmental temperature, an excess of the liquid crystal in the pixel display area **20** passes through the opening **28** and flows into the area **26** which has room to accommodate the liquid crystal. Therefore, the problem that the excess of the liquid crystal stays at the lower position of the liquid crystal display device due to the weight, and the thickness of the cell of that portion becomes irregular, is overcome.

FIG. **6** is a view illustrating a modified example of the present invention. In this example, the substrate **12** includes an alignment film **34**. The alignment film **34** is provided inside the threshold pattern **24**. Further, an alignment film **34***a* which is the same as the above alignment film is arranged on a first portion **26***c* close to the opening **28** in the area **26** between the annular seal **18** and the threshold pattern **24**, and no alignment film is arranged in a second portion **26***d* which is farther than the first portion **26***c* from the opening **28**.

The liquid crystal **16** tends to wet the alignment films **34** and **34***a*. In the area **26** between the annular seal **18** and the threshold pattern **24**, therefore, the liquid crystal **16** tends to be locked by the first portion **26***c* where the alignment film **34***a* exists but is not locked by the second portion **26***d* without the alignment film. Therefore, the liquid crystal **16** tends to be concentrated in the first portion **26***c* close to the opening **28**. The alignment film **34***a* is arranged over only a distance necessary for a margin in the amount of the liquid crystal.

FIG. **8** is a view illustrating a modified example of the present invention. The substrate **12** of FIG. **8** is the same as the substrate of FIG. **2** except for the shape of the threshold pattern **24**. In FIG. **8**, the threshold pattern **24** is formed substantially in parallel with one side of the annular seal **18** of a rectangular shape with a gap from the one side of the annular seal **18**. The ends of the threshold pattern **24** come in contact with both side surfaces of the annular seal **18**, and a space which is closed except the opening **28** is formed between the threshold pattern **24** and the one side of the annular seal **18**. In the embodiment described above, the area **26** between the annular seal **18** and the threshold pattern **24** was of an annular shape. However, the area **26** of FIG. **8** is straight. In this case, too, the threshold pattern **24** having the opening **28** exhibits the similar operation as that of the above-mentioned embodiment, thus controlling vacuum bubbles that could not be controlled and providing an increased margin for a change in the volume of the liquid crystal caused by a change in the environmental temperature.

As described above, the present invention makes it possible to increase an environmental margin for the amount of the liquid crystal in the panel fabricated using a dripping and bonding device.

The invention claimed is:

1. A liquid crystal display device comprising a pair of substrates, a liquid crystal inserted in an annular seal between said pair of substrates, and a threshold pattern provided in a frame portion between said annular seal and a pixel display area, said threshold pattern having an opening connecting said pixel display area with an area between said annular seal and said threshold pattern,

wherein an alignment film is arranged on a first portion near said opening in the area between said annular seal and said threshold pattern, and no alignment film is arranged on a second portion farther than the first portion from said opening.

2. A liquid crystal display device according to claim **1**, wherein said threshold pattern extends substantially in parallel with at least one side of said annular seal.

3. A liquid crystal display device according to claim **1**, wherein said threshold pattern annularly extends substantially in parallel with said annular seal with a gap from said annular seal.

4. A liquid crystal display device according to claim **1**, wherein said threshold pattern extends substantially in parallel with at least one side of said annular seal with a gap from at least one side of said annular seal, and a closed space is formed between said threshold pattern and at least the one side of said annular seal except for said opening.

5. A liquid crystal display device according to claim **1**, wherein the liquid crystal is dripped on one substrate, and the annular seal has no injection hole.

6. The liquid crystal display device according to claim **1**, wherein the area between said annual seal and said threshold pattern includes:

a portion where the liquid crystal exists in a sufficient amount; and

a portion where the amount of the liquid crystal is small and vacuum bubbles are contained.

7. The liquid crystal display device according to claim **6**, wherein:

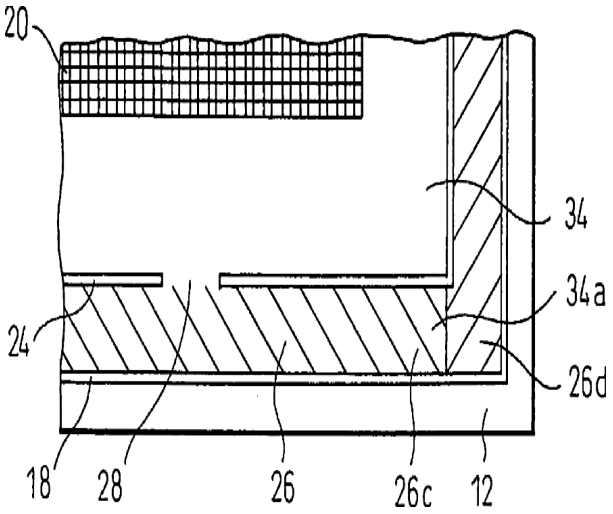
the opening is provided below the pixel display area;

the portion where the liquid crystal exists in the sufficient amount is at a part near the opening; and

the portion where the amount of the liquid crystal is small and vacuum bubbles are contained is at a part far from the opening compared with the part where the portion where the liquid crystal exists in the sufficient amount is located.

* * * * *

专利名称(译)	液晶显示装置		
公开(公告)号	US7148943	公开(公告)日	2006-12-12
申请号	US10/802006	申请日	2004-03-16
[标]申请(专利权)人(译)	富士通显示技术股份有限公司		
申请(专利权)人(译)	富士通显示器科技股份有限公司		
当前申请(专利权)人(译)	夏普株式会社		
[标]发明人	SUZUKI HIDEHIKO		
发明人	SUZUKI, HIDEHIKO		
IPC分类号	G02F1/1339 G02F1/1341		
CPC分类号	G02F1/1339 G02F2001/13415		
优先权	2003077816 2003-03-20 JP		
其他公开文献	US20040183987A1		
外部链接	Espacenet USPTO		

摘要(译)

液晶显示装置具有一对基板，插入基板之间的环形密封件中的液晶，以及设置在环形密封件和像素显示区域之间的框架部分中的阈值图案。阈值图案具有将像素显示区域与环形密封件和阈值图案之间的区域连接的开口。响应于液晶的膨胀和收缩，液晶可以在阈值图案中的空间和环形密封件与阈值图案之间的区域之间移动。