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(19) **United States**(12) **Patent Application Publication****Lyu et al.**(10) **Pub. No.: US 2006/0114402 A1**(43) **Pub. Date: Jun. 1, 2006**(54) **LIQUID CRYSTAL DISPLAY HAVING WIDE VIEWING ANGLE**

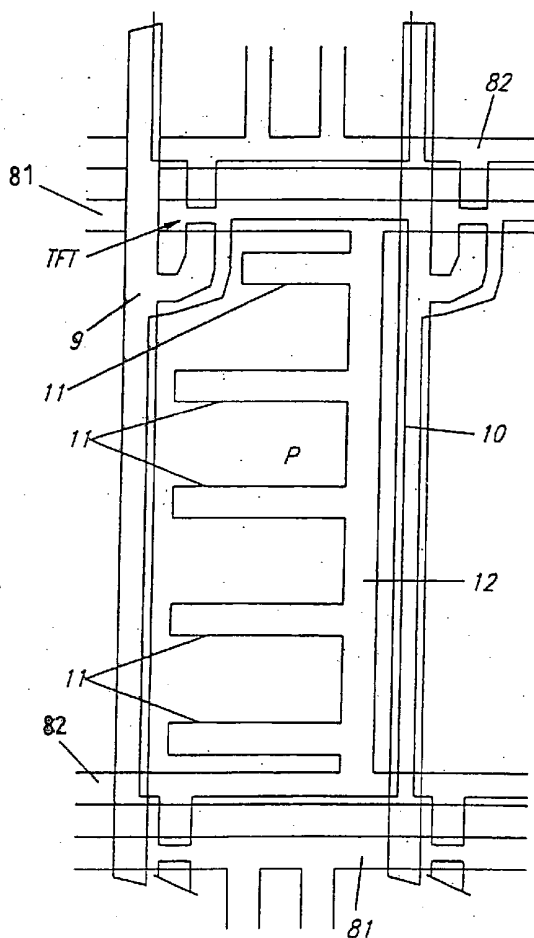
division of application No. 09/087,408, filed on May 29, 1998, now Pat. No. 6,285,431.

(76) Inventors: **Jae-Jin Lyu**, Kwangju-kun (KR);  
**Kyeong Hyeon Kim**, Seongnam-city (KR);  
**Hea-Ri Lee**, Seoul (KR);  
**Jian-Min Chen**, Suwon-city (KR)(30) **Foreign Application Priority Data**May 29, 1997 (KR) ..... 97-21708  
Aug. 25, 1997 (KR) ..... 97-40665Correspondence Address:  
**CANTOR COLBURN, LLP**  
**55 GRIFFIN ROAD SOUTH**  
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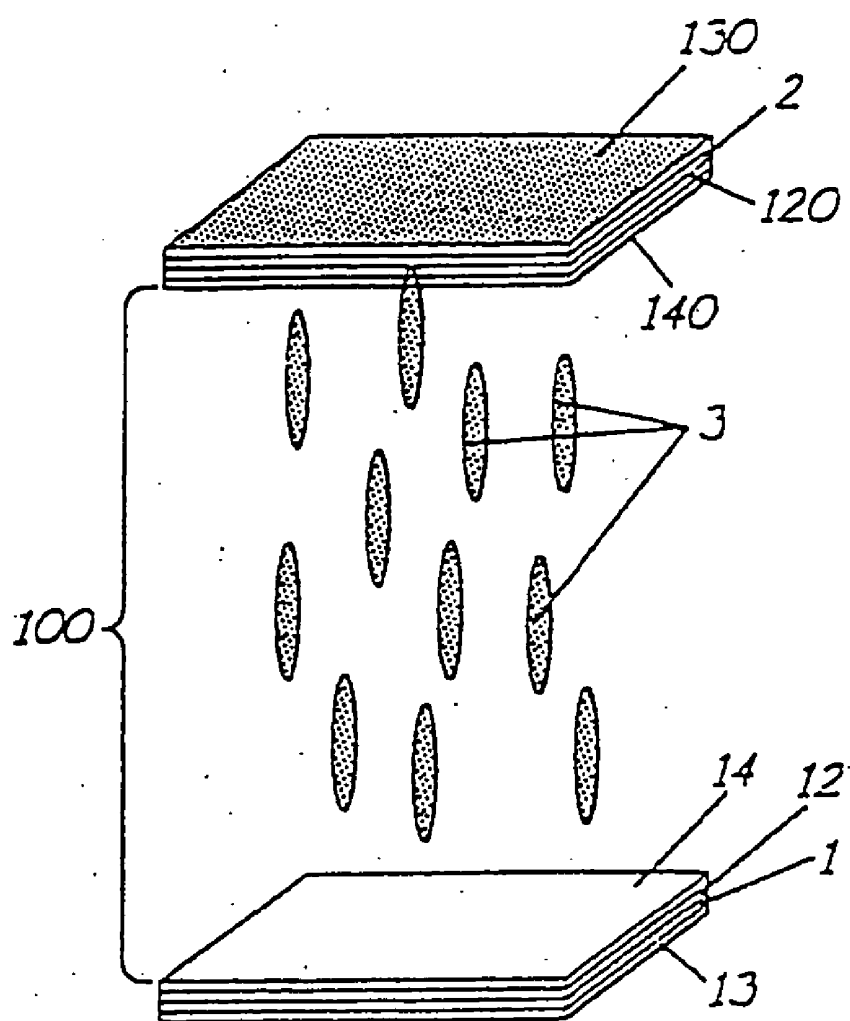
(60) Continuation of application No. 10/903,480, filed on Aug. 2, 2004, now Pat. No. 7,016,004, which is a continuation of application No. 09/877,481, filed on Jun. 8, 2001, now Pat. No. 6,771,344, which is a

(57) **ABSTRACT**

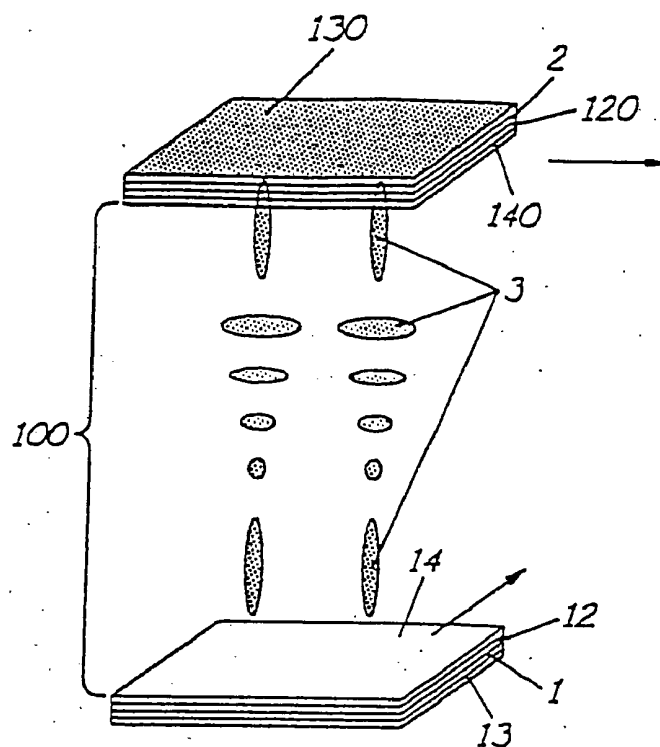
Apertures are formed in the common electrode or in the pixel electrode of a liquid crystal display to form a fringe field. Storage capacitor electrodes are formed at the position corresponding to the apertures to prevent the light leakage due to the disclination caused by the fringe field. The apertures extend horizontally, vertically or obliquely. The apertures in adjacent pixel regions may have different directions to widen the viewing angle.



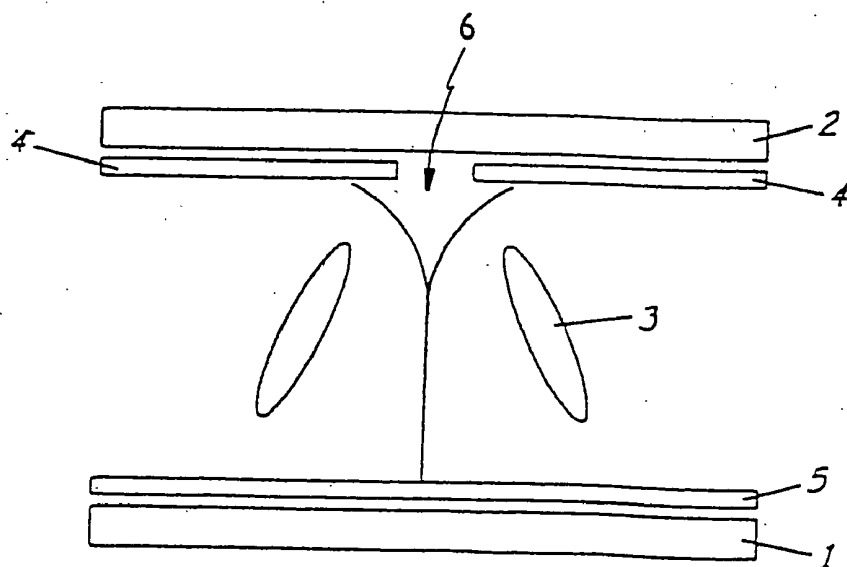
**FIG. 1A**



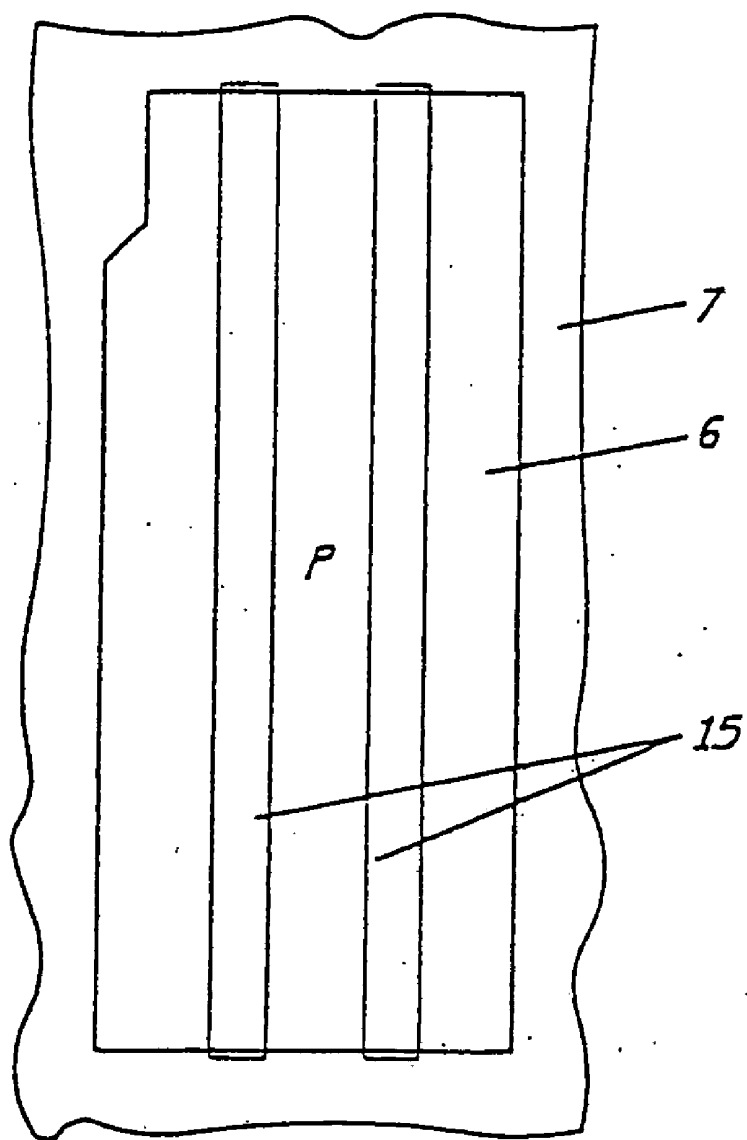
**FIG. 1B**



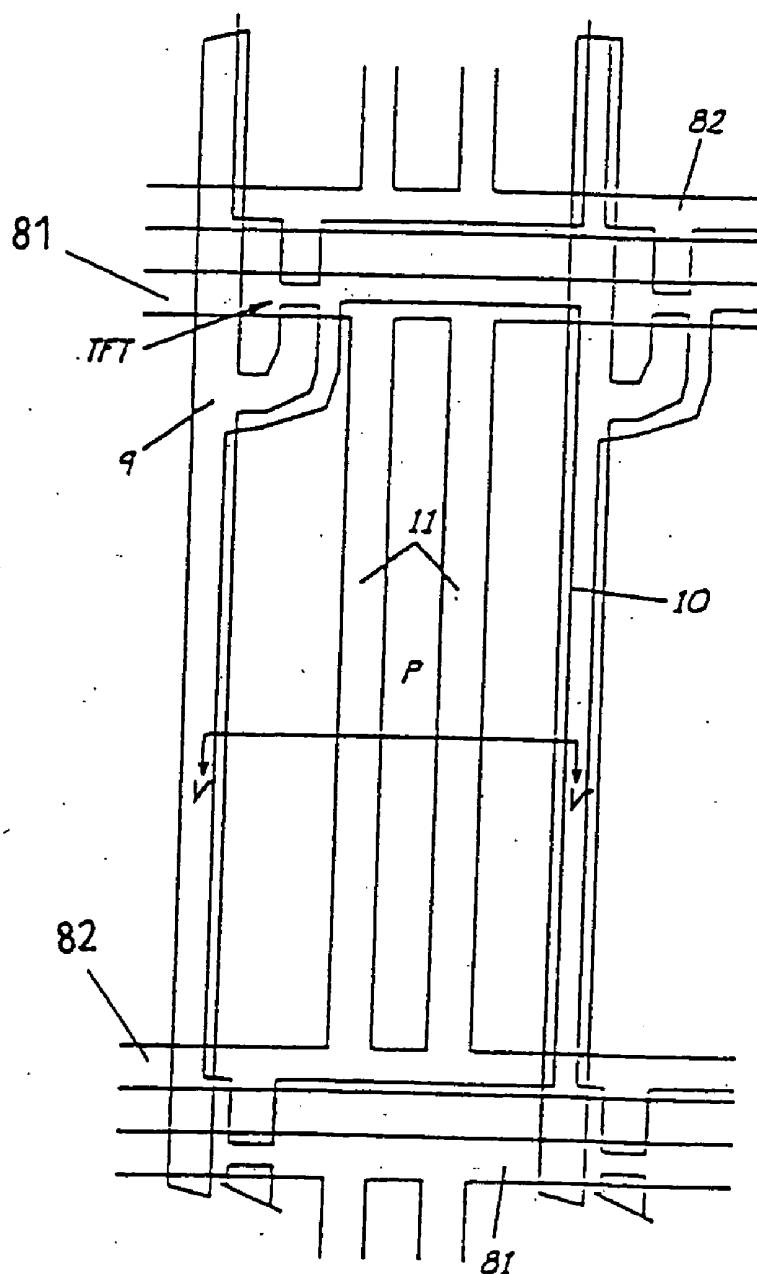
**FIG. 2**



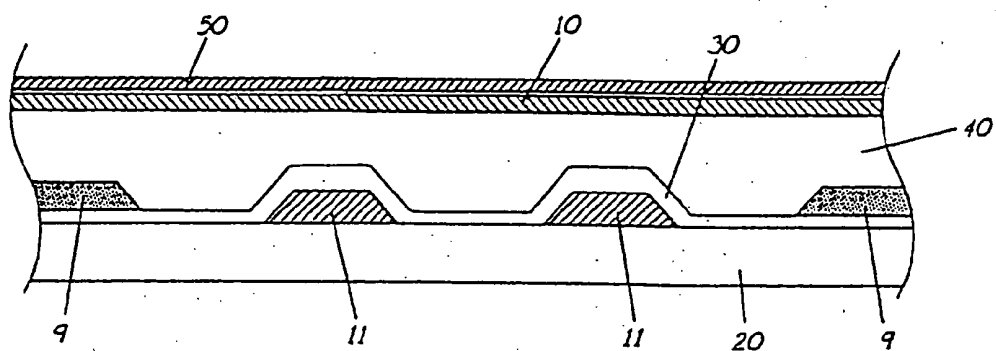
**FIG. 3**



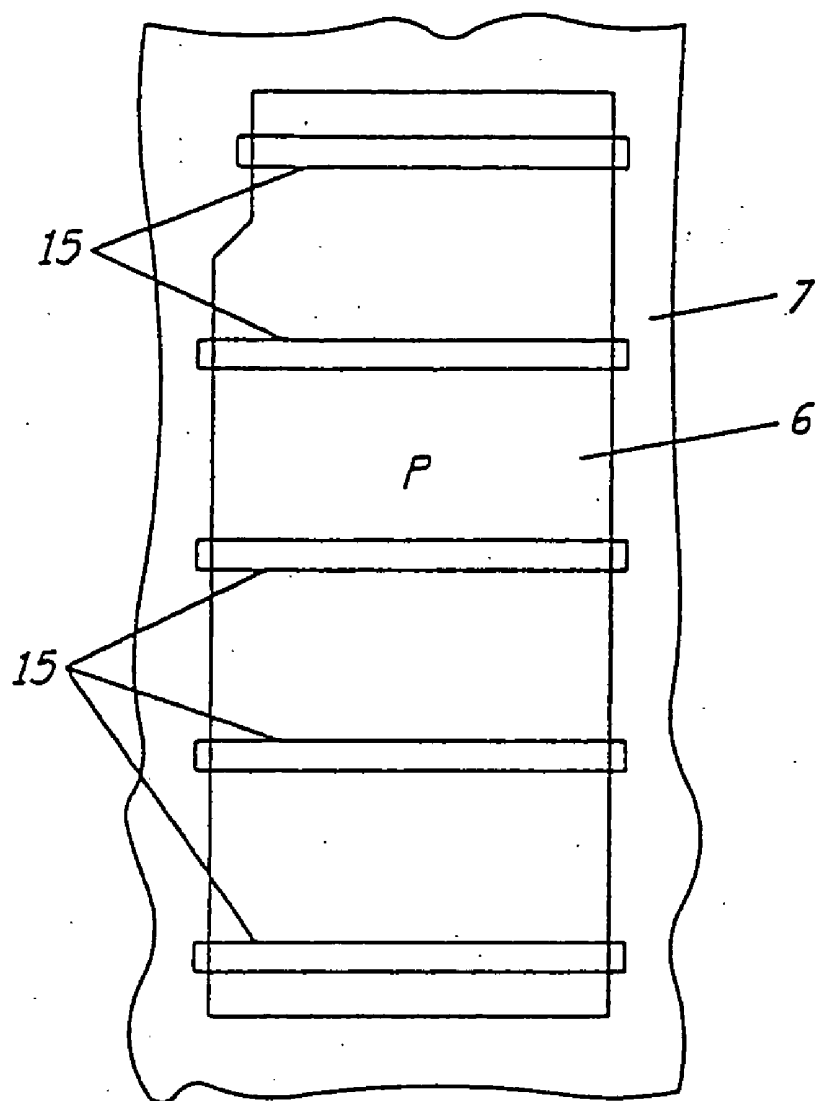
**FIG. 4**



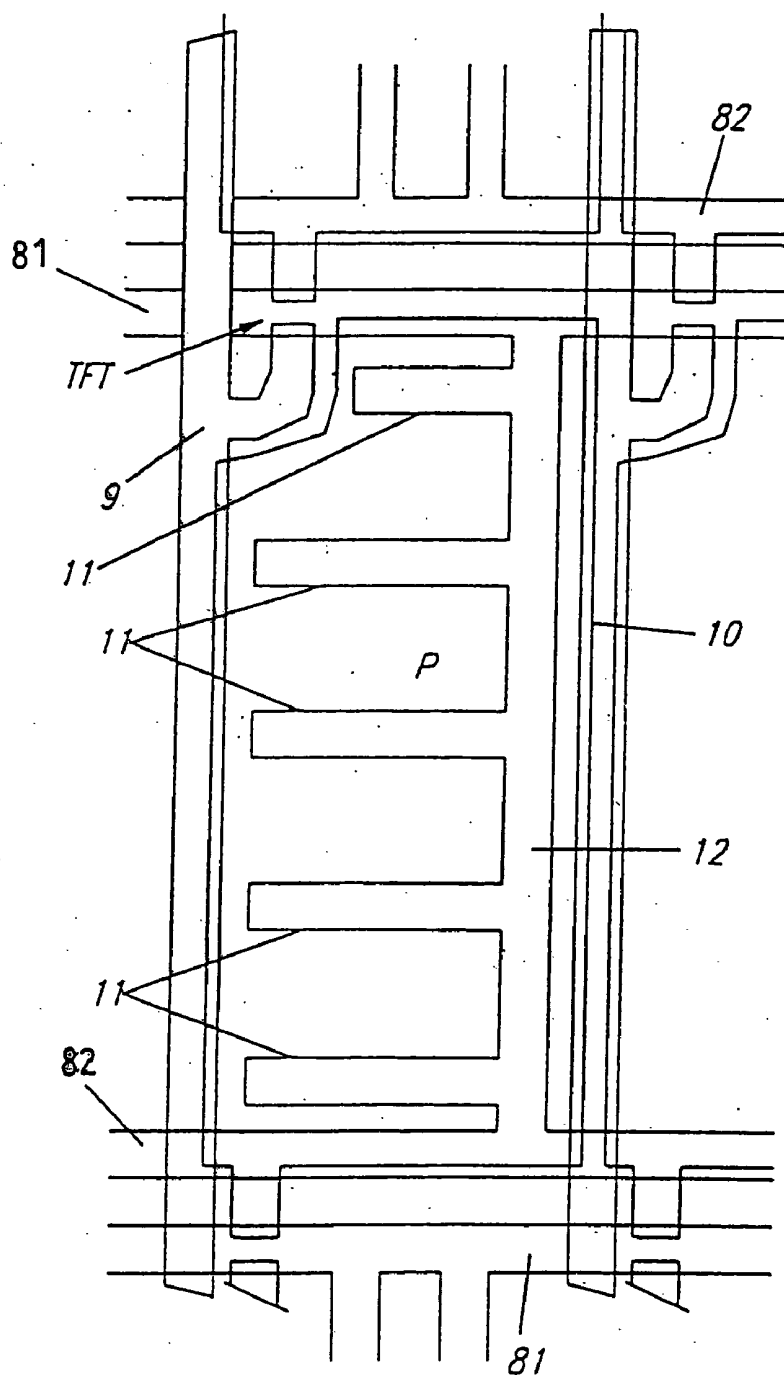
**FIG. 5**



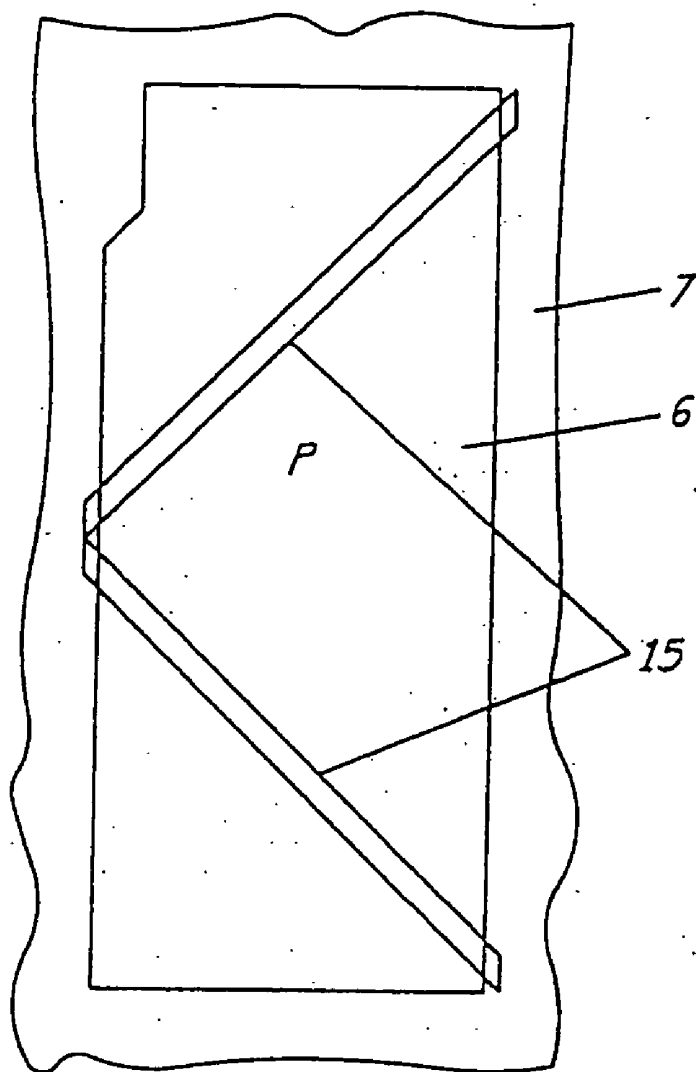
**FIG. 6**



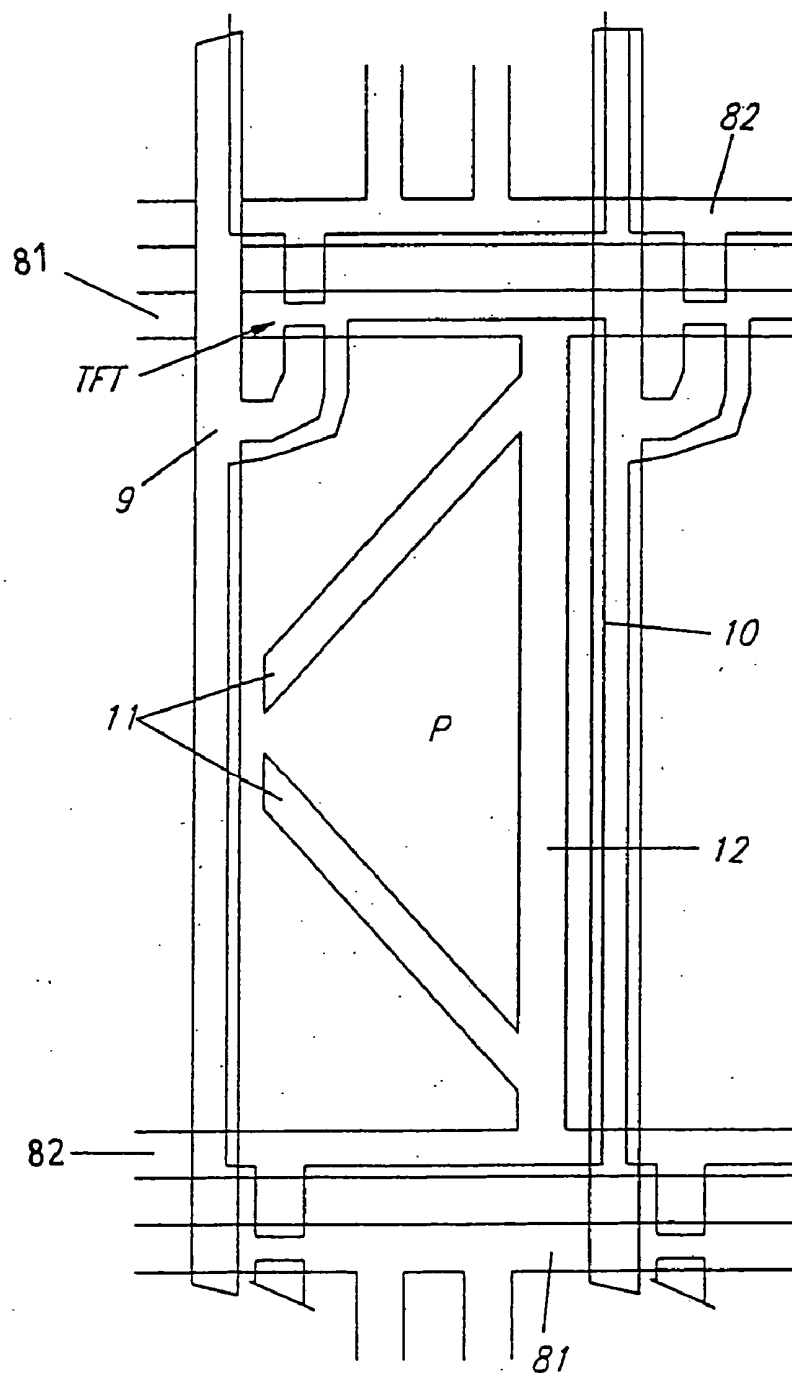
**FIG. 7**



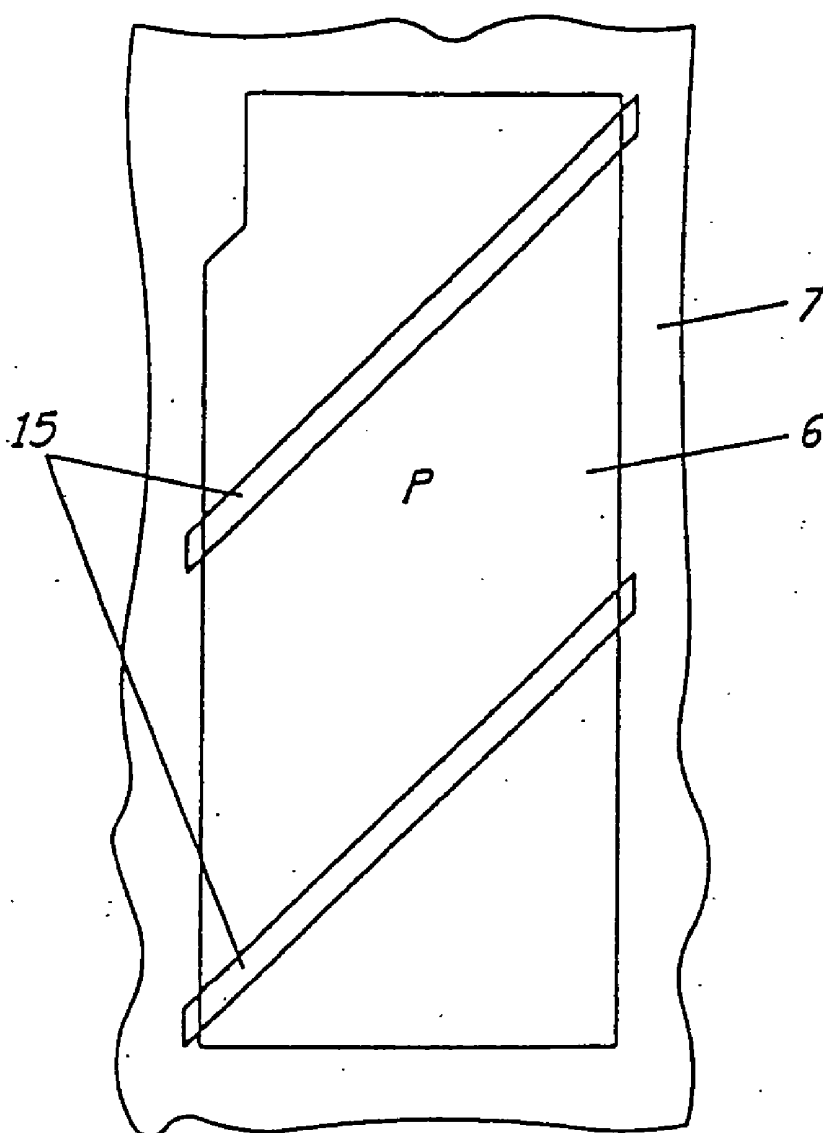
**FIG. 8**



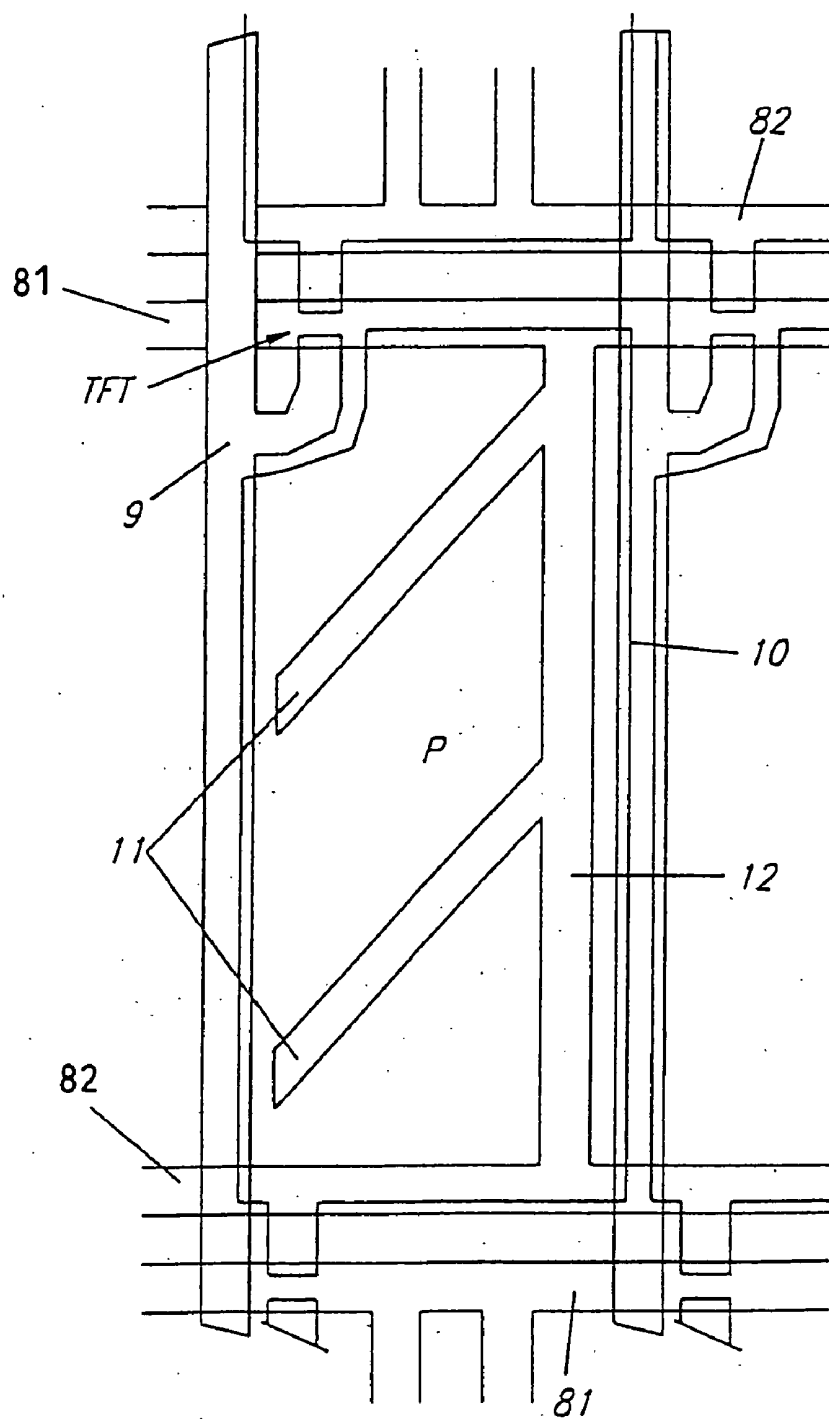
**FIG. 9**



**FIG. 10**



**FIG. 11**



**FIG. 12**

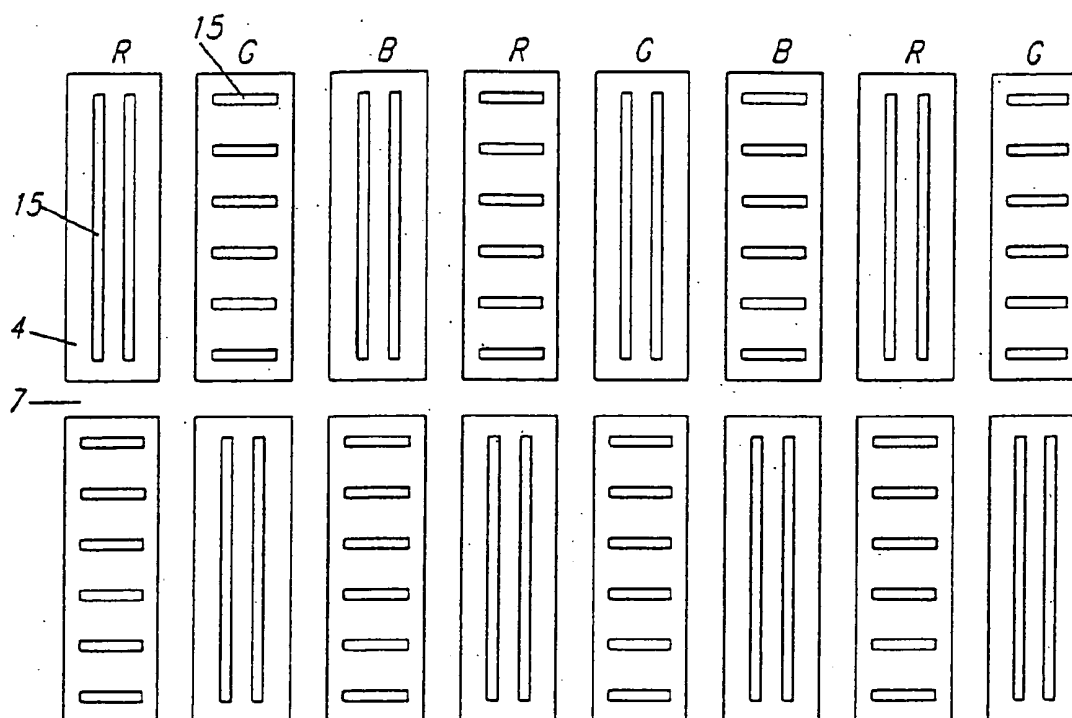


FIG. 13A

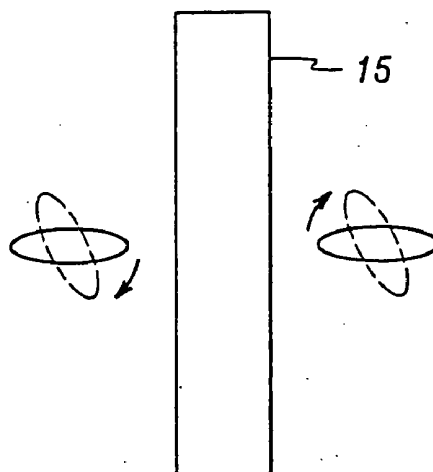
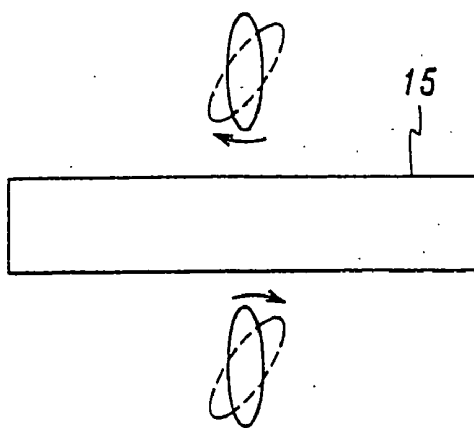
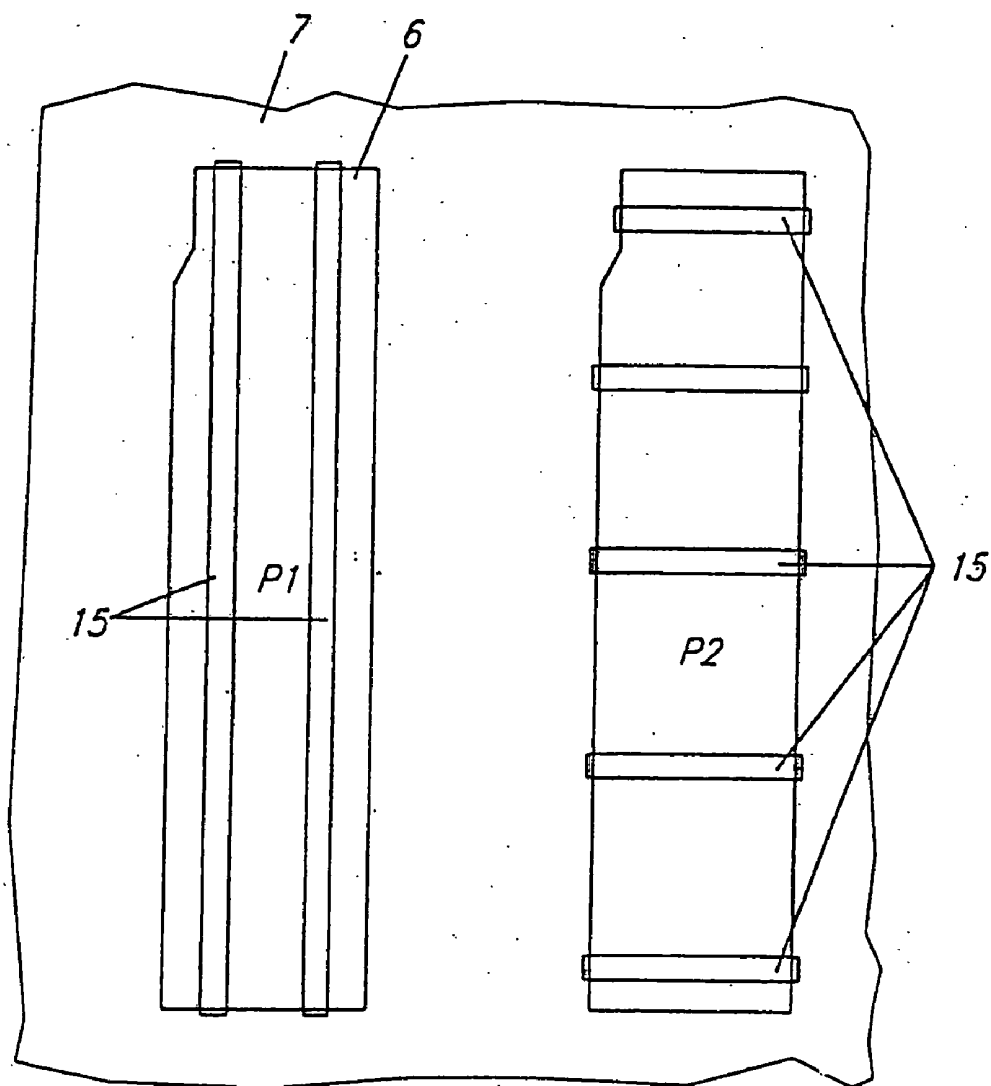


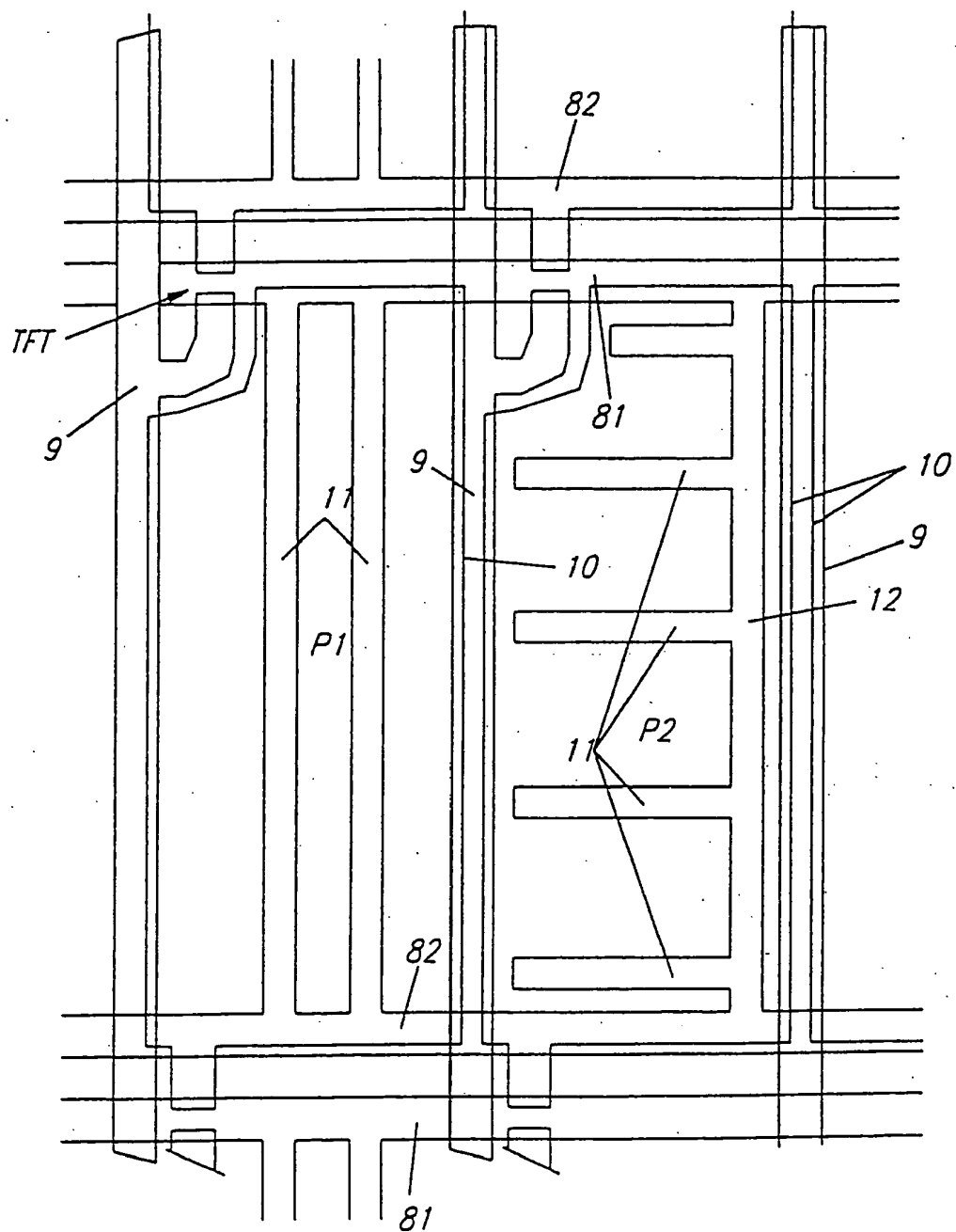
FIG. 13B



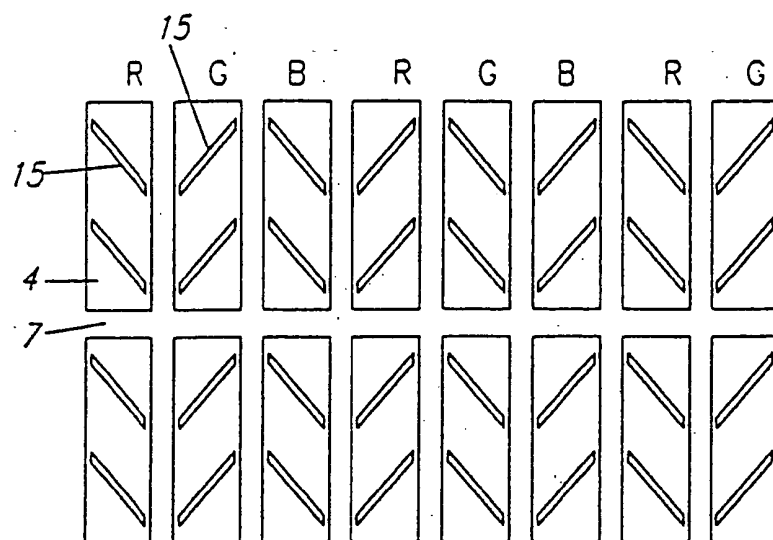
**FIG. 14**



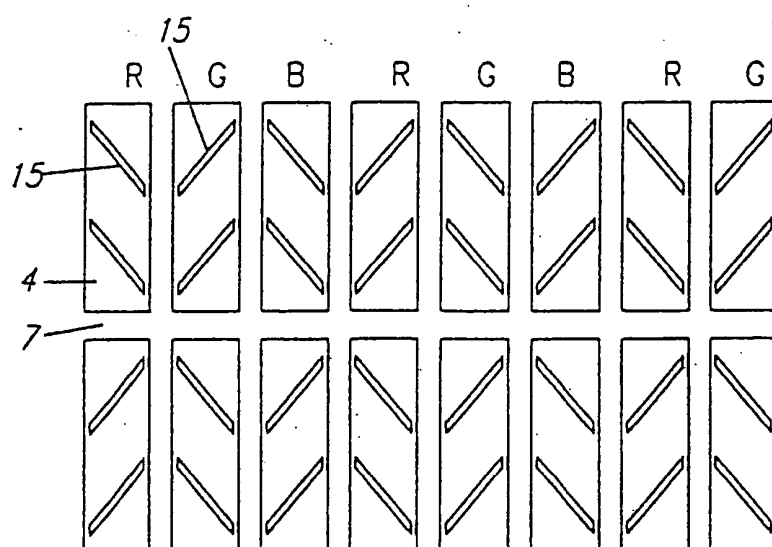
**FIG. 15**



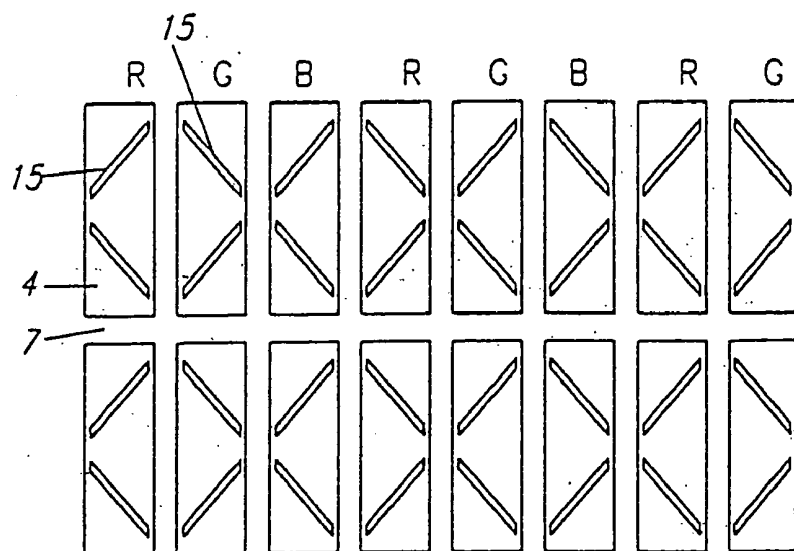
**FIG. 16**



**FIG. 17**



**FIG.18**



**FIG.19**

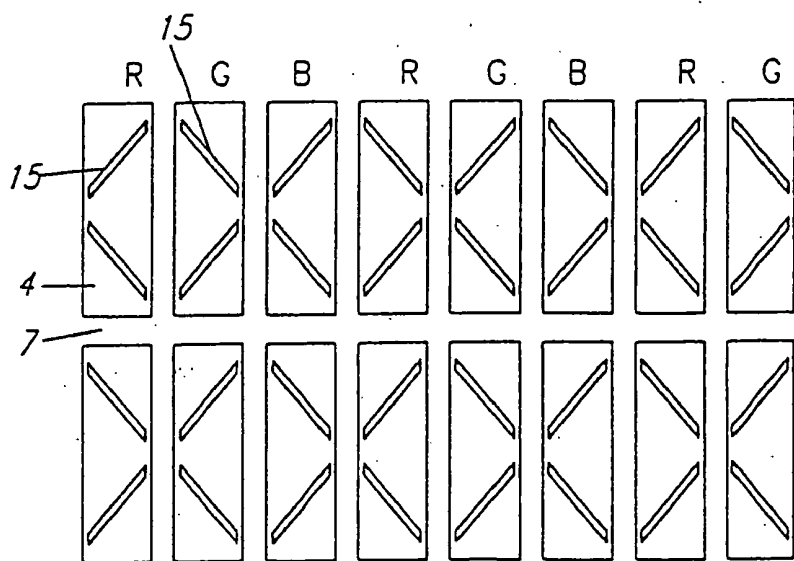
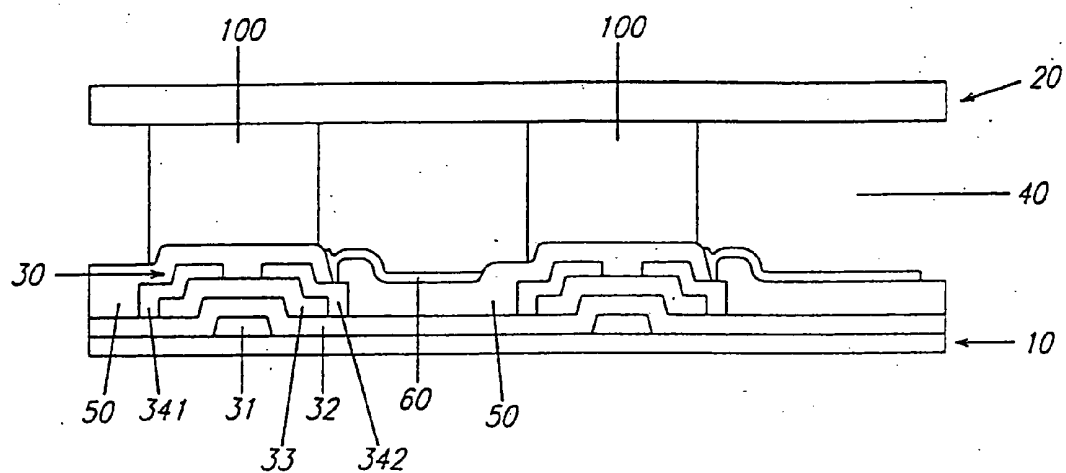


FIG. 20



## LIQUID CRYSTAL DISPLAY HAVING WIDE VIEWING ANGLE

### BACKGROUND OF THE INVENTION

[0001] (a) Field of the Invention

[0002] The present invention relates to a liquid crystal display having wide viewing angle.

[0003] (b) Description of the Related Art

[0004] A liquid crystal display (LCD) includes two substrates and a liquid crystal layer interposed therebetween. The transmittance of the light is controlled by the strength of the electric field applied to the liquid crystal layer.

[0005] A conventional twisted nematic (TN) liquid crystal display, which is one of the most widely used LCD, has a couple of transparent substrates which have transparent electrodes respectively on their inner surfaces, a liquid crystal layer between two substrates, and a couple of polarizers which are attached to the outer surfaces of the substrates respectively. In off state of the LCD, i.e., in the state that the electric field is not applied to the electrodes, the long axes of the liquid crystal molecules are parallel to the substrates and twisted spirally with a constant pitch from the inner surface of one substrate to that of the other substrate, and thus the orientation of the long axes of the liquid crystal molecules vary continuously.

[0006] However, the contrast ratio of the conventional TN LCD in a normally black mode may not be so high because the incident light is not fully blocked in its off state, i.e., in absence of the electric field.

[0007] To solve this problem, a vertically aligned twisted nematic (VATN) mode LCD is proposed in the U.S. Pat. No. 3,914,022 and in "Eurodisplay '93", pp. 158-159 by Takahashi.

[0008] The VATN in normally black mode may have an off state which is sufficiently dark, because the liquid crystal molecules are aligned perpendicular to the substrates in off state. However, the viewing angle of the VATN LCD may not be so wide.

[0009] On the other hand, T. Yamamoto et al. disclosed a VATN simple matrix LCD using fringe fields in "SID '91, pp. 762-765", and Lien proposed a structure having an aperture in the pixel electrode to solve the problem of low transmittance in on state of a simple matrix multi domain VATN.

[0010] However, the structure that Lien proposed, may have light leakage generated near the aperture.

### SUMMARY OF THE INVENTION

[0011] It is therefore an object of the present invention to widen the viewing angle of LCD.

[0012] It is another object of the present invention to prevent the disclination of LCD.

[0013] These and other objects features and advantages are provided according to the present invention, by a liquid crystal display comprising a first substrate having a common electrode, a second substrate having a pixel electrode and a storage capacitor electrode. One of the electrodes has an

aperture and the storage capacitor electrode is located at the position corresponding to the aperture.

[0014] The storage capacitor electrode prevents the light leakage due to a fringe field generated from the aperture.

[0015] Between the first and the second substrates, a liquid crystal layer having negative dielectric anisotropy may be interposed. The liquid crystal layer may include chiral nematic liquid crystal or nematic liquid crystal having chiral dopant of 0.01-3.0 wt %.

[0016] Two substrates may have alignment layers respectively, to align the molecular axes of the liquid crystal molecules perpendicular to the substrates. The alignment layers may be rubbed or not.

[0017] The storage capacitor electrode may be connected to a gate line and the number of the storage capacitor electrode may be more than one.

[0018] It is preferable that the width of the aperture is 3-15  $\mu\text{m}$  and the distance between the apertures is 8-50  $\mu\text{m}$ .

[0019] To obtain the wide viewing angle, the linear apertures in adjacent pixel regions extend in the different directions. For example, if the direction of the aperture of one pixel is parallel to the gate line the aperture of the adjacent pixel is preferably perpendicular to the gate line. As a result, the liquid crystal molecules rotate in 4 directions.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIGS. 1A and 1B are schematic diagrams of the alignment of liquid crystal molecules of a VATN LCD respectively in black state and white state according to an embodiment of the present invention.

[0021] FIG. 2 shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention.

[0022] FIG. 3 is a layout view of a common substrate according to the first embodiment of the present invention.

[0023] FIG. 4 is a layout view of a TFT (thin film transistor) substrate according to the first embodiment of the present invention.

[0024] FIG. 5 is a sectional view of a TFT substrate shown in FIG. 4 taken along the line V-V'.

[0025] FIG. 6 is a layout view of a common substrate according to the second embodiment of the present invention.

[0026] FIG. 7 is a layout view of a TFT substrate according to the second embodiment of the present invention.

[0027] FIG. 8 is a layout view of a common substrate according to the third embodiment of the present invention.

[0028] FIG. 9 is a layout view of a TFT substrate according to the third embodiment of the present invention.

[0029] FIG. 10 is a layout view of a common substrate according to the fourth embodiment of the present invention.

[0030] FIG. 11 is a layout view of a TFT substrate according to the fourth embodiment of the present invention.

[0031] FIG. 12 is a layout view of a substrate according to an embodiment of the present invention.

[0032] **FIGS. 13A and 131** show rotated directions of the liquid crystal molecules near the apertures.

[0033] **FIG. 14** is a layout view of a common substrate according to the fifth embodiment of the present invention.

[0034] **FIG. 15** is a layout view of a TFT substrate according to the fifth embodiment of the present invention.

[0035] **FIG. 16-19** are layout views of substrates according to the sixth to the ninth embodiments of the present invention.

[0036] **FIG. 20** is a sectional view of LCD according to an embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the present invention are shown. This invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the thickness of layers and regions are exaggerated for clarity.

[0038] **FIGS. 1A and 1B** are schematic diagrams of the alignment of liquid crystal molecules of a VATN LCD respectively in black state and white state according to an embodiment of the present invention. **FIG. 2** shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention.

[0039] As shown in **FIGS. 1A and 1B** two glass substrates **1** and **2** are spaced apart from each other. On the inner surfaces of the substrates **1** and **2**, transparent electrodes **12** and **120** made of a transparent conductive material such as ITO (indium tin oxide) or the like are formed respectively, and alignment layers **14** and **140** are formed thereon respectively. Between the substrates **1**, and **2**, a liquid crystal layer **100** including a chiral nematic liquid crystal having negative dielectric anisotropy or a nematic liquid crystal doped with chiral dopant of 0.01-0.3 wt % is disposed. On the outer surfaces of the substrates **1** and **2** polarizers **13** and **130** are attached. The polarizers **13** and **130** polarize the rays incident on the liquid crystal layer **100** and the rays out of the liquid crystal layer **100** respectively. The polarizing directions of the polarizers **13** and **130** are perpendicular to each other. The alignment layers **14** and **140** May be rubbed or not.

[0040] **FIG. 1A** shows the off state that the electric field is not applied, where the long molecular axes of the liquid crystal molecules **3** in the liquid crystal layer **100** are aligned perpendicular to the surface of the substrates **1** and **2** by the aligning force of the alignment layers **14** and **140**.

[0041] The polarized light by the polarizer **13** attached to the lower substrate **1** passes through the liquid crystal layer **100** without changing its polarization. Then, the light is blocked by the analyzer **130** attached to the upper substrate **2** to make a black state.

[0042] **FIG. 1B** shows the on state that the sufficient electric field is applied to the liquid crystal layer **100** by the

electrode **4** and **5**, where the liquid crystal molecules **3** in the liquid crystal layer **100** are twisted spirally by 90° from the lower substrate **1** to the upper substrate **2**, and the director of the liquid crystal layer **100** varies continuously. However, near the inner surfaces of two substrates **1**, **2**, the aligning force of the alignment layers **14**, **140** is larger than the force due to the applied electric field, and the liquid crystal molecules stay vertically aligned.

[0043] The polarized light, by the polarizer **13** passes through the liquid crystal layer **100** and its polarization is rotated by 90° according to the variation of the director of the liquid crystal layer **100**. Therefore, the light passes through the analyzer **130** to make a white state.

[0044] **FIG. 2** shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention. An ITO electrode **4** formed on the upper substrate **2** has an aperture **6**. In absence of electric field as shown in **FIG. 1A**, the liquid crystal molecules **3** stay in its vertically aligned state to show the black state. If the electric field applied to the liquid crystal layer by the electrodes **4** and **5**, in most regions between the electrodes **4** and **5**, the field direction is perpendicular to the substrates **1** and **2**. However, near the aperture of the ITO electrode **4**, the electric field is not completely perpendicular to the substrate **2**. The electric field near the aperture is called the fringe field. The long axes of the liquid crystal molecules tend to be perpendicular to the field direction since the liquid crystal layer have negative dielectric anisotropy. Therefore, the directions of the long axes of the liquid crystal molecules are tilted and twisted near the fringe field.

[0045] An LCD according to embodiments of the present invention includes a TFT (thin film transistor) substrate and a common substrate. On the TFT substrate, a plurality of gate lines and data lines crossing each other are formed and the gate lines and the data lines define pixel regions. On the common substrate, a common electrode having apertures and a black matrix which defines pixel regions are formed.

[0046] According to the first to the fourth embodiments of the present invention, a storage capacitor electrode is formed at the position corresponding to the aperture to shield the light leakage.

[0047] Now, the first embodiment of the present invention will be described with reference to **FIGS. 3-5**.

[0048] **FIG. 3** is a layout view of a common substrate of a liquid crystal display according to the first embodiment of the present invention. **FIG. 3** shows a pixel region, where a common electrode has apertures.

[0049] As shown in **FIG. 3**, a black matrix pattern **7** is formed along boundary of a pixel region **P** and a common electrode **6** is, formed to cover the entire surface of the common substrate. The common electrode **6** has two longitudinally long linear apertures **15** which are spaced apart from and parallel to each other in a pixel region.

[0050] It is preferable that the width of the apertures **15** may be 3-15  $\mu\text{m}$ , and the distance between the apertures **15** may be 8-50  $\mu\text{m}$ . The width of 3-12  $\mu\text{m}$  and the distance of 10-30  $\mu\text{m}$  would be better.

[0051] **FIG. 4** is a layout view of a TFT substrate according to the first embodiment of the present invention, and **FIG. 5** is a sectional view of the TFT substrate taken along the line V-V' of **FIG. 4**.

[0052] As shown in **FIGS. 4 and 5**, a first and a second gate lines **81** and **82** spaced apart from each other are formed on a transparent glass substrate **20**, and extend in the horizontal or transverse direction. Two storage capacitor electrodes **11** which are separated from and parallel to each other connected to both the gate lines **81** and **82** are formed on the substrate **20**. The storage capacitor electrodes **11** are longitudinally lay, and they are located at the positions corresponding to the apertures **15** in the common electrode **6** on the common substrate.

[0053] A gate insulating layer **30** covers the storage capacitor electrodes **11** and the first and the second gate lines **81** and **82**. A data line **9** perpendicular to the gate lines **81** and **82** is formed on the gate insulating layer **30**. A TFT having a gate electrode which is a portion of the first gate line **81** is formed at a portion near the intersection of the first gate line **81** line and the data line **9**. A planarized passivation layer **40** is formed thereon, and a pixel electrode **10** overlapping the first and the second gate lines **81** and **8** and the data line **9** is formed on the passivation layer **40**. An alignment layer **50** is formed thereon, and the alignment layer **50** may be rubbed or may not.

[0054] Although the linear apertures in the common, electrode extend longitudinally in this embodiment, they may extend horizontally or obliquely.

[0055] **FIGS. 6 and 7** are the respective layout views of the common and TFT substrates having horizontal apertures according to the second embodiment.

[0056] As shown in **FIG. 6**, a black matrix pattern **7** is formed along the boundary of a pixel region **P**, and a common electrode **6** is formed to cover the entire surface of the common substrate. The common electrode **6** has a plurality of horizontally long linear apertures **15** which are spaced apart from and parallel to each other in a pixel region.

[0057] The width and the distance of the apertures **15** may be the same as those of the first embodiment.

[0058] On the other hand, as shown in **FIG. 7**, a first and a second gate lines **81** and **82** which are separated from each other and extend horizontally and a branch **12** connecting the gate lines **81** and **82** extending in a vertical direction are formed on a transparent glass substrate **20**. A plurality of storage capacitor electrodes **11** which are parallel to each other and to the gate lines **81** and **82** are formed on the substrate and connected to the branch **12**. The storage capacitor electrodes **11'** are transversely lay, and they are located at the positions corresponding to the apertures **15** in the common electrode **6** on the common substrate.

[0059] **FIGS. 8-11** are layout views of common and TFT substrates having oblique apertures according to the third and the fourth embodiments. In the third and the fourth embodiment the apertures make an angle of  $0^{\circ}$ - $90^{\circ}$  to the data line and the gate line.

[0060] As shown in **FIGS. 8 and 10**, a black matrix pattern **7** is formed along the boundary of a pixel region **P**, and a common electrode **6** is formed to cover the entire surface of the common substrate. The common electrode **6** has two obliquely long linear apertures **15** which are spaced apart from each other in a pixel region.

[0061] In the third embodiment shown in **FIG. 8**, each pixel has an aperture extending in the down left direction

from the up right edge and an aperture extending in the up left direction from the bottom right edge, and the end of apertures **15** reach the left central edge of the pixel. On the other hand in the fourth embodiment illustrated in **FIG. 10**, each pixel has two parallel apertures extending in the up right or the down left direction.

[0062] The width and the distance of the apertures **15** may be the same as those of the first embodiment.

[0063] **FIGS. 9 and 11** are the layout views of TFT substrates according to the third and the fourth embodiments of the present invention.

[0064] As shown in **FIG. 9**, a first and a second gate lines **81** and **82** which are separated from each other and extend horizontally and a branch **12** connecting the gate lines **81** and **82** extending in a vertical direction are formed on a transparent glass substrate **20**. Two storage capacitor electrodes **11** on the substrate extend obliquely from the gate lines **81** and **82** to the left center of the pixel region **P**, and are connected to the branch **12**.

[0065] A TFT substrate illustrated in **FIG. 11** has a first and a second gate lines **81** and **82**, a branch **12** and a data line **9** having the same shapes as those in the third embodiment shown in **FIG. 9**. Two, storage capacitor electrodes **11** parallel to each other extend obliquely in the up right or the bottom left direction and are connected to the branch **12**.

[0066] In the third and the fourth embodiments as in the first embodiment, the position of the storage capacitor electrodes **11** are corresponding to the apertures **15** in the common electrode **6** on the common substrate to shield the light leakage due to a fringe field.

[0067] In the third and the fourth embodiments of the present invention, the alignment layers formed on the pixel electrode may be rubbed or may not. When the alignment layers are rubbed, the rubbing direction may make an angle of  $0^{\circ}$ - $135^{\circ}$  with respect to the direction of the linear aperture.

[0068] Next, the fifth embodiment of the present invention will be described. In the fifth embodiment, adjacent pixels have apertures extending different directions to widen the viewing angle.

[0069] **FIG. 12** is a layout view of a common substrate according to the fifth embodiment.

[0070] As shown in **FIG. 12**, a black matrix pattern **7** is formed and defines a plurality of pixel regions corresponding to the red, green and blue color filters **R**, **G** and **B**. An ITO electrode **4** having a plurality of linear apertures **15** is formed thereon. The extending directions of the linear apertures of adjacent pixel regions are different from each other, i.e., horizontal apertures and vertical apertures are arranged alternately by pixel. For example, a red pixel region has vertical apertures and an green pixel region adjacent to the red pixel region has horizontal apertures.

[0071] It is assumed to display red color using this LCD. Then, the blue and the green pixels remain in their OFF state and only the red pixels turn on. If the extending direction of the apertures of a first red pixel is horizontal, and the extending direction of the aperture of a second red pixel adjacent to the first red pixel is vertical.

[0072] Now the behaviors of the liquid crystal molecules are described with reference to **FIGS. 13A and 13B** in this case.

[0073] The linear apertures **15** of the ITO electrode **4** extends vertically in **FIG. 13A**, while the linear apertures **15** of the ITO electrode **4** extends horizontally in **FIG. 13B**.

[0074] Here, the liquid crystal molecules are left-handed when viewed from the bottom of the drawing sheet.

[0075] When the voltage is applied to the electrodes **4** and **5**, the liquid crystal molecules bit in the directions perpendicular to the direction of the electric field due to the voltage difference between the electrodes **4** and **5**, as shown in **FIG. 2**. In addition, as shown in **FIGS. 13A and 13B**, the liquid crystal molecules rotate clockwise in xy plane.

[0076] The tilt directions of the liquid crystal molecules vary according to the extending directions of the apertures. Since the tilt directions of the molecules opposite each other with respect to an aperture are opposite, and there are two extending directions of the apertures, the number of the tilt direction is about four on the Y axis in upper part twist to the right to the X axis, and those on the Y axis in lower part twist to the left to X axis due to the linear aperture formed along the Y axis.

[0077] Since the liquid crystal molecules tilt and rotate in four different directions, the viewing angles of up, down, left and right directions are equal and the gray inversion does not occur.

[0078] Now, the structures of the color filter and the TFT substrate according to the fifth embodiment are described more fully.

[0079] **FIG. 14** is a layout view of a common substrate showing two adjacent pixels.

[0080] As shown in **FIG. 14**, a black matrix pattern **7** which defines pixel regions **P1**, **P2** is formed on the substrate, and a common electrode **6** formed thereon.

[0081] The common electrode **6** has two vertical linear apertures **15** parallel to each other in the first pixel region **P1**, and has a plurality of horizontal linear apertures **15** parallel to each other in the second pixel region **P2** adjacent to the first pixel region **P1**.

[0082] The width and the distance of the apertures may be the same as those of the first embodiment.

[0083] **FIG. 15** is a layout view of a TFT substrate according to the fifth embodiment of the present invention. In a pixel region **P1** corresponding to the pixel region **P1** on the common substrate in **FIG. 14**, a first and a second gate lines **81** and **82** and two vertical storage capacitor electrodes **11** parallel to each other and connecting the gate lines **81** and **82** are formed as those in **FIG. 4**. In a pixel region **P2**, a branch **12** connecting two gate lines **81** and **82** extends parallel to a data line **9**, and a plurality of storage capacitor electrodes **11** extend parallel to the gate lines **81** and **82** from the branch **12**.

[0084] As all the above-described embodiments, the storage capacitor electrodes **11** are located at the positions corresponding to the apertures **15** in the common electrode **6**.

[0085] The storage capacitor electrodes **11** overlaps a pixel electrode **10** to form storage capacitors, and play a role of a black matrix to prevent the light leakage caused by the disclination due to the apertures' **15** in common electrode **6**.

[0086] The apertures in adjacent pixel regions may have various shapes. **FIGS. 16-19** are layout views of the sixth to the ninth embodiments having variously shaped apertures in adjacent pixel regions.

[0087] An LCD according to the sixth embodiment shown in **FIG. 16** has first pixels having apertures shown in **FIG. 10** and second pixels having apertures of shapes which is the same as the apertures in the first pixels rotated by 180° with respect to the central point of the pixel. In horizontal direction, two kinds of pixels are arranged alternately, and in vertical direction, pixels in a column are the same kind. As a whole, the apertures form a chevron shape in the sixth embodiment. An LCD according to the seventh embodiment shown in **FIG. 17** has the same arrangement in the horizontal direction, however, in the vertical direction, two kinds of pixels are arranged alternately as in the horizontal direction. In the seventh embodiment, the apertures form a chevron shape in a row, but when viewing adjacent rows, the apertures form X or diamond shapes,

[0088] An LCD according to the eighth embodiment shown in **FIG. 18** has first pixels having apertures shown in **FIG. 8** and the second pixels having apertures of shapes which is the same as the apertures in the first pixels rotated by 180° with respect to the central point of the pixel. In horizontal direction two kinds of pixels are arranged alternately, and in vertical direction, pixels in a column are the same kind. As a whole, the apertures form an X or diamond shape. An LCD according to the ninth embodiment shown in **FIG. 19** has the same arrangement in the horizontal direction, however, in the vertical direction, two kinds of pixels are arranged alternately as in the horizontal direction. In the ninth embodiment, the apertures form an X or diamond shape in a row.

[0089] According to the embodiments of the present invention, column shaped spacers made of metal or organic material may be used instead of ball shaped spacers since the ball shaped spacers may cause light leakage due to the disturbance of the liquid crystal molecules near the spacers.

[0090] **FIG. 20** shows a sectional view of an LCD having spacers according to an embodiment of the present invention. A liquid crystal layer **40** is interposed between a substrate **10** having a TFT **30** and a substrate **20** having a color filter (not shown). The TFT **30** formed on the lower substrate **10** includes a gate electrode **31**, a gate insulating layer **32** formed thereon a semiconductor layer **33** formed on a portion of the gate insulating layer **32** over the gate electrode **31**, source/drain electrodes **341**, **342** formed on the semiconductor layer **33**. A passivation layer **50** covers the entire surface of the substrate **10** having the TFT **30**. A pixel electrode **60** is formed in the pixel region and electrically connected to the drain electrode **342** through a contact hole in the passivation layer **50**. A spacer **100** made of a metal or an organic material is formed on the TFT.

[0091] In the embodiments of the present invention, the apertures are formed in the common electrode **6**, however, the apertures can be formed in the pixel electrode **10**. When the apertures are formed in the pixel electrode **10**, the fringe field generated between the pixel electrode **10** and the common electrode **6** may be affected by the voltages applied to the data line **9** the gate lines **81** and **82** and the storage capacitor electrode **11**. To remove the influence due to the voltage applied to those signal lines, it is preferable that the

thickness of the passivation layer **50** is equal to or more than 3  $\mu\text{m}$  by using organic insulating material.

[0092] In the embodiments of the present invention, although the storage capacitor electrodes **11** are connected to the gate lines **81** and **82**, the storage capacitor electrodes **11** may be connected to another signal sources.

[0093] According to the embodiments of the present invention, the liquid crystal molecules are tilted in the various directions due to the fringe field to have a wide viewing angle, and the storage capacitor electrodes prevents the light leakage near the fringe field.

[0094] In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation the scope of the invention being set forth in the following claims.

1.-59. (canceled)

**60.** A liquid crystal display comprising:

a gate line formed on a first substrate;

a data line formed on the first substrate and the gate line;

a first field-generating electrode formed on the first substrate, having a lower part and an upper part and having an first aperture; and

a second substrate, spaced apart from the first substrate, wherein the first aperture of the upper part slantingly extends upward with respect to the gate line, and the first aperture of the lower part slantingly extends downward with respect to the gate line.

**61.** A liquid crystal display of claim **1**, wherein the first aperture of the upper part and the gate line are at an angle of 30~50 degrees, and the first aperture of the lower part and the gate line are at an angle of 30~50 degrees.

**62.** A liquid crystal display of claim **1**, the first substrate more comprising:

a second field-generating electrode neighboring the first field-generating electrode having a second aperture,

wherein the second aperture of the second field-generating electrode is bilateral symmetry with the first aperture of the first field-generating electrode.

**63.** A liquid crystal display of claim **1**, the first substrate more comprising:

a thin film transistor connecting the data line, the gate line and the field-generating electrode.

**64.** A liquid crystal display of claim **1**, further comprising a liquid crystal layer having negative dielectric anisotropy and interposed between the first and the second substrates.

**65.** A liquid crystal display of claim **5**, wherein the liquid crystal layer comprises a chiral nematic liquid crystal.

**66.** A liquid crystal display of claim **5**, wherein the liquid crystal layer comprises a nematic liquid crystal including chiral dopant of 0.01 to 3.0 wt %.

**67.** A liquid crystal display of claim **5**, further comprising two alignment layers formed on the first and the second substrates respectively and aligning the molecular axes of liquid crystal molecules in the liquid crystal layer in the direction perpendicular to the substrates.

**68.** A liquid crystal display of claim **8**, wherein the alignment layers are not rubbed.

**69.** A liquid crystal display of claim **1**, wherein the width of the first aperture is in the range of 3-15  $\mu\text{m}$ .

**70.** A liquid crystal display comprising:

a gate line formed on a first substrate;

a data line formed on the first substrate and the gate line;

a second substrate, spaced apart from the first substrate; and

a first field-generating electrode formed on the second substrate, having a lower part and an upper part and having an first aperture,

wherein the first aperture of the upper part slantingly extends upward with respect to the gate line, and the first aperture of the lower part slantingly extends downward with respect to the gate line.

**71.** A liquid crystal display of claim **11**, wherein the first aperture of the upper part and the gate line are at an angle of 30~50 degrees, and the first aperture of the lower part and the gate line are at an angle of 30~50 degrees.

**72.** A liquid crystal display of claim **11**, further comprising a liquid crystal layer having negative dielectric anisotropy and interposed between the first and the second substrates.

**73.** A liquid crystal display of claim **13**, wherein the liquid crystal layer comprises a chiral nematic liquid crystal.

**74.** A liquid crystal display of claim **13**, wherein the liquid crystal layer comprises a nematic liquid crystal including chiral dopant of 0.01 to 3.0 wt %.

**75.** A liquid crystal display of claim **13**, further comprising two alignment layers formed on the first and the second substrates respectively and aligning the molecular axes of liquid crystal molecules in the liquid crystal layer in the direction perpendicular to the substrates.

**76.** A liquid crystal display of claim **16**, wherein the alignment layers are not rubbed.

**77.** A liquid crystal display of claim **11**, wherein the width of the first aperture is in the range of 3-15  $\mu\text{m}$ .

\* \* \* \* \*

孔径形成在液晶显示器的公共电极或像素电极中以形成边缘场。存储电容器电极形成在与孔对应的位置处，以防止由于边缘场引起的交错导致的漏光。孔径水平，垂直或倾斜地延伸。相邻像素区域中的孔可以具有不同的方向以加宽视角。

