US 20060066790A1

(19) **United States**

(12) **Patent Application Publication**

Tanaka et al.

(10) **Pub. No.: US 2006/0066790 A1**

(43) **Pub. Date: Mar. 30, 2006**

(54) **SEMITRANSMISSIVE LIQUID CRYSTAL DISPLAY PANEL**

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(21) Appl. No.: **11/237,814**

(22) Filed: **Sep. 29, 2005**

(30) **Foreign Application Priority Data**

Sep. 30, 2004 (JP) 2004-289338

Publication Classification

(51) **Int. Cl.**
G02F 1/1337 (2006.01)
G02F 1/1335 (2006.01)

(52) **U.S. Cl.** **349/123**; 349/114

(57) **ABSTRACT**

A semitransmissive liquid crystal display panel **10** has a first substrate **11** having, formed in each of the areas demarcated by signal lines and scan lines laid in a grid-like shape thereon, a reflective portion and a transmissive portion formed by a pixel electrode **15** having a slit **17**, a second substrate **19** having formed thereon a color filter **21**, a common electrode **22**, and ridges **23** and **41**, alignment films **24** laid over the first and second substrates **11** and **19** and processed for vertical alignment, and a liquid crystal layer **25** laid between the first and second substrates **11** and **19** and showing a negative dielectric constant anisotropy. When no electric field is applied to the liquid crystal layer **25**, the liquid crystal molecules are vertically aligned, and, when an electric field is applied to the liquid crystal layer **25**, the liquid crystal molecules are horizontally aligned and inclined in the directions restricted by the slit **17** and the ridges **23** and **41**. The slit **17** is formed in a central portion of the pixel electrode in the transmissive portion, and the ridges **23** and **41** are formed at the periphery of the pixel electrode **15** and in a central portion of the reflective portion.

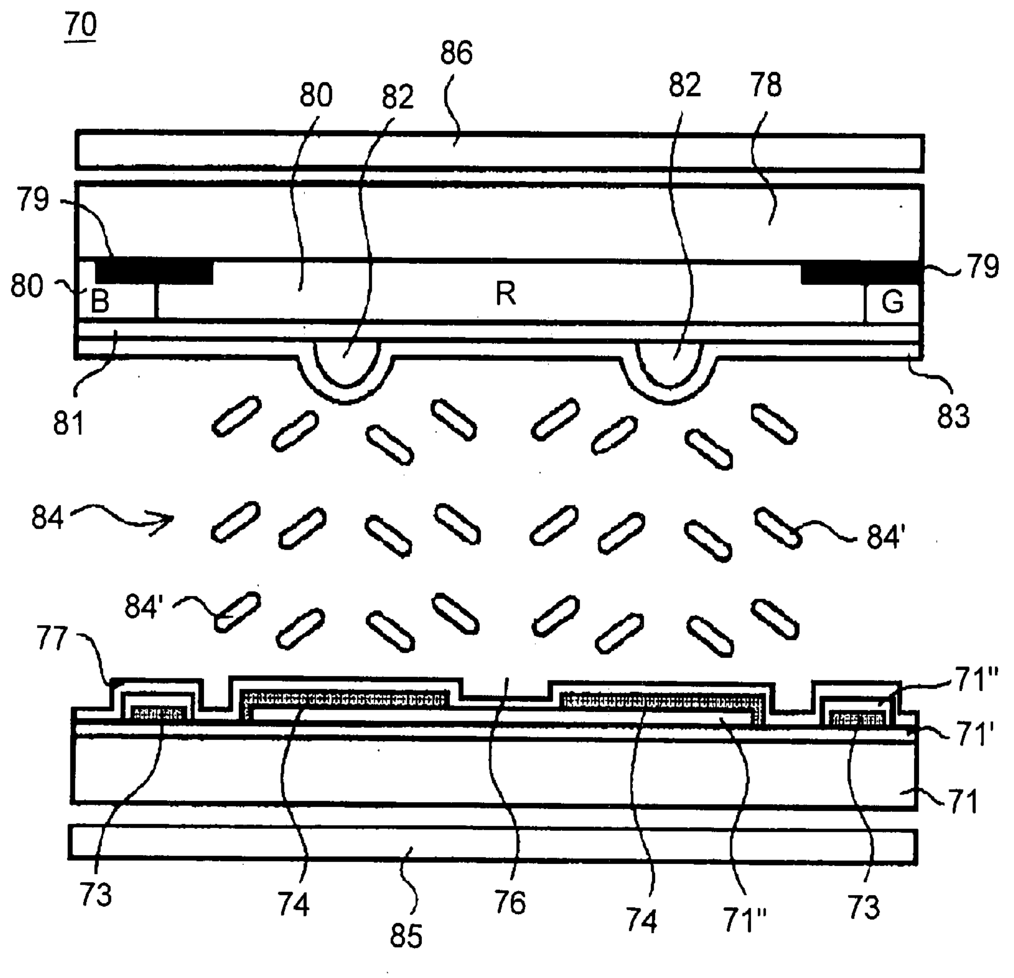
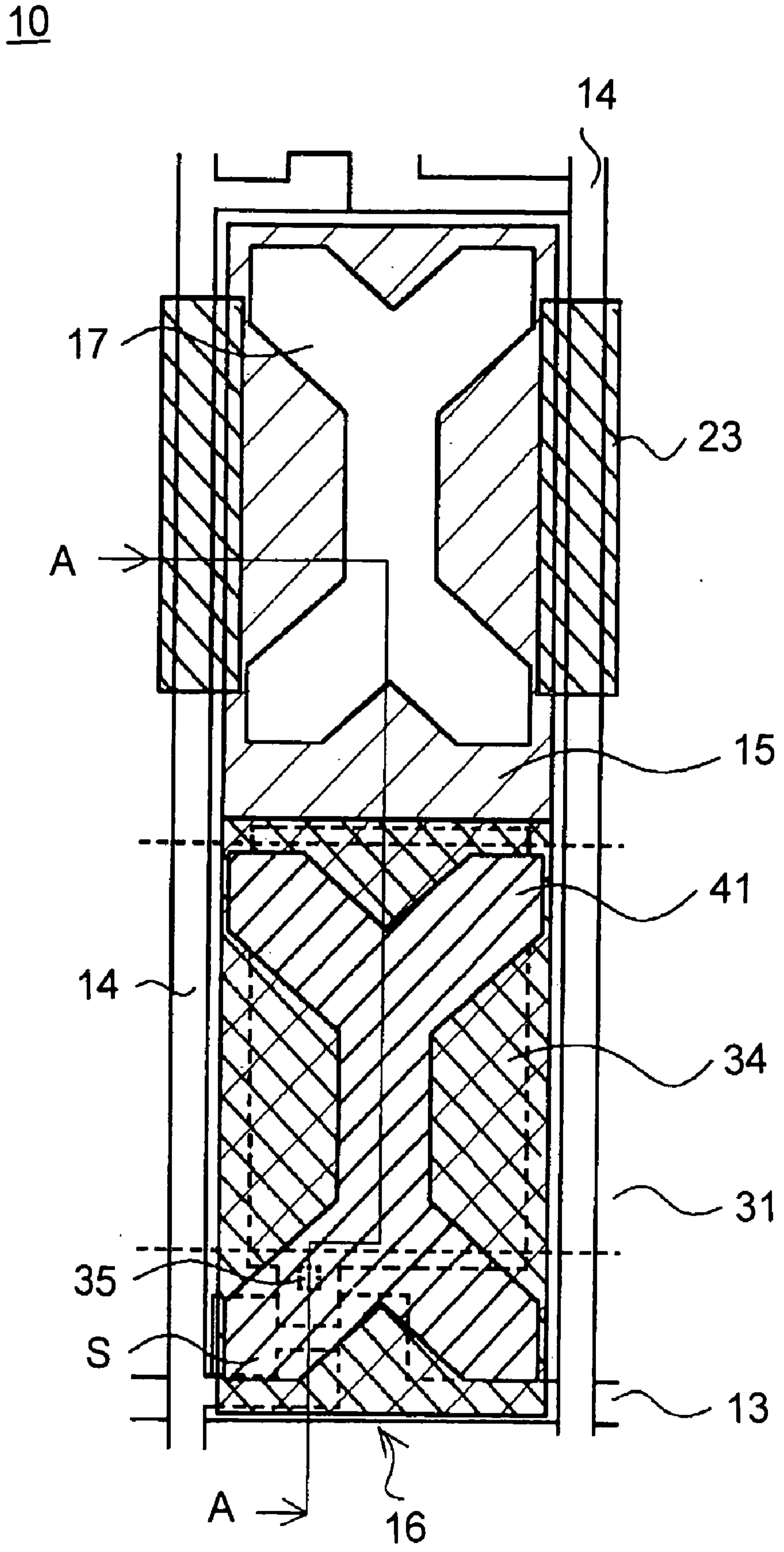


FIG.1



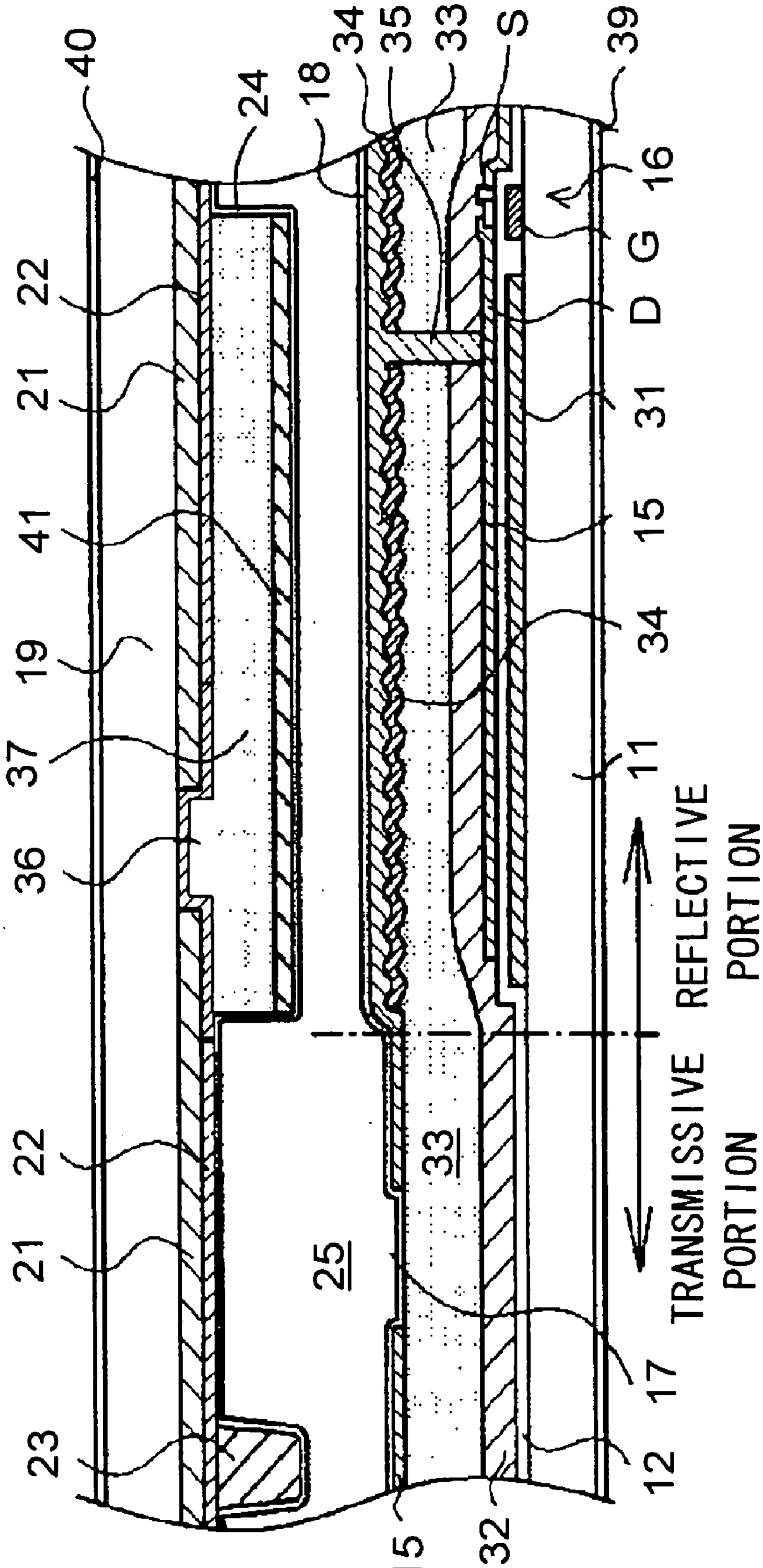

40
24
18
34
35
33
S
39
16
G
D
22
21
41
19
37
36
31
15
34
11
REFLECTIVE PORTION
TRANSMISSIVE PORTION
22
21
25
33
17
23
12
15
32

FIG.2

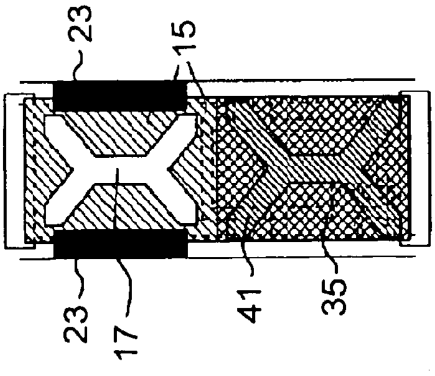


FIG.3A

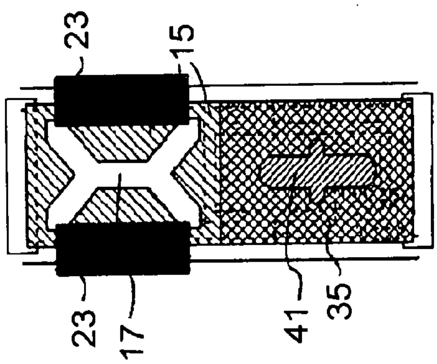


FIG.3B

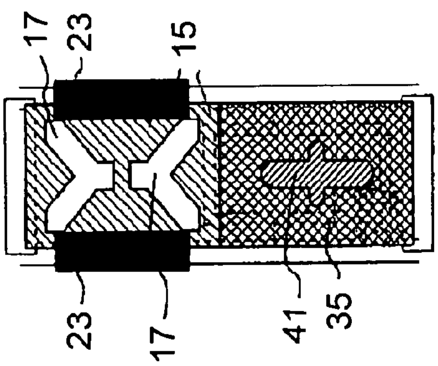


FIG.3C

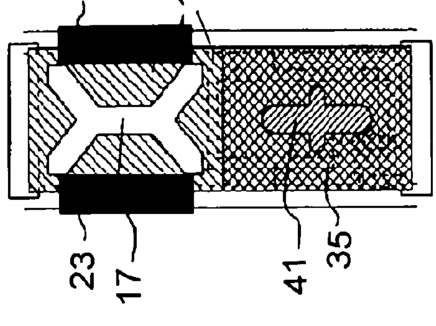


FIG.3D

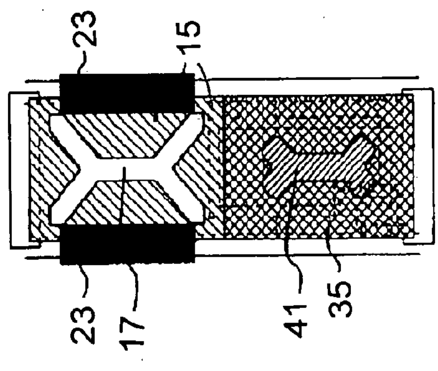


FIG.3E

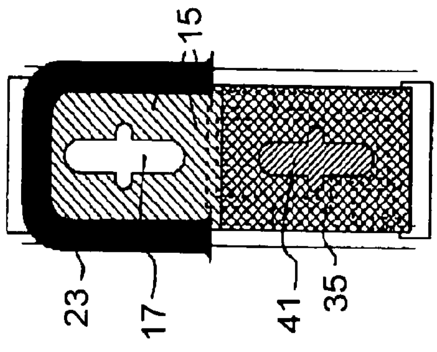


FIG.3F

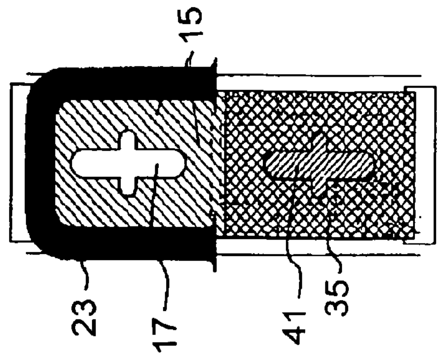


FIG.3G

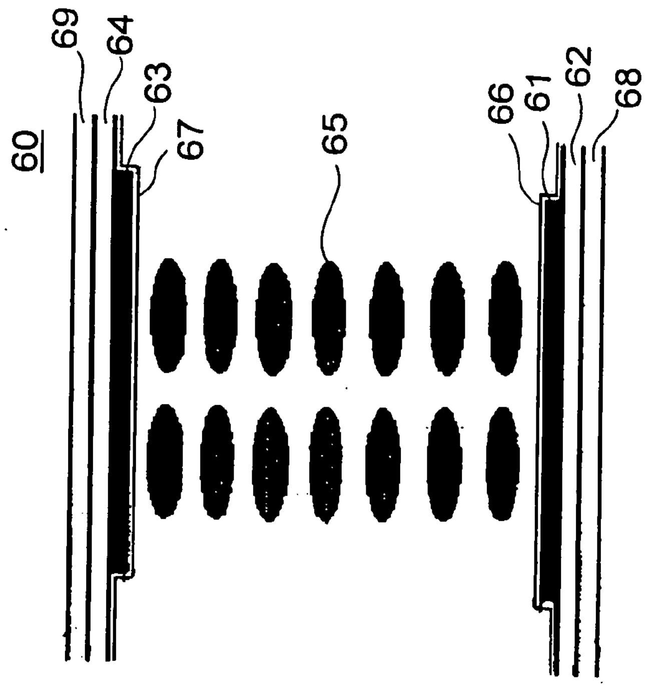


FIG.4B

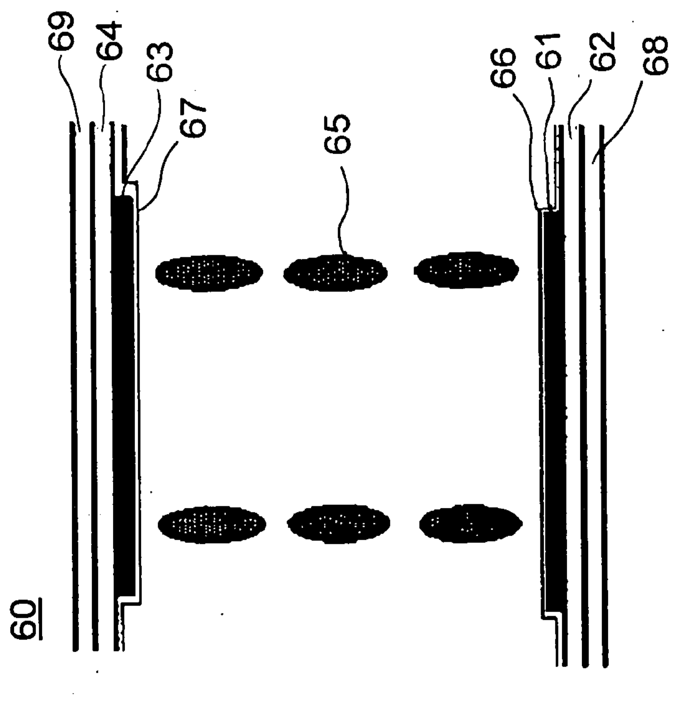


FIG.4A

FIG.5

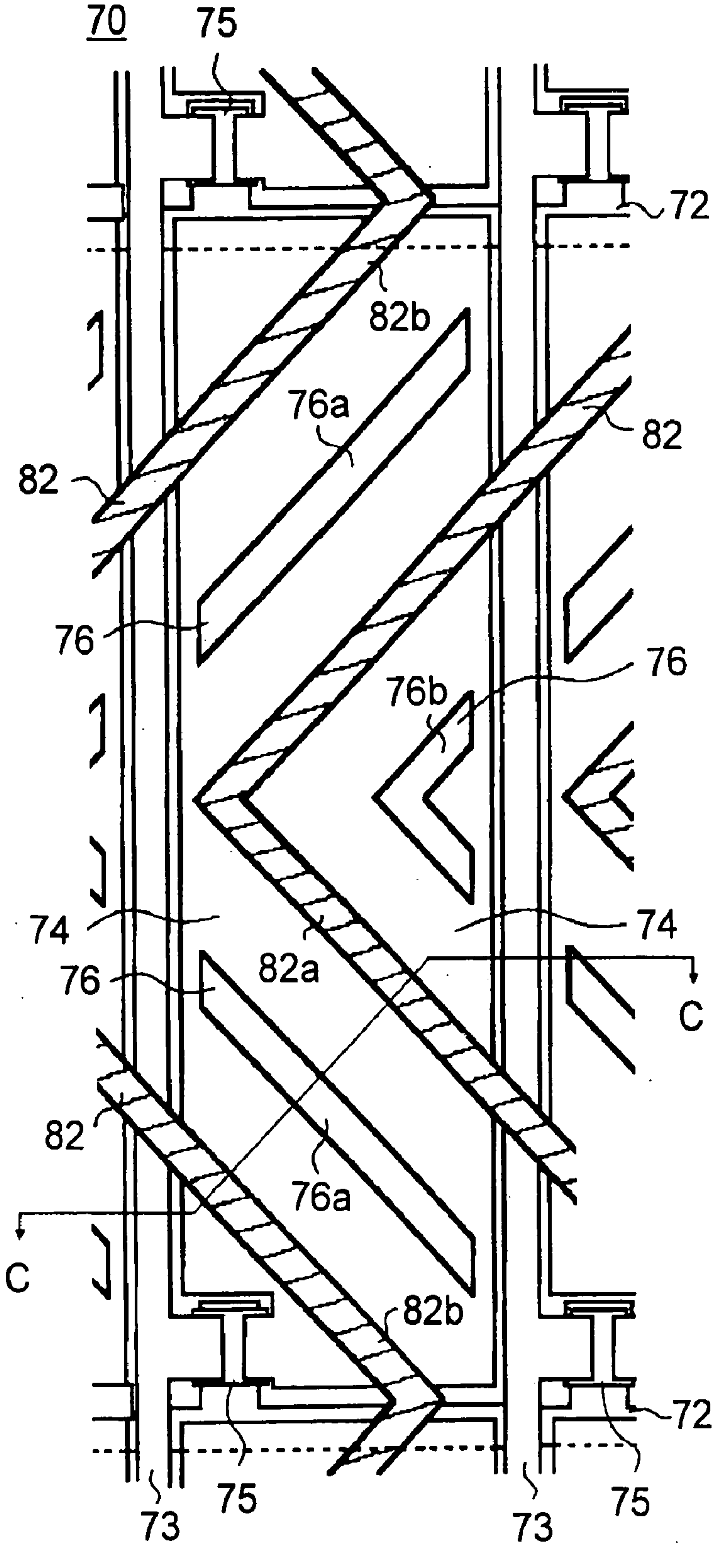

70
75
72
82b
76a
82
82
76
76
76b
74
74
82a
76
C
82
76a
C
82b
72
75
75
73
73
75

FIG.6

70

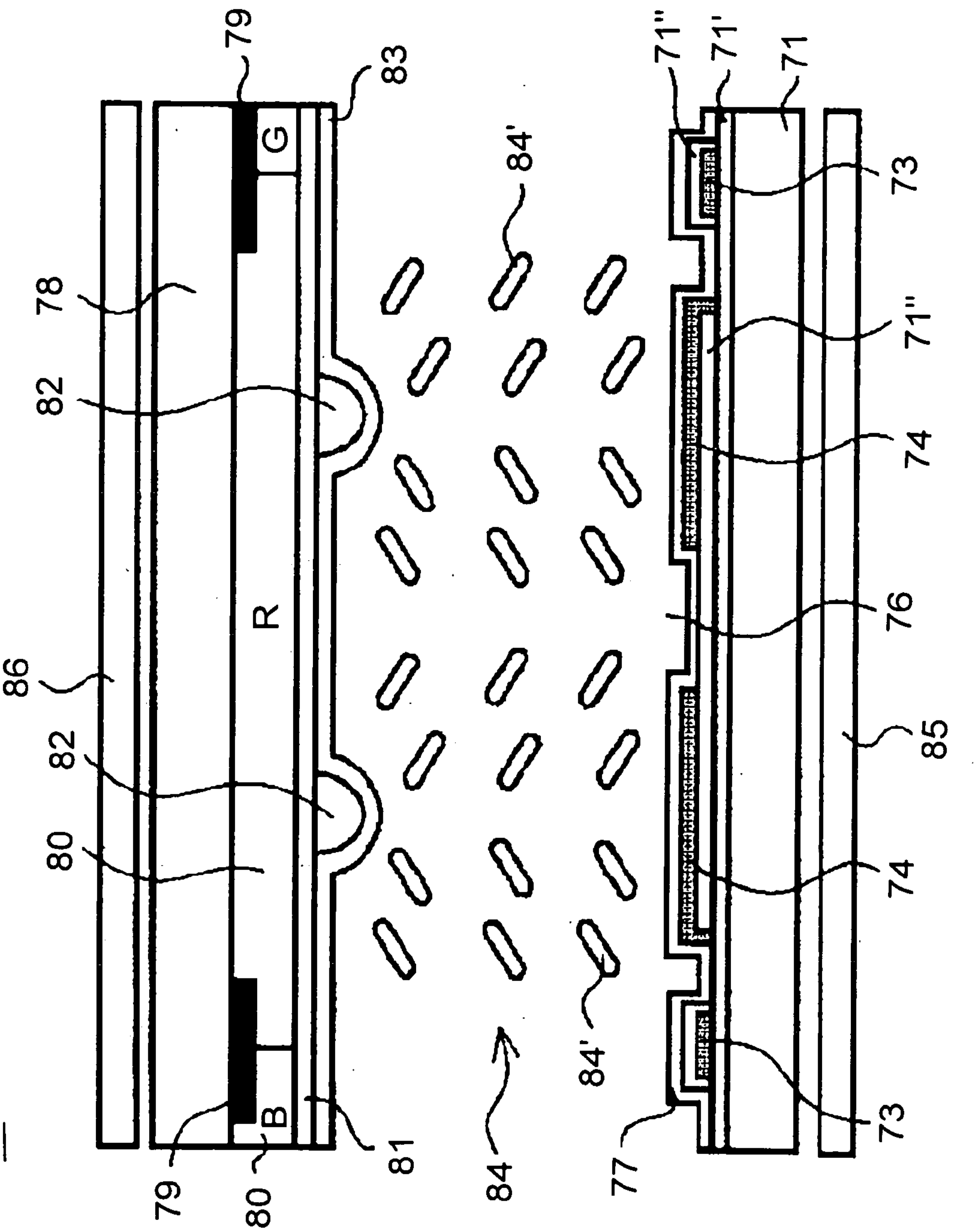

79
83
71"
71'
71
84'
G
73
78
71"
82
74
R
76
86
85
82
80
74
73
84'
B
79
80
81
84
77

FIG.7

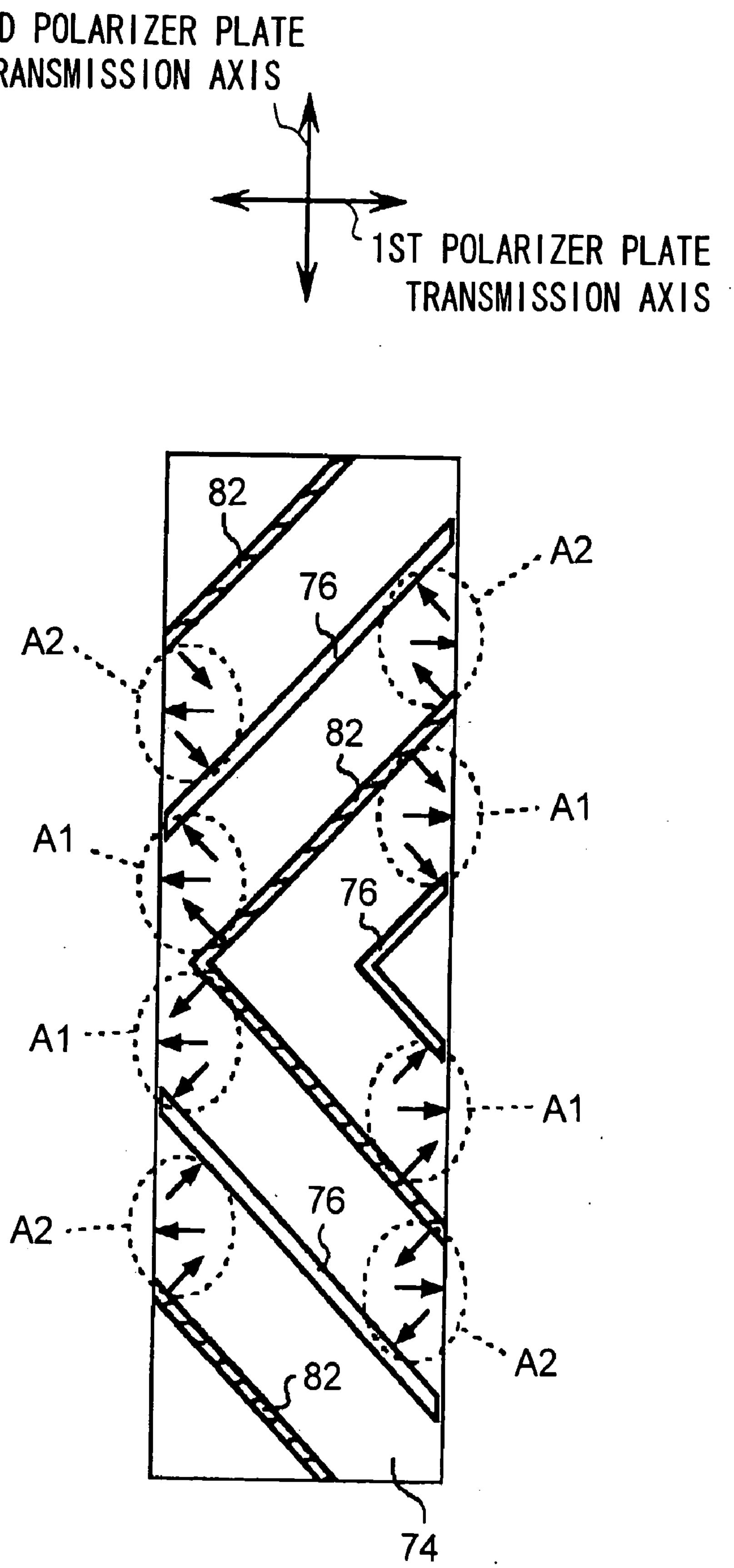

2ND POLARIZER PLATE
TRANSMISSION AXIS
1ST POLARIZER PLATE
TRANSMISSION AXIS
82
76
A2
A2
82
A1
A1
76
A1
A1
76
A2
A2
82
74

FIG.8

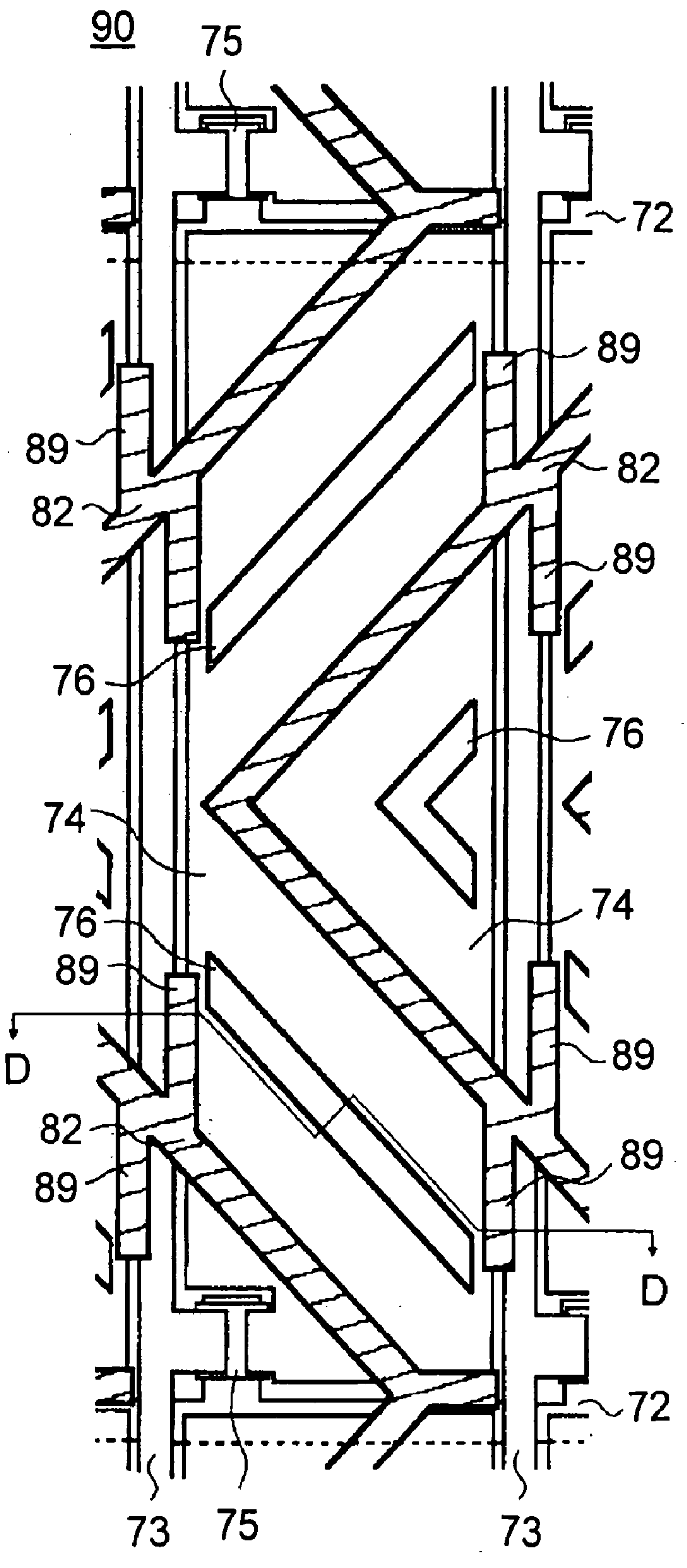


FIG.9A

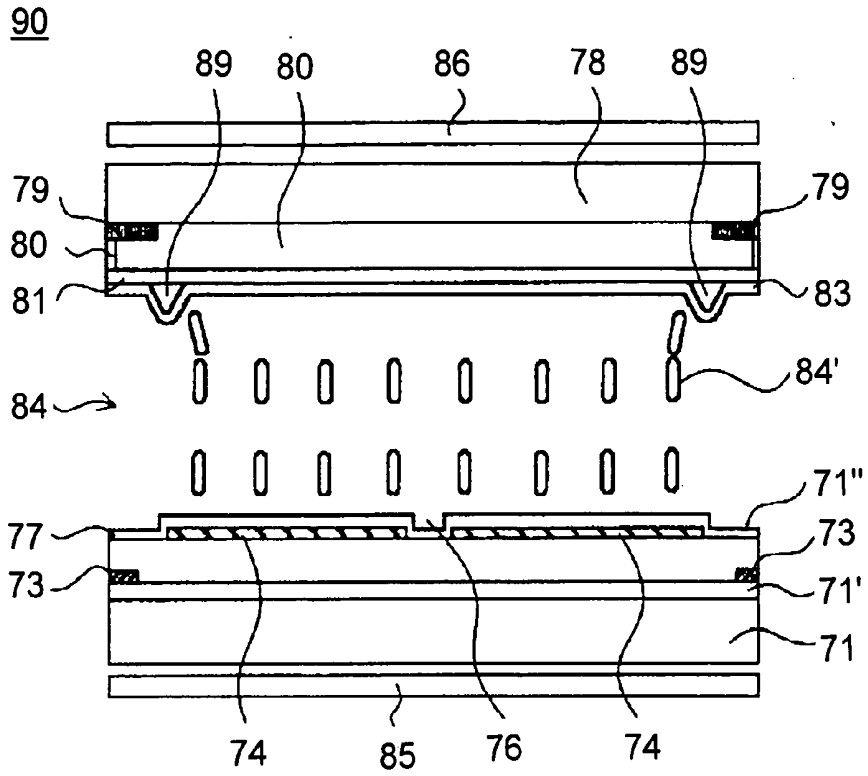
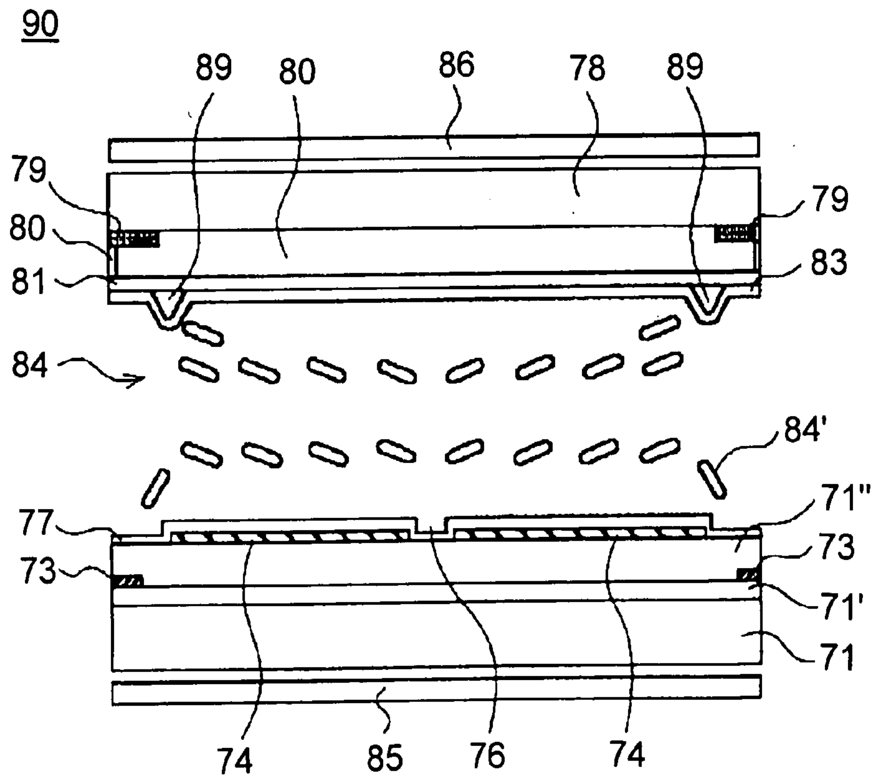

90
89
80
86
78
89
79
79
80
81
83
84'
84
71"
77
73
73
71'
71
74
85
76
74

FIG.9B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74
85
76
74

SEMITRANSMISSIVE LIQUID CRYSTAL DISPLAY PANEL

[0001] This application is based on Japanese Patent Application No. 2004-289338 filed on Sep. 30, 2004, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a semitransmissive liquid crystal display panel. More particularly, the present invention relates to a semitransmissive liquid crystal display panel of a multi-domain vertical alignment type.

[0004] 2. Description of Related Art

[0005] Generally, liquid crystal display apparatuses offer the advantages of being slim, lightweight, and power-saving. In particular, TFT (thin-film transistor) liquid crystal display apparatuses are widely used in portable data terminals to large-screen television monitors. One type of liquid crystal display panel for use in liquid crystal display apparatuses is those of a VA (vertical alignment) type. VA-type liquid crystal display panels are widely known to offer fast response combined with a wide viewing angle.

[0006] **FIG. 4A** shows a section of a VA-type liquid crystal display panel. The VA-type liquid crystal display panel **60** has, sealed between two substrates **62** and **64**, liquid crystal whose dielectric constant shows a negative anisotropy. On one substrate **62** is laid a pixel electrode **61**. On the other substrate **64** is laid a common electrode **63**. Over the substrates **62** and **64** are laid alignment films **66** and **67**, respectively, which have both been processed for vertical alignment. Outside the substrates **62** and **64** are laid polarizer plates **68** and **69**, respectively, which are laid in a cross-Nicol arrangement.

[0007] When no electric field is applied between the two electrodes **61** and **63**, the liquid crystal molecules **65** between the substrates are vertically aligned. Thus, the linearly polarized light transmitted through one polarizer plate is then, as it is, transmitted through the liquid crystal layer, and is then intercepted by the other polarizer plate. This makes the liquid crystal display panel **60** appear dark, that is, black.

[0008] By contrast, when an electric field is applied between the two electrodes **61** and **63**, as shown in **FIG. 4B**, the liquid crystal molecules **65** between the substrates are horizontally aligned. Thus, the linearly polarized light transmitted through one polarizer plate is then, through birefringence it undergoes when transmitted through the liquid crystal layer, formed into elliptically polarized light, which is then transmitted through the other polarizer plate. This makes the liquid crystal display panel **60** appear bright, that is, white.

[0009] In this VA-type liquid crystal display panel **60**, when no electric field is applied between the two electrodes **61** and **63**, all the liquid crystal molecules **65** are so aligned as to stand upright on the alignment films **66** and **67**, vertically thereto. By contrast, when an electric field is applied between the two electrodes **61** and **63**, it is not possible to control the orientations in which the individual liquid crystal molecules **65** are tilted in the horizontal direction.

[0010] Thus, left as they are, the liquid crystal molecules **65**, when horizontally aligned, are tilted in random directions. Disadvantageously, this results in notably uneven display, and causes disclination due to disturbed alignment of liquid crystal molecules at the periphery of each pixel.

[0011] These disadvantages can be overcome in the following manner. When no electric field is applied between the electrodes **61** and **63**, the liquid crystal molecules **65** are made to stand inclined at a slight angle (pre-tilt angle) to the vertical axis, with the inclination direction distributed similarly among the individual pixels. In this way, it is possible to restrict the direction in which the liquid crystal molecules **65** are tilted when a voltage is applied between the electrodes **61** and **63**, and thereby to achieve even display.

[0012] Japanese Patent Application Laid-open No. H11-242225 and Japanese Patent Application Laid-open No. 2001-083517 disclose liquid crystal display panels of an MVA (multi-domain vertical alignment) type in which, when no electric field is applied between the electrodes, the liquid crystal molecules are inclined. In an MVA-type liquid crystal display panel, ridges and grooves are formed in pixels so that the inside of a single pixel is divided into a plurality of domains.

[0013] **FIG. 5** is a plan view showing the pixel structure of the MVA-type liquid crystal display panel. **FIG. 6** is a sectional view of **FIG. 5** taken along line C-C. In the liquid crystal display panel **70**, over a transparent first substrate **71** such as a glass plate, a gate insulating film **71'** is laid, and, on top thereof, scan lines **72** and signal lines **73** are laid in a grid-like pattern.

[0014] Each area enclosed by two adjacent scan lines **72** and two adjacent signal lines **73** corresponds to one pixel, and, within this area, a pixel electrode **74** is laid. At the intersection between a scan line **72** and a signal line **73**, a TFT **75** as a switching device is formed, and is connected to the pixel electrode **74**. Part of the pixel electrode **74** overlaps the adjacent scan line **72**, with an insulating film **71"** laid in between. This overlap functions as an auxiliary capacitance. The pixel electrode **74** has a plurality of slits **76** (described later) formed therein. The pixel electrode **74** is covered with an alignment film **77** that has been processed for vertical alignment.

[0015] On the other hand, on a transparent second substrate **78** such as a glass substrate, a black matrix **79** is formed so as to demarcate the individual pixels, and in addition color filters **80** are laid one for each pixel. As the color filters **80**, one of red (R), green (G), and blue (B) filters is laid to correspond to each pixel. Over the color filters **80** is laid a common electrode **81**, which is a transparent electrode of, for example, ITO. On top of the common electrode **81**, ridges **82** are formed in a predetermined pattern. The common electrode **81** and the ridges **82** are covered with an alignment film **83** that has been processed for vertical alignment.

[0016] Between the first and second substrates **71** and **78** is laid a liquid crystal layer **84** whose dielectric constant shows a negative anisotropy. When no electric field is present between the pixel electrode **74** and the common electrode **81**, the liquid crystal molecules **84'** are vertically aligned by being restricted by the alignment films **77** and **83**. When an electric field is present between the pixel electrode

74 and the common electrode 81, the liquid crystal molecules 84' are inclined in the horizontal direction. Here, the liquid crystal molecules 84' are inclined in predetermined directions by being restricted by the slits 76 and the ridges 82, producing a plurality of domains within a single pixel. It should be noted that FIG. 6 schematically shows a state in which an electric field is present between the pixel electrode 74 and the common electrode 81.

[0017] Outside the first substrate 71, a first polarizer plate 85 is laid. Outside the second substrate 78, a second polarizer plate 86 is laid. The first and second polarizer plates 85 and 86 are so set that their transmission axes are perpendicular to each other. The orientations of the first and second polarizer plates 85 and 86 are set according to the relationship between their transmission axes and the orientations in which the liquid crystal molecules 84' are inclined. The relationship between the transmission axes of the first and second polarizer plates 85 and 86 and the directions in which the liquid crystal molecules 84' are inclined will be discussed in detail later. Here, for the sake of simplicity, it is assumed that the transmission axis of the first polarizer plate 85 runs in the same direction in which the scan lines 72 extend, and the transmission axis of the second polarizer plate 86 runs in the same direction in which the signal lines 73 extend.

[0018] When no electric field is present between the pixel electrode 74 and the common electrode 81, the liquid crystal molecules 84' are vertically aligned. Thus, the linearly polarized light transmitted through the first polarizer plate 85 is then, while remaining linearly polarized light, transmitted through the liquid crystal layer 84, and is then intercepted by the second polarizer plate 86, resulting in black display. By contrast, when a predetermined voltage is applied to the pixel electrode 74 and thus an electric field is present between the pixel electrode 74 and the common electrode 81, the liquid crystal molecules 84' are inclined in the horizontal direction. Thus, the linearly polarized light transmitted through the first polarizer plate 85 is then, when transmitted through the liquid crystal layer 84, formed into elliptically polarized light, and is then transmitted through the second polarizer plate 86, resulting in white display.

[0019] Next, the shapes of the slits 76 and the ridges 82 will be described. The slits 76 are formed by removing parts of the pixel electrode 74 by photolithography or the like. The ridges 82 is formed, for example, by laying a resist layer of acrylic resin or the like and then forming it into a predetermined pattern by photolithography.

[0020] The ridges 82 are formed in zigzags to run across a plurality of pixels, and the straight parts of the ridges 82 extend in directions at 45° to the signal lines 73, as viewed from a direction normal to the second substrate 78. In each pixel, in a substantially central part thereof, a ridge 82*a* running from the pixel adjacent on one side thereof bends at 90° and then runs back to the pixel adjacent on the same side. Moreover, in each pixel, near two corners, other ridges 82*b* running from the pixel adjacent on the other side run parallel to the straight parts of the perpendicularly bending ridge 82*a*.

[0021] The slits 76 are formed to run along the mid lines between two adjacent ridges 82. In the example currently discussed, as shown in FIG. 5, each pixel electrode 74 has three silts 76 formed therein; specifically two slits 76*a* are formed between the ridges 82*a* and 82*b*, and another slit 76*b* is formed between the ridge 82*a* and an edge of the pixel electrode 74.

[0022] The center lines of the slits 76*a* are parallel to the adjacent ridges 82, and thus run in directions inclined at 45° to the signal lines 73. The center lines of the slits 76*a* thus corresponds to the directions in which the slits 76*a* extend. Likewise, the slit 76*b* extend parallel to the adjacent ridge 82*a*. The direction in which the ridge 82*a* adjacent to the slit 76*b* extends bends perpendicularly within the pixel, and thus the direction in which the slit 76*b* extends bends within the pixel.

[0023] The liquid crystal molecules 84' are aligned in orientations at 90° to the ridges 82 and the slits 76, as viewed from a direction normal to the first and second substrates 71 and 78. Moreover, with respect to a direction normal to the first and second substrates 71 and 78, the liquid crystal molecules 84' are inclined in opposite directions between on opposite sides of the ridges 82 and the slits 76.

[0024] Outside the first and second substrates 71 and 78 are laid a first and a second polarizer plate 85 and 86, respectively. As seen from a direction normal to the first and second substrates 71 and 78, the angles between the transmission axes of the first and second polarizer plates 85 and 86 and the directions of the ridges 82 are set at 45°.

[0025] Thus, the angles between the inclined liquid crystal molecules 84' and the transmission axes of the first and second polarizer plates 85 and 86 are 45°. When the angles between the inclined liquid crystal molecules 84' and the transmission axes of the first and second polarizer plates 85 and 86 are 45°, light is transmitted through the first and second polarizer plates 85 and 86 most efficiently.

[0026] In the MVA-type liquid crystal display panel 70 described above, advantageously, the alignment films do not need to be processed by rubbing, and alignment division can be achieved by the laying of linear structures (76 and 82). This makes it possible to obtain a wide viewing angle combined with high contrast. Moreover, since there is no need to perform rubbing, the liquid crystal display panel 70 is easy to fabricate. In addition, there is no possibility of contamination with shavings of alignment films during rubbing.

[0027] The MVA-type liquid crystal display panel 70 described above, however, has the following disadvantages. The liquid crystal molecules are, in reality, not inclined in an ideal manner, making it impossible to achieve optimum display. In particular, at the periphery of the pixel electrode 74, the liquid crystal molecules 84' are inclined not only by being restricted by the ridges 82 and the slits 76 but also by being influenced by the edge of the pixel electrode 74, often resulting in uneven display and the like.

[0028] FIG. 7 is a plan view schematically showing how the liquid crystal molecules 84' are inclined. Arrows inside the pixel electrode 74 indicate the directions in which the liquid crystal molecules 84' are inclined. The orientations of those arrows indicate the orientations of the liquid crystal molecules, when inclined, from their ends closer to the second substrate 78 having the ridges 82 to their ends closer to the first substrate 71 having the pixel electrode 74.

[0029] The orientations of the liquid crystal molecules 84' are so restricted as to be inclined at about 90° to the ridges

82 and the slits 76. Moreover, the liquid crystal molecules 84' are inclined in opposite directions between on opposite sides of the slits 76 and the ridges 82 near their outlines. Thus, the liquid crystal molecules 84' are inclined in the same directions near the outlines of mutually adjacent ridges 82 and slits 76.

[0030] At the edge of the pixel electrode 74, the liquid crystal molecules 84' are so influenced as to be inclined in directions at 90° to the edge. Since the edge of the pixel electrode 74 is not parallel to the slits 76 or the ridges 82, it adversely influences the inclination of the liquid crystal molecules 84'. This influence at the edge varies greatly according to how the slits 76 and the ridges 82 are located near the edge.

[0031] For example, in regions A1 shown in **FIG. 7**, the orientations of arrows near the slits 76 and the ridges 82 are about 45° deviated from the orientations of arrows near the edge. By contrast, in regions A2, the orientations of arrows near the slits 76 and the ridges 82 are about 135° deviated from the orientations of arrows near the edge. Thus, the inclination of the liquid crystal molecules 84' is more disturbed in the regions A2, making uneven display more likely in the regions A2 than in the regions A1.

[0032] As described above, in the conventional MVA-type liquid crystal display panel 70, at an end of each pixel, the alignment of the liquid crystal molecules 84' is disturbed by the edge of the pixel electrode 74. This results in the problem of disclination occurring at the periphery of the pixel.

[0033] With a view to overcoming this problem unique to an MVA-type liquid crystal display panel, namely the appearance of misaligned regions, Japanese Patent Application Laid-open No. 2001-083517 mentioned previously discloses another structure. **FIG. 8** is a plan view showing a pixel of a so structured liquid crystal display panel. **FIGS. 9A and 9B** are sectional views of **FIG. 8** taken along line D-D. While **FIG. 9A** shows a state observed when no electric field is applied, **FIG. 9B** shows a state observed when an electric field is applied. In **FIGS. 8, 9A**, and 9B, such parts as are found also in the liquid crystal display panel 70 shown in **FIGS. 5 and 6** are identified with common reference numerals.

[0034] In the liquid crystal display panel 90, auxiliary ridges 89 are additionally laid outside the effective pixel area so as to be contiguous with the ridges 82 for controlling the alignment of the liquid crystal molecules 84'. In other respects, the structure here is substantially the same as that of the liquid crystal display panel 70 shown in **FIGS. 5 and 6**. In this MVA-type liquid crystal display panel 90, the liquid crystal molecules 84' are less influenced by the edge of the pixel electrode 74 or by the electric fields from the adjacent pixels. Thus, it is possible to effectively alleviate disclination.

[0035] In portable appliances employing liquid crystal display panels, research and development have been done on liquid crystal display panels. A semitransmissive liquid crystal display panel offers advantages of both a transmissive one and a reflective one, and using it helps reduce power consumption. The above-described technique of MVA has also been applied to such semitransmissive liquid crystal display panels.

[0036] Japanese Patent Application Laid-open No. 2004-069767 discloses an MVA-type semitransmissive liquid crystal display panel. In this liquid crystal display panel, slits are provided in the common electrode of both a reflective portion and a transmissive portion on the color filter side, and open regions or elevating members are provided, as an aligning means for dividing the alignment of liquid crystal molecules, near the pixel electrode of the reflective portion and the pixel electrode of the transmissive portion.

[0037] In small-screen liquid crystal display panels used in the display section of mobile appliances such as digital cameras and cellular phones, very high resolutions have recently come to be sought-after. For example, nowadays, for about 2.2-inch screens, 320×240-pixel (QVGA) liquid crystal display panels are widely used. In addition, development are being done on 640×480-pixel (VGA) liquid crystal display panels for about 2.2-inch screens, hence with resolutions of 300 ppi and over.

[0038] In such small-screen, high-resolution liquid crystal display panels, compared with liquid crystal display panels or the like for, for example, 40-inch-screen television monitors, the size of one pixel is very small. A pixel typically has an auxiliary capacitance formed therein for the purpose of holding a voltage after an active device has turned off. Disadvantageously, as the size of a pixel becomes smaller, it becomes increasingly difficult to secure a sufficient capacitance as an auxiliary capacitance.

[0039] Liquid crystal display panels designed for mobile appliances are supposed to be used both outdoors and indoors. For this reason, for such application are often used semitransmissive liquid crystal display panels, which offer advantages of both transmissive and reflective ones, promising higher brightness like the former and permitting power saving like the latter. In a semitransmissive liquid crystal display panel, a reflective portion and a transmissive portion are provided within one pixel. It is therefore necessary, when the above-described technique of MVA is adopted, to form ridges and slits for restricting the alignment of liquid crystal molecules while giving consideration to their influence on display. Disadvantageously, this often makes it difficult to lay such ridges and slits.

SUMMARY OF THE INVENTION

[0040] An object of the present invention is to provide an MVA-type semitransmissive liquid crystal display panel that permits a sufficient capacitance to be secured as an auxiliary capacitance and that offers satisfactory display quality.

[0041] To achieve the above object, according to the present invention, a semitransmissive liquid crystal display panel is provided with: first and second substrates that are disposed to face each other, the first substrate having signal lines and scan lines laid thereon in a grid-like pattern so as to demarcate pixels within each of which a reflective portion and a transmissive portion are formed; a liquid crystal layer that is laid between the first and second substrates and whose dielectric constant shows a negative anisotropy; alignment films that are laid over the first and second substrates, respectively, and that have been processed for vertical alignment; and an alignment restricter that is laid on at least one of the first and second substrates, the alignment restricter restricting the directions in which liquid crystal molecules are inclined. Here, the liquid crystal molecules are vertically aligned when no electric field is applied to the liquid crystal layer, and are horizontally aligned and inclined in the directions restricted by the alignment restricter when an electric field is applied to the liquid crystal layer. Furthermore, in this liquid crystal display panel, by the use of an auxiliary capacitance electrode, an auxiliary capacitance is formed on the first substrate in the reflective portion thereof, and the alignment restricter is formed on the second substrate in the reflective portion thereof and on the first substrate in the transmissive portion thereof.

[0042] With this structure, even in an MVA-type semitransmissive liquid crystal display panel, it is possible to secure an auxiliary capacitance electrode in such a way that it occupies the greater part of the reflective portion, and thereby to secure a sufficient auxiliary capacitance. Moreover, it is possible, while securing a high auxiliary capacitance in the reflective portion, to restrict the alignment of liquid crystal molecules also in the reflective portion. Furthermore, it is possible to alleviate disclination resulting from different alignments of liquid crystal molecules acting against each other near the boundary between the transmissive and reflective portions. Thus, it is possible to realize an MVA-type semitransmissive liquid crystal display panel that offers satisfactory display quality.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] **FIG. 1** is a plan view schematically showing one pixel of a semitransmissive liquid crystal display panel embodying the invention, as viewed through a color filter;

[0044] **FIG. 2** is a sectional view along line A-A shown in **FIG. 1**;

[0045] **FIGS. 3A** to 3G are plan views schematically showing one pixel of other semitransmissive liquid crystal display panels embodying the invention, as viewed through a color filter;

[0046] **FIGS. 4A and 4B** are sectional views showing a conventional VA-type liquid crystal display apparatus;

[0047] **FIG. 5** is a plan view showing one pixel of a conventional MVA-type liquid crystal display panel;

[0048] **FIG. 6** is a sectional view along line C-C shown in **FIG. 5**;

[0049] **FIG. 7** is a diagram schematically showing how liquid crystal molecules are inclined in a conventional MVA-type liquid crystal display panel;

[0050] **FIG. 8** is a plan view showing one pixel of another conventional MVA-type liquid crystal display panel; and

[0051] **FIGS. 9A and 9B** are sectional views along line D-D shown in **FIG. 8**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0052] Hereinafter, embodiments of the present invention will be described with reference to the drawings. The following description deals with semitransmissive liquid crystal display panels as embodiments to which the technical idea of the present invention is applied. It should however be understood that the present invention may be practiced in any manner other than specifically described below. The embodiments described below are directed to small-screen liquid crystal display panels for use in the display section of mobile appliances such as digital cameras and cellular phones, and in particular to those for about 2.2-inch screens with 640×480 pixels (VGA), hence with resolutions of 300 ppi and over, and with 320×240 pixels (QVGA). Accordingly, in these liquid crystal display panels, the size of one pixel is far smaller than in liquid crystal display panels or the like for, for example, 40-inch-screen television monitors.

[0053] **FIG. 1** is a plan view schematically showing the part corresponding to one pixel of a semitransmissive liquid crystal display panel embodying the invention, as viewed through a color filter. **FIG. 2** is a sectional view along line A-A shown in **FIG. 1**.

[0054] In the semitransmissive liquid crystal display panel **10**, over a transparent first substrate **11** such as a glass substrate, a gate insulating film **12** is laid, and, on top thereof, scan lines **13** and signal lines **14** are laid in a grid-like pattern. Each area enclosed by two adjacent scan lines **13** and two adjacent signal lines **14** corresponds to one pixel, and, within this area, a pixel electrode **15** is laid. This pixel is divided, at the middle thereof, into a reflective portion and a transmissive portion.

[0055] In a central portion of the pixel electrode **15** in the transmissive portion, a slit **17** (described in detail later) is formed. At the intersection between a scan line **13** and a signal line **14**, a TFT **16** as switching device is formed, and is connected to the pixel electrode **15**. Almost all over the reflective portion, an auxiliary capacity electrode **31** is laid on top of the first substrate **11**.

[0056] The gate electrode G of the TFT **16** is connected to the scan line **13**. The source electrode S of the TFT **16** is connected to the signal line **14**. The drain electrode D of the TFT **16** is laid above the auxiliary capacity electrode **31**, with a gate insulating film **12** laid in between. The auxiliary capacity electrode **31** is so secured as to occupy a large area almost all over the reflective portion, and accordingly the drain electrode D is so secured as to occupy a large area. In this way, it is possible to secure a high auxiliary capacity within one pixel.

[0057] Almost all over the surface of the TFT **16** and the surface of the gate insulating film **12**, an insulating film **32** and an interlayer insulating film **33**, both transparent, are laid. Any level differences on the surface of the interlayer insulating film **33** are removed to obtain a constant cell gap, and thus the surface of the interlayer insulating film **33** is formed flat. Slight surface irregularities, however, are left on the surface of the interlayer insulating film **33** in the reflective portion. This helps eliminate directivity and disperse the reflected light.

[0058] Over the surface of the interlayer insulating film **33** in the reflective portion is laid a reflective electrode **34** of a highly reflective metal such as silver or aluminum. On the surface of the reflective electrode **34** and on the surface of the interlayer insulating film **33** in the transmissive portion is laid a pixel electrode **15** of a transparent electrically conductive material such as ITO. The surface of the pixel electrode **15** and the slit **17** are covered with an alignment film **18** that has been processed for vertical alignment. The pixel electrode **15** in the reflective portion and the drain electrode D of the TFT **16** are electrically connected together by a contact hole **35**.

[0059] On the other hand, on a transparent second substrate **19** such as a glass substrate, a black matrix (unillustrated) is formed so as to demarcate the individual pixels. Moreover, on the second substrate **19**, color filters **21** are laid so that one of red (R), green (G), and blue (B) filters corresponds to each pixel.

[0060] The color filter **21** is so formed as to have the same thickness in the reflective and transmissive portions. Part of the color filter **21** is cut out to leave a cut-out portion **36**. In the reflective portion, the light incident thereon passes through the color filter **21** twice, namely at the time of incidence and at the time of emergence. Thus, leaving the cut-out portion **36** helps make the reflective portion appear the same color as the transmissive portion.

[0061] On the color filter **21** is laid a common electrode **22**, which is a transparent electrode of, for example, ITO. On the common electrode **22**, ridges **23** are formed in a predetermined pattern. Moreover, all over the reflective portion, on the color filters **21**, a top coat **37** is laid with a predetermined thickness. On the top coat **37**, a ridge **41** is formed in a predetermined pattern. The common electrode **22** and the ridges **23** and **41** are covered with an alignment film **24** that has been processed for vertical alignment.

[0062] Between the first and second substrates **11** and **19** is laid a liquid crystal layer **25** whose dielectric constant shows a negative anisotropy. When no electric field is present between the pixel electrode **15** and the common electrode **22**, the liquid crystal molecules are vertically aligned by being restricted by the alignment films **18** and **24**. When an electric field is present between the pixel electrode **15** and the common electrode **22**, the liquid crystal molecules are inclined in the horizontal direction. Here, the liquid crystal molecules are inclined in predetermined directions by being restricted by the slit **17** and the ridges **23**, producing a plurality of domains within a single pixel. Outside the first and second substrates **11** and **19** are laid $\lambda/4$ phase difference plates **39** and **40**, respectively.

[0063] Next, the shapes of the slit **17** and the ridges **23** will be described. The slit **17** is formed by removing part of the pixel electrode **15** by photolithography or the like. The ridges **23** are formed, for example, by laying a resist layer of acrylic resin or the like and then forming it into a predetermined pattern by photolithography. In this embodiment, the ridges **23** are formed one on each side of the rectangular transmissive portion so as to extend in the direction in which the pixel electrode **15** extends, the two ridges **23** thus located side by side above the signal lines **14**.

[0064] The slit **17** is formed in a central portion of the pixel electrode **15** in the transmissive portion so as to be located between the ridges **23**. In this embodiment, the slit **17** is formed in the shape of a thick erect Y and a thick inverted Y combined together so as to be symmetric about a horizontal middle line. The ridge **41** in the reflective portion is formed, like the slit **17** in the transmissive portion, in the shape of a thick erect Y and a thick inverted Y combined together so as to be symmetric about a horizontal middle line.

[0065] In the semitransmissive liquid crystal display panel **10** structured as described above, substantially no ridge exists in a central portion of the transmissive portion facing the pixel electrode **15**. Thus, no part of the light transmitted through the pixel electrode **15** in the transmissive portion is absorbed by a ridge. Moreover, the liquid crystal molecules are inclined in directions perpendicular to the ridges **23** and the slit **17** with respect to a direction normal to the semitransmissive liquid crystal display panel **10**.

[0066] Here, the liquid crystal molecules are so inclined as to point from the ridges **23** of the second substrate **19** to the slit **17** of the first substrate **11**. Thus, at ends of the pixel where the ridges **23** and the slit **17** cross each other, the deviation of the orientations of the liquid crystal molecules is as small as, for example, 45°. Thus, it is possible to alleviate disclination, thereby to make display and brightness less uneven, and to obtain satisfactory display quality in the transmissive portion.

[0067] On the other hand, in the reflective portion, almost all the area thereof is occupied by the drain electrode D. Since the drain electrode D and the pixel electrode **15** are at the same potential, even if a slit is formed in the pixel electrode **15**, it cannot restrict alignment because of the influence of the drain electrode D. Thus, when the ridge **41** is formed on the common electrode **22**, the liquid crystal molecule can be aligned in predetermined directions.

[0068] Here, since the ridge **41** is formed in a central portion of the reflective portion, the liquid crystal molecules are so inclined as to point from the ridge **41** of the second substrate **78** to the ends of the pixel of the first substrate **71**. In this way, even in the reflective portion, providing an alignment restricting means makes it possible to realize the feature of MVA.

[0069] Moreover, no member that would disturb the alignment of liquid crystal molecules exits between the reflective and transmissive portions, and the alignment continuously changes between the reflective and transmissive portions. This makes it possible to realize an MVA-type semitransmissive liquid crystal display panel that operates with reduced disclination and thus with less uneven display and brightness and that offers satisfactory display quality. From the viewpoint of preventing a lowering of brightness, it is preferable to make the ridges **23** so wide that the width of the signal lines **14** falls within the width of the ridges **23** and that, as seen in a plan view, the ridges **23** do not much overhang from the signal lines **14**.

[0070] The shapes of the slit **17**, of the ridges **23** in the transmissive portion, and of the ridge **41** in the transmissive portion are not limited to those shown in **FIG. 1** as adopted in this embodiment, but may be modified in many ways. For example, in the liquid crystal display panel shown in **FIG. 3A**, the slit **17**, the ridges **23**, and the ridge **41** all have smaller widths than in the liquid crystal display panel shown in **FIG. 1**.

[0071] In the liquid crystal display panel shown in **FIG. 3B**, the slit **17** in the transmissive portion has a smaller width than in the liquid crystal display panel shown in **FIG. 1**. Moreover, the ridge **41** in the reflective portion is cross-shaped so as to be wide and long in the direction in which the pixel electrode **15** extends and narrow and short in the direction perpendicular thereto.

[0072] In the liquid crystal display panel shown in **FIG. 3C**, the slit **17** in the transmissive portion is divided into two parts each bifurcated at one end and thus substantially Y-shaped, with one part inverted relative to and separate from the other. These two parts are located symmetrically in the direction in which the pixel electrode **15** extends. Moreover, the ridge **41** in the reflective portion is cross-shaped so as to be long in the direction in which the pixel electrode **15** extends and short in the direction perpendicular thereto. The ridge **41** may have the same width in the two mutually perpendicular directions.

[0073] In the liquid crystal display panel shown in **FIG. 3D**, the slit **17** in the transmissive portion has a smaller width than in the liquid crystal display panel shown in **FIG. 1**. Moreover, the ridge **41** in the reflective portion is cross-shaped so as to be long in the direction in which the pixel electrode **15** extends and short in the direction perpendicular thereto. The ridge **41** may have the same width in the two mutually perpendicular directions.

[0074] In the liquid crystal display panel shown in **FIG. 3E**, the slit **17** in the transmissive portion has a smaller width than in the liquid crystal display panel shown in **FIG. 3D**. Moreover, the ridge **41** in the reflective portion is smaller than in the liquid crystal display panel shown in **FIG. 3A**.

[0075] In the liquid crystal display panels shown in **FIGS. 3F and 3G**, the slit **17** in the transmissive portion and the ridge **41** in the reflective portion are cross-shaped, with different widths and different lengths, so as to be long in the direction in which the pixel electrode **15** extends. The ridge **41** extending in the direction in which the pixel electrode **15** extends has a greater width in **FIG. 3F** than in **FIG. 3G**. Moreover, the ridge **23** in the transmissive portion is U-shaped so as to surround the transmissive portion except along the boundary between the reflective and transmissive portion.

[0076] In the semitransparent liquid crystal display panels shown in **FIGS. 3A** to **3**G also, an alignment pattern similar to that conventionally achieved by MVA can be achieved in the reflective portion. Moreover, since no member that would disturb the alignment of liquid crystal molecules exits between the reflective and transmissive portions, the alignment continuously changes even between the reflective and transmissive portions. This makes it possible to realize a semitransmissive liquid crystal display panel that operates with reduced disclination and that offers satisfactory display quality.

LIST OF REFERENCE NUMERALS

[0077] **10** Liquid Crystal Display Panel

[0078] **11** First Substrate

[0079] **12** Gate Insulating Film

[0080] **13** Scan Line

[0081] **14** Signal Line

[0082] **15** Pixel Electrode

[0083] **16** TFT

[0084] **17** Slit

[0085] **19** Second Substrate

[0086] **21** Color Filter

[0087] **22** Common Electrode

[0088] **23**,**41** Ridge

[0089] **25** Liquid Crystal Layer

[0090] **31** Auxiliary Capacity Electrode

[0091] **33** Interlayer Insulating Film

[0092] **34** Reflective Electrode

[0093] **36** Cut-out Portion

What is claimed is:

1. A semitransmissive liquid crystal display panel comprising:

first and second substrates that are disposed to face each other, the first substrate having signal lines and scan lines laid thereon in a grid-like pattern so as to demarcate pixels within each of which a reflective portion and a transmissive portion are formed;

a liquid crystal layer that is laid between the first and second substrates and whose dielectric constant shows a negative anisotropy;

alignment films that are laid over the first and second substrates, respectively, and that have been processed for vertical alignment; and

an alignment restricter that is laid on at least one of the first and second substrates, the alignment restricter restricting a direction in which liquid crystal molecules are inclined,

the liquid crystal molecules being vertically aligned when no electric field is applied to the liquid crystal layer, and being horizontally aligned and inclined in a direction restricted by the alignment restricter when an electric field is applied to the liquid crystal layer,

wherein, by use of an auxiliary capacitance electrode, an auxiliary capacitance is formed on the first substrate in the reflective portion thereof, and

wherein the alignment restricter is formed on the second substrate in the reflective portion thereof and on the first substrate in the transmissive portion thereof.

2. The semitransmissive liquid crystal display panel of claim 1,

wherein the alignment restricter formed on the first substrate in the transmissive portion thereof is a slit formed in a central part of the transmissive portion.

3. The semitransmissive liquid crystal display panel of claim 1,

wherein the alignment restricter is a slit or ridge having at least one branched-off portion.

4. The semitransmissive liquid crystal display panel of claim 1,

wherein the alignment restricter formed in the transmissive portion is a slit formed in a pixel electrode on the first substrate, and a ridge is formed at a periphery of the transmissive portion so as to overlap the signal lines as seen in a plan view.

5. The semitransmissive liquid crystal display panel of claim 1, wherein the liquid crystal layer has different thicknesses in the reflective and transmissive portions.

* * * * *

patsnap

专利名称(译)	半透射式液晶显示面板		
公开(公告)号	US20060066790A1	公开(公告)日	2006-03-30
申请号	US11/237814	申请日	2005-09-29
[标]申请(专利权)人(译)	三洋电机株式会社 鸟取三洋电机株式会社		
申请(专利权)人(译)	SANYO ELECTRIC CO.，LTD. 鸟取三洋电机有限公司.		
当前申请(专利权)人(译)	SANYO ELECTRIC CO.，LTD. 鸟取三洋电机有限公司.		
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IPC分类号	G02F1/1337 G02F1/1335		
CPC分类号	G02F1/133707 G02F1/1393 G02F1/136213 G02F1/134336		
优先权	2004289338 2004-09-30 JP		
外部链接	Espacenet USPTO		

摘要(译)

半透射式液晶显示面板10具有第一基板11，该第一基板11形成在由信号线划分的每个区域中，并且在其上以网格状形状布置的扫描线，形成由像素电极15形成的反射部分和透射部分。狭缝17，其上形成有滤色器21的第二基板19，公共电极22和脊23和41，放置在第一和第二基板11和19上并经过垂直对准处理的取向膜24和液晶层25位于第一和第二基板11和19之间，并显示出负介电常数各向异性。当没有电场施加到液晶层25时，液晶分子垂直排列，并且当电场施加到液晶层25时，液晶分子水平排列并在受到限制的方向上倾斜。狭缝17和脊23和41.狭缝17形成在透射部分中的像素电极的中心部分中，脊23和41形成在像素电极15的外围并且在中心部分中。反射部分。