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(54) LIQUID CRYSTAL DISPLAY DEVICE

FLÜSSIGKRISTALLANZEIGEEINRICHTUNG

DISPOSITIF D'AFFICHAGE À CRISTAUX LIQUIDES

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(73) Proprietor: **Sharp Kabushiki Kaisha**
Osaka-shi, Osaka 545-8522 (JP)

(72) Inventors:
- **HASHIMOTO, Yoshito**
  Osaka-shi, Osaka 545-8522 (JP)
- **OHGAMI, Hiroyuki**
  Osaka-shi, Osaka 545-8522 (JP)
- **SHIBASAKI, Masakazu**
  Osaka-shi, Osaka 545-8522 (JP)
- **KUBO, Masumi**
  Osaka-shi, Osaka 545-8522 (JP)
- **IYAMA, Yuichi**
  Osaka-shi, Osaka 545-8522 (JP)
- **SOGA, Masayuki**
  Osaka-shi, Osaka 545-8522 (JP)

(74) Representative: **Müller - Hoffmann & Partner**
Patentanwälte
Innere Wiener Strasse 17
81667 München (DE)

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Description

TECHNICAL FIELD

[0001] The present invention relates to a liquid crystal display device and specifically to a liquid crystal display device which has a plurality of divisional alignment regions in a pixel.

BACKGROUND ART

[0002] As of now, liquid crystal display devices under development which have wide viewing angle characteristics includes liquid crystal display devices utilizing the IPS (In-Plane-Switching) mode which is a transverse electric field mode or the FFS (Fringe Field Switching) mode, and liquid crystal display devices utilizing the VA (Vertical Alignment) mode. The VA mode is better for mass production than the transverse electric field mode and is therefore used in a wide range of TV applications and mobile applications.

[0003] The VA mode liquid crystal display devices are generally classified into MVA (Multidomain Vertical Alignment) mode liquid crystal display devices, in which one pixel includes a plurality of domains of different liquid crystal alignment directions, and CPA (Continuous Pinwheel Alignment) mode liquid crystal display devices in which the liquid crystal alignment direction continuously varies around a rivet or the like formed on an electrode at the center of a pixel.

[0004] In the MVA mode liquid crystal display devices, the alignment control means which extend in two mutually-orthogonal directions are provided to form four liquid crystal domains in one pixel, in which the azimuthal angles of the directors representing the liquid crystal domains are 45° relative to the polarization axes (transmission axes) of a pair of polarizing plates in a crossed nicols arrangement. Assuming that the direction of the polarization axis of one of the polarizing plates is azimuthal angle 0° and that the counterclockwise direction is the positive direction, the azimuthal angles of the directors of the four liquid crystal domains are 45°, 135°, 225°, and 315°. Such a structure which includes four domains in one pixel is referred to as "four-division alignment structure" or simply "4D structure". When, in each of the four domains, the alignment direction and the polarization axis of the polarizing plate form an angle of 45°, the change in retardation in a liquid crystal region can be utilized most efficiently.

[0005] The MVA mode liquid crystal display devices are not suitable to small pixels (for example, the shorter side is less than 100 μm, particularly less than 60 μm). For example, when slits (or ribs) are used as the alignment control means, the width of the slits need to be about 10 μm or more in order to obtain a sufficient alignment control force. If the slit width is narrower than this, sufficient alignment control force cannot be obtained. To form four domains, it is necessary to form, in a counter electrode, slits ("<"-shaped slit) extending in directions different by 90° from each other when seen in a direction normal to the substrate and to form, in a pixel electrode, slits which are separated by a certain space from the counter electrode slits and which extend parallel to the counter electrode slits. Specifically, both the counter electrode and the pixel electrode in one pixel need to have a plurality of slits extending in the direction of 45°-225° and the direction of 135°-315° and having the width of about 10 μm.

[0006] However, when the above-described slits are applied to a pixel whose shorter side is less than 100 μm, the ratio of the area of the slits to the pixel area increases, and accordingly, part of the pixel area which fails to contribute to display increases, so that the transmittance (brightness) significantly decreases. In the case of a small-size liquid crystal display device of finer definition, e.g., 2.4-inch VGA for use in mobile phones, the pixel pitch (row direction × vertical direction) is, for example, 25.5 μm×76.5 μm. In such a small pixel, the above-described slits cannot be formed.

[0007] In the CPA mode liquid crystal display devices, a rivet is formed of a resin or the like in the counter electrode at the pixel center, such that the rivet and a diagonal electric field produced at an edge of the pixel electrode serve to regulate the alignment of the liquid crystal. Provided in the respective gaps between the two polarizing plates and the liquid crystal layer are 1/4-wave plates (quarter wave plates). By utilizing omniazimuthal, radial slope alignment domains and circular polarization, high transmittance (brightness) can be achieved.

[0008] The CPA mode which utilizes the 1/4-wave plates achieves high transmittance but disadvantageously provides a low contrast ratio and a narrow viewing angle as compared with the MVA mode. Specifically, when the 1/4-wave plates are used, the display (especially, the display at lower gray levels (lower brightness)) appears brighter, i.e., so-called "whitish dots" are conspicuous, when observed in a diagonal viewing angle than when observed in front of the display surface (when observed in a direction normal to the display surface (viewing angle 0°)).

[0009] To solve the above problems of the liquid crystal display device in the MVA mode and the CPA mode, liquid crystal display devices as disclosed in Patent Document 1, Patent Document 2, and Patent Document 3 have been proposed. In the liquid crystal display devices of these patent documents, the four-division alignment structure is realized by forming in the pixel electrodes a large number of narrow slits extending in the direction of 45°-225° and in the direction of 135°-315° (referred to as "fishbone pixel electrode") such that the liquid crystal is aligned parallel to the slits. In liquid crystal display devices which use such fishbone pixel electrodes, large slits or rivets are not formed in pixels, and linearly-polarized light is used without using 1/4-wave plates. Therefore, display can be realized with high transmittance, high contrast ratio, and wide viewing angle.

[0010] Note that the liquid crystal display devices of these patent documents include alignment sustaining layers on surfaces of the upper and lower substrates on the liquid crystal layer side for making the liquid crystal have an appropriate pretilt angle during absence of voltage application to the liquid crystal. These alignment sustaining layers are formed by polymerizing monomers contained in the liquid crystal layer during application of a voltage to the liquid crystal.

[Patent Document 1] Japanese Laid-Open Patent Publication No. 2003-255305
[Patent Document 2] Japanese Laid-Open Patent Publication No. 2003-149647
[Patent Document 3] Japanese Laid-Open Patent Publication No. 2006-330638

[0011] JP 2004 077699 A discloses a liquid crystal display device the transmittance of which has excellent in-plane uniformity. The liquid crystal display device is equipped with first and second substrates placed opposite to each other; a pixel electrodes disposed on the surface of the first substrate opposite to the second substrate: a common electrode disposed on the surface of the second substrate opposite to the first substrate and a liquid crystal layer interposed between the pixel electrode and the common electrode. The pixel electrode is provided with a plurality of sub-pixel electrodes, separated from and electrically connected to one another wherein each of the plurality of sub-pixel electrodes is provided with a plurality of comb-shaped conductive layers of which the shapes of the teeth of comb in the longitudinal directions are mutually different and which are mutually electrically connected. The shapes of patterns formed of the mutually different longitudinal directions are mutually identical among the plurality of sub-pixel electrodes, and the directions of the patterns are mutually different among the plurality of sub-pixel electrodes.

[0012] EP 2 224 283 A1 discloses a liquid crystal display device of high picture quality with high brightness and small display unevenness. A vertical alignment type liquid crystal display device which has a plurality of pixels includes: a first electrode which includes, in each of the plurality of pixels, a plurality of first branch portions extending in a first direction and a plurality of second branch portions extending in a second direction that is different from the first direction; a second electrode disposed so as to oppose the first electrode; and a liquid crystal layer interposed between the first electrode and the second electrode, wherein a width of each of the plurality of first branch portions and the plurality of second branch portions is in a range not less than 1.4 μm and not more than 8.0 μm.

[0013] The above objects are solved by the claimed matter according to the independent claims.

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0014] The pixel electrodes of the liquid crystal display devices described in the aforementioned patent documents have a plurality of linear electrode portions (also referred to as "branch portions" or "line portions") extending in the direction of 45°-225° and the direction of 135°-315°. Abnormal alignment of the liquid crystal, or such a phenomenon that the liquid crystal alignment direction becomes unstable, can occur depending on the shape or size of the linear electrode portions or the shape or size of the plurality of slits extending parallel to the linear electrode portions (also referred to as "linear space portions"), resulting in the problems of variation in transmittance across the display surface, display unevenness, and abnormal gray scale.

[0015] The conventional liquid crystal display device which has linear electrode portions has another problem which will be described below.

[0016] FIG. **13** is a plan view schematically showing a structure of one pixel in a liquid crystal display device described in Patent Document 1. FIG. **14** shows the electric field distribution in a cross section of the pixel shown in FIG. **13** taken along line **B-B'.** FIG. **15** shows the brightness distribution in the pixel shown in FIG. **13.** FIG. **16** shows the alignment of the liquid crystal in the pixel shown in FIG. **13.**

[0017] As shown in FIG. **13,** a pixel **210** of a liquid crystal display device **200** of Patent Document 1 is enclosed by scanning lines **22** and signal lines **23.** Near an intersection of the scanning line **22** and the signal line **23,** a TFT (Thin Film Transistor) **35** for switching the pixel **210** is provided. In the central area of the pixel **210,** an auxiliary capacitance line **24** is provided extending parallel to the scanning lines **22.**

[0018] The pixel electrode **230** provided in the pixel **210** includes a plurality of line portions of two different widths (wider line portions **230a** and narrower line portions **230b**) extending in the 45°-225° direction and the 135°-315° direction. In the pixel **210,** the line portions in the right upper region **210a** (the right half of the area lying above the auxiliary capacitance line **24**) and the left lower region 210c (the left half of the area lying below the auxiliary capacitance line **24**) are all extending in the 45°-225° direction. The line portions in the left upper region **210b** (the left half of the area lying above the auxiliary capacitance line **24**) and the right lower region **210d** (the right half of the area lying below the auxiliary capacitance line **24**) are all extending in the 135°-315° direction. In each of the regions, the plurality of line portions **230a** are interposed between the plurality of line portions **230b.** Therefore, each of these four regions **210a, 210b, 210c,** and

210d includes two boundaries between the wider line portions **230a** and the narrower line portions **230b.**

[0019] The inventor of the present application conducted researches and found that, as shown in FIG. **14,** in the vicinity of the boundaries between the region **A** in which the wider line portions **230a** are provided and the region **B** in which the narrower line portions **230b** are provided, an equipotential surface which is produced by application of a voltage across the liquid crystal layer becomes unstable. If there are many such boundaries, the brightness distribution during the white display has large dark portions in the vicinity of the boundaries as shown in FIG. **15** (encircled portions in the drawing). This may be because the alignment direction of the liquid crystal deviates from a desired orientation (an orientation parallel to the direction in which the line portions extend) due to the unstableness of the equipotential surface near the boundaries as illustrated in FIG. **16.**

[0020] The present invention was conceived with the view of solving the above problems. One of the objects of the present invention is to provide a liquid crystal display device of high display quality, which has high transmittance and which is excellent in grayscale and viewing angle characteristics.

MEANS FOR SOLVING THE PROBLEMS

[0021] The above objects are solved by the claimed matter according to the independent claims.

[0022] In one embodiment, each of the plurality of second branch portions in the first region has the first width, and each of the plurality of second branch portions in the second region has the second width.

[0023] In one embodiment, any adjacent two of the plurality of first branch portions in the first region are separated by a first space, and any adjacent two of the plurality of first branch portions in the second region are separated by a second space that is different from the first space.

[0024] In one embodiment, any adjacent two of the plurality of second branch portions in the first region are separated by the first space, and any adjacent two of the plurality of second branch portions in the second region are separated by the second space.

[0025] In one embodiment, the first region and the second region respectively correspond to one region and the other region of a pixel which are separated by a gate bus line or CS line.

[0026] In one embodiment, the first region and the second region respectively correspond to one region and the other region of a pixel which are separated by a line parallel to a source bus line.

[0027] In one embodiment, the first direction and the second direction are orthogonal to each other, and directions of the transmission axes of the pair of polarizing plates and the first direction are different by 45°, 135°, 225°, or 315°.

[0028] In one embodiment, when a voltage is applied across the liquid crystal layer, four liquid crystal domains among which an alignment direction of liquid crystal molecules is different are formed in each of the first region and the second region.

[0029] In one embodiment, each of the plurality of pixels includes a third region separated from the first region or the second region by a line parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates, the first electrode includes the plurality of first branch portions and the plurality of second branch portions in the third region, and each of the plurality of first branch portions and the plurality of second branch portions in the third region has a third width that is different from the first width or the second width.

[0030] In one embodiment, any adjacent two of the plurality of second branch portions in the first region are separated by the first space, and any adjacent two of the plurality of second branch portions in the second region are separated by the second space.

[0031] In one embodiment, each of the plurality of pixels includes a third region separated from the first region or the second region by a line parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates, the first electrode includes the plurality of first branch portions and the plurality of second branch portions in the third region, and any adjacent two of the plurality of first branch portions in the third region and any adjacent two of the plurality of second branch portions in the third region are separated by a third space that is different from the first space or the second space.

EFFECTS OF THE INVENTION

[0032] A liquid crystal display device of the present invention has a plurality of regions among which the width or space of the branch portions of a fishbone type electrode is different, the plurality of regions being separated by a boundary line parallel to or perpendicular to the directions of the transmission axes of the polarizing plates, such that branch portions of different widths are not adjacently positioned in a liquid crystal domain. Thus, the liquid crystal display device of the present invention is capable of high quality display, in which the brightness is high and the grayscale or viewing angle characteristics are excellent.

BRIEF DESCRIPTION OF DRAWINGS

[0033]

[FIG. **1**] A plan view schematically showing a structure of one pixel in a liquid crystal display device.
[FIG. **2**] A schematic cross-sectional view of the liquid crystal display device of FIG. 1 taken along line A-A' .
[FIG. **3**] A plan view schematically showing a shape of a pixel electrode of the liquid crystal display device of Fig 1.
[FIG. **4**] A graph illustrating the VT characteristic of a pixel of the liquid crystal display device of Fig 1. [FIG. **5**] A graph for illustrating the viewing angle characteristics of a pixel of the liquid crystal display device of Fig 1.
[FIG. **6**] An image showing a state of white display in pixels of the liquid crystal display device of Fig 1.
[FIG. **7**] A plan view schematically showing a structure of one pixel in a liquid crystal display device of another example 2 .
[FIG. **8**] A graph illustrating the VT characteristic of a pixel of the liquid crystal display device of embodiment 2.
[FIG. **9**] A graph for illustrating the viewing angle characteristics of a pixel of the liquid crystal display device of example 2.
[FIG. **10**] A plan view schematically showing a structure of one pixel in a liquid crystal display device of an embodiment of the present invention.
[FIG. **11**] A graph illustrating the VT characteristic of a pixel of the liquid crystal display device of the embodiment .
[FIG. **12**] A graph for illustrating the viewing angle characteristics of a pixel of the liquid crystal display device of the embodiment .
[FIG. **13**] A plan view schematically showing a structure of one pixel in a liquid crystal display device described in Patent Document 1.
[FIG. **14**] A diagram showing the electric field distribution in a cross section of the pixel shown in FIG. **13** taken along line **B-B'**.
[FIG. **15**] An image showing the brightness distribution in the pixel shown in FIG. **13.**
[FIG. **16**] A diagram showing the alignment of the liquid crystal in the pixel shown in FIG. **13.**

DESCRIPTION OF THE REFERENCE NUMERALS

[0034]

10	pixel
20	TFT substrate
21	glass substrate
22	scanning line
23	signal line
24	auxiliary capacitance line
25	insulation layer
26	alignment film
30	pixel electrode
30a, 30a', 30b, 30b'	trunk portion
30c, 30c', 30d, 30d'	branch portion
31, 31'	first region
32, 32'	second region
35	TFT

36	auxiliary capacitance electrode
37	boundary line
40	counter substrate
41	transparent substrate
42	CF layer
43	common electrode
44	alignment film
50	liquid crystal layer
60a, 60b	polarizing plate
70	pixel electrode
70a, 70a', 70a", 70b, 70b', 70b"	trunk portion
70c, 70c', 70c", 70d, 70d', 70d"	branch portion
71	first region
72	second region
73	third region
77a, 77b	boundary line
100, 101, 102	liquid crystal display device

BEST MODE FOR CARRYING OUT THE INVENTION

[0035] Hereinafter, the structures of liquid crystal display devices of an embodiment of the present invention are described with reference to Figs 10-12, although the present invention is not limited to the embodiments described below.

(Example 1)

[0036] FIG. **1** is a plan view schematically showing a structure of one pixel in a liquid crystal display device **100** of an example 1. FIG. **2** is a schematic cross-sectional view of the liquid crystal display device **100** taken along line **A-A'** of FIG. **1.**

[0037] The liquid crystal display device **100** is a vertical alignment type liquid crystal display device which includes a plurality of pixels **10** having the structure shown in FIG. **1** and which performs display in a normally-black mode using the pixels **10** arranged in a matrix. The liquid crystal display device **100** further includes, as shown in FIG. **2,** a TFT substrate **20** which is an active matrix substrate, a counter substrate **40** which is a color filter substrate, and a liquid crystal layer **50** disposed between these substrates. The liquid crystal layer **50** includes nematic liquid crystal which has negative dielectric constant anisotropy ($\Delta\varepsilon<0$).

[0038] The outer side of the TFT substrate **20** (opposite to the liquid crystal layer **50**) is provided with a polarizing plate **60a.** The outer side of the counter substrate **40** is provided with a polarizing plate **60b.** The polarizing plates **60a** and **60b** are in a crossed nicols arrangement such that the light transmission axis of one of the polarizing plates extends in the horizontal direction of FIG. **1,** and the light transmission axis of the other extends in the vertical direction. Note that, in the description below, the azimuthal direction from left to right in FIG. **1** is referred to as "azimuthal direction 0°", relative to which the azimuthal angles are allocated counterclockwise.

[0039] As shown in FIG. **1** and FIG. **2,** the TFT substrate **20** includes a glass substrate (transparent substrate) **21,** scanning lines (gate bus lines) **22,** signal lines (data bus lines) **23** and auxiliary capacitance lines (Cs lines) **24** which are provided on the glass substrate **21,** an insulation layer **25** which is provided over the lines, and pixel electrodes **30**

and an alignment film **26** which are provided on the insulation layer **25.**

[0040] Each of the pixels **10** is surrounded by two adjacent scanning lines **22** and two adjacent signal lines **23.** Each pixel **10** includes a TFT **35** for switching a display voltage for the pixel electrode **30.** The gate electrode and the source electrode of the TFT **35** are electrically connected to the scanning line **22** and the signal line **23,** respectively, and the drain electrode is electrically connected to the pixel electrode **30.** Provided under the pixel electrode **30** at the center of the pixel **10** is an auxiliary capacitance electrode **36** which is electrically connected to the auxiliary capacitance line **24.**

[0041] The counter substrate **40** includes a transparent substrate **41,** a CF (color filter) layer **42** provided on the transparent substrate **41** (on a surface of the transparent substrate on the liquid crystal layer **50** side), a common electrode **43** provided on the CF layer **42,** and an alignment film **44** provided on the common electrode **43.**

[0042] The alignment film **26** of the TFT substrate **20** and the alignment film **44** of the counter substrate **40** both include an alignment layer and an alignment sustaining layer. The alignment layer is a vertical alignment film formed over the substrate by application. The alignment sustaining layer is formed, after the formation of liquid crystal cells, by photopolymerization of photopolymerizable monomers mixed in a liquid crystal material in advance with application of a voltage across the liquid crystal layer **50.** During the polymerization of the monomers, a voltage is applied across the liquid crystal layer **50** by the pixel electrode **30** and the common electrode **43.** A diagonal electric field which occurs depending on the shape of the pixel electrode **30** causes liquid crystal molecules to align, and with the liquid crystal molecules being in that state, the monomers are irradiated with light to be polymerized.

[0043] Using the thus-formed alignment sustaining layer enables liquid crystal molecules to sustain (memorize) their alignment (azimuthal directions of pretilt) even after removal of the voltage (even in a state of no voltage application). In the present example, the alignment films **26** and **44** are configured to provide the liquid crystal with a pretilt angle of 2° throughout the entire pixel **10.** The technique of forming such an alignment film is referred to as PSA (Polymer Sustained Alignment) technique. The details of this technique are described in Patent Documents 2 and 3. These patent documents are incorporated by reference in this specification. The detailed description of the alignment sustaining layer is herein omitted.

[0044] Note that, as shown in FIG. **1,** the pixel **10** is constituted of a first region **31** which is on the upper side of a virtual boundary line **37** passing through the center of the auxiliary capacitance line **24,** and a second region **32** which is on the lower side of the boundary line **37.** In other words, the pixel **10** is constituted of the first region **31** and the second region **32,** which are separated from each other by a line parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates **60a** and **60b** (boundary line **37**). The first region **31** and the second region **32** can alternatively be defined as regions separated from each other by the auxiliary capacitance line **24.** A pixel arrangement in which these regions are separated by the scanning line **22** or the signal line **23** may be employed.

[0045] Next, the shape of a pixel electrode **30** is described with reference to FIG. **3.**

[0046] FIG. **3** is a plan view showing the shape of the pixel electrode **30.** As shown in FIG. **3,** the pixel electrode **30** includes trunk portions **30a** and **30a'** extending in the direction of azimuthal angle 0°-180°, trunk portions **30b** and **30b'** extending in the direction of azimuthal angle 90°-270°, a plurality of branch portions **30c** and **30c'** (first branch portions) extending in the direction of azimuthal angle 45°-225° (first direction), and a plurality of branch portions **30d** and **30d'** (second branch portions) extending in the direction of azimuthal angle 135°-315° (second direction).

[0047] In the first region **31,** the pixel electrode **30** includes the trunk portions **30a** and **30b** that intersect each other at right angles in the central area of the first region **31,** and the plurality of branch portions **30c** and the plurality of branch portions **30d** that branch off from the trunk portion **30a** or **30b.** Among divisional parts of the first region **31** separated by the trunk portion **30a** and the trunk portion **30b,** the right upper part (or "domain"), the left upper part, the left lower part, and the right lower part in the drawing are referred to as the first domain **31a,** the second domain **31b,** the third domain **31c,** and the fourth domain **31d,** respectively. In the first domain **31a,** the branch portions **30c** extend from the trunk portion **30a** or **30b** in the 45° direction. In the second domain **31b,** the branch portions **30d** extend from the trunk portion **30a** or **30b** in the 135° direction. In the third domain **31c,** the branch portions **30c** extend from the trunk portion **30a** or **30b** in the 225° direction. In the fourth domain **31d,** the branch portions **30d** extend from the trunk portion **30a** or **30b** in the 315° direction.

[0048] Widths L1 (first widths) of the branch portions **30c** and the branch portions **30d** are all equal. The distance between any adjacent two of the branch portions **30c** in each of the first domain **31a** and the third domain **31c** and the distance between any adjacent two of the branch portions **30d** in each of the second domain **31b** and the fourth domain **31d,** distances S1, are all equal.

[0049] In the second region **32,** the pixel electrode **30** includes the trunk portions **30a'** and **30b'** that intersect each other at right angles in the central area of the second region **32,** and the plurality of branch portions **30c'** and the plurality of branch portions **30d'** that branch off from the trunk portion **30a'** or **30b'.** Among divisional parts of the second region **32** separated by the trunk portion **30a'** and the trunk portion **30b',** the right upper part, the left upper part, the left lower part, and the right lower part in the drawing are referred to as the first domain **32a,** the second domain **32b,** the third domain **32c,** and the fourth domain **32d,** respectively. In the first domain **32a,** the branch portions 30c' extend from the trunk portion **30a'** or **30b'** in the 45° direction. In the second domain **32b,** the branch portions **30d'** extend from the trunk portion **30a'** or **30b'** in the 135° direction. In the third domain **32c,** the branch portions **30c'** extend from the trunk portion **30a'** or **30b'** in the 225° direction. In the fourth domain **32d,** the branch portions **30d'** extend from the trunk portion **30a'** or **30b'** in the 315° direction.

[0050] All of the branch portions **30c'** and the branch portions **30d'** have equal widths (second width L2) which are different from width L1. The distance between any adjacent two of the branch portions **30c'** in each of the first domain **32a** and the third domain **32c** and the distance between any adjacent two of the branch portions **30d'** in each of the second domain **32b** and the fourth domain **32d,** distances S2, are all equal. Distance S2 is different from distance S1.

[0051] Note that width L1 and width L2 of the branch portions each refer to a dimension of a branch portion perpendicular to the direction in which the branch portions extend. Distances S1 and S2 between two branch portions each refer to a dimension of a gap (slit portion) formed between adjacent two branch portions that is perpendicular to the direction in which the branch portions extend. Width L1 and width L2 are sometimes referred to as "line width L1" and "line width L2", respectively. Distance S1 and distance S2 are sometimes referred to as "slit width S1" and "slit width S2", respectively. The values of width L1 and distance S1 are, for example, 1.5 μm and 3.0 μm, respectively. The values of width L2 and distance S2 are, for example, 2.5 μm and 2.5 μm, respectively. Widths L1 and L2 and distances S1 and S2 are not limited to these values, but may desirably be set to 5.0 μm or less.

[0052] The pixel electrode **30** which has the above-described shape and the alignment films **26** and **44** form a multi-domain of 4D structure in each of the first region **31** and the second region **32.** When no voltage is applied, the azimuthal directions of the pretilt of the liquid crystal molecules in the respective domains are parallel to the branch portions **30c, 30d, 30c'**, or **30d'** in the respective domains, depending on the azimuthal directions memorized in the alignment films **26** and **44.** When a voltage is applied, the liquid crystal molecules of the respective domains are oriented in polar angle directions whose azimuthal directions are parallel to the branch portions **30c, 30d,** 30c', or **30d'** in the domains (the azimuthal directions of the directors of the domains) and which are more parallel to the substrate surface. In this case, the azimuthal directions of the orientation are coincident with the azimuthal directions of the pretilt, and therefore, the orientation in correct azimuthal directions with an extremely high response rate is realized.

[0053] Since the liquid crystal display device **100** of example 1 has the pixel electrode **30** which has the above-described shape, the boundary between the domain formed by the branch portions **30c** and **30d** in the first region **31** and the domain formed by the branch portions **30c'** and **30d'** in the second region lies on the boundary line **37** (or on the auxiliary capacitance line **24**). Thus, the respective domains do not include any region in which a wider branch portion and a narrower branch portion be adjacently positioned.

[0054] FIG. **4** is a graph illustrating the voltage dependence of the transmittance (VT characteristic) in the first region **31** and the second region **32** when the display surface is viewed from a position in front of the display surface (in the polar angle 0° direction). In the graph, lines a and b represent the VT characteristics in the first region **31** and the second region **32,** respectively.

[0055] Between the first region **31** and the second region **32,** the width of the branch portions and the space between two branch portions are different. Accordingly, the liquid crystal alignment control force is also different between these two regions. Therefore, the different VT characteristics such as shown in FIG. **4** are obtained in the two regions. Note that the VT characteristic across the entire display surface is equal to the average of these two VT characteristics.

[0056] In general, the VT characteristic achieved by a pixel electrode having a specific shape is different from an ideal characteristic, and therefore, defects such as whitish or blackish dots can occur in display. In the liquid crystal display device of example 1, two different VT characteristics can be obtained in one pixel, and the VT characteristic achieved across the entire display surface is equal to the average of the two VT characteristics. Therefore, ideal brightness and grayscale characteristics can be obtained by appropriately setting widths L1 and L2 and distances S1 and S2 depending on the size, shape, or use of the liquid crystal display device.

[0057] FIG. **5** is a graph for illustrating the viewing angle characteristics of the liquid crystal display device 100 of example 1. In FIG. **5**, line m represents the relationship between the transmittance obtained when the display surface of the liquid crystal display device **100** which has the pixel **10** is viewed from a position in front of the display surface (front transmittance) and the transmittance obtained when the display surface is viewed in a direction defined by azimuthal angle 45° and polar angle 60° (diagonal transmittance). This relationship is hereinafter simply referred to as "viewing angle characteristic". Specifically, line m represents the average of the viewing angle characteristics obtained in the first region **31** and the second region **32.** Line n represents the viewing angle characteristic obtained in the first region **31** (in which the pixel electrode does not have two different line widths or slit widths). Note that line 1 in FIG. **5** is a reference line on which the front transmittance and the diagonal transmittance are equal.

[0058] As seen from FIG. **5,** by arranging pixel electrode portions having two line widths or slits widths into two separate regions as in the present example, the difference between the front transmittance and the diagonal transmittance becomes small, i.e., the viewing angle characteristics improve, as compared with a case where a pixel electrode used has a single line width and a single slit width.

[0059] FIG. **6** is an image showing a state of white display in the first region **31** and the second region **32.** As shown in FIG. **15,** in the conventional liquid crystal display device, each of the four domains includes two regions (one pixel includes eight regions) in which a wider branch portion and a narrower branch portion are adjacently positioned, so that abnormal alignment of the liquid crystal occurs. As a result, during the white display, a relatively large dark portion occurs in the central area of the pixel, deteriorating the transmittance and brightness. On the other hand, in example 1, the pixel electrode 30 has the above-described shape, and therefore, the eight domains of the pixel **10** do not include any region in which a wider branch portion and a narrower branch portion be adjacently positioned. Thus, according to example 1, the abnormal alignment of the liquid crystal is unlikely to occur, and display with high brightness can be achieved in which occurrence of a dark portion is prevented as shown in FIG. **6.**

[0060] Thus, the liquid crystal display device of example 1 is capable of high quality display with excellent grayscale characteristics and viewing angle characteristics and with high brightness. Note that the shape of the pixel electrode **30** of embodiment 1 may be applied to the shape of the counter electrode in one pixel. In this case also, substantially the same effects as those described above can be obtained.

example 2)

[0061] Hereinafter, a liquid crystal display device of an example 2 is described. The liquid crystal display device of example 2 has a pixel electrode of another fishbone shape in place of the pixel electrode **30** of the liquid crystal display device of example 1, and the other elements are the same as those of example 1. Thus, only the pixel electrode is described below.

[0062] FIG. **7** is a plan view schematically showing one of a plurality of pixel electrodes **70** arranged in a liquid crystal display device **101** of example 2.

[0063] As shown in FIG. **7,** the pixel electrode **70** includes trunk portions **70a, 70a',** and **70a"** extending in the direction of azimuthal angle 0°-180°, trunk portions **70b, 70b',** and **70b"** extending in the direction of azimuthal angle 90°-270°, a plurality of branch portions **70c, 70c',** and **70c"** (first branch portions) extending in the direction of azimuthal angle 45°-225° (first direction), and a plurality of branch portions **70d, 70d**', and **70d"** (second branch portions) extending in the direction of azimuthal angle 135°-315° (second direction).

[0064] The pixel of example 2 includes a first region **71,** a second region **72,** and a third region **73** which are separated by two virtual boundary lines **77a** and **77b** extending parallel to the scanning line (parallel to or vertical to the directions of the transmission axes of the pair of polarizing plates). The boundary line **77a** separates the first region **71** and the second region **72** from each other. The boundary line **77b** separates the second region **72** and the third region **73** from each other.

[0065] In the first region **71,** the pixel electrode **70** includes the trunk portions **70a** and **70b** that intersect each other at right angles in the central area of the first region **71,** and the plurality of branch portions **70c** and the plurality of branch portions **70d** that branch off from the trunk portion **70a** or **70b.** Among divisional parts of the first region **71** separated by the trunk portion **70a** and the trunk portion **70b,** the right upper part (or "domain"), the left upper part, the left lower part, and the right lower part in the drawing are referred to as the first domain **71a,** the second domain **71b,** the third domain **71c,** and the fourth domain **71d,** respectively. In the first domain **71a,** the branch portions **70c** extend from the trunk portion **70a** or **70b** in the 45° direction. In the second domain **71b,** the branch portions **70d** extend from the trunk portion **70a** or **70b** in the 135° direction. In the third domain **71c,** the branch portions **70c** extend from the trunk portion **70a** or **70b** in the 225° direction. In the fourth domain **71d,** the branch portions **70d** extend from the trunk portion **70a** or **70b** in the 315° direction.

[0066] The widths of the branch portions **70c** and **70d** (first line widths) are all equal. The distance between any adjacent two of the branch portions **70c** in each of the first domain **71a** and the third domain **71c** and the distance between any adjacent two of the branch portions **70d** in each of the second domain **71b** and the fourth domain **71d** (first slit widths) are all equal.

[0067] In the second region **72,** the pixel electrode includes the trunk portions **70a'** and **70b'** that intersect each other at right angles in the central area of the second region **72,** and the plurality of branch portions **70c'** and the plurality of branch portions **70d'** that branch off from the trunk portion **70a'** or **70b'.** Among divisional parts of the second region **72** separated by the trunk portion **70a'** and the trunk portion **70b',** the right upper part, the left upper part, the left lower part, and the right lower part in the drawing are referred to as the first domain **72a,** the second domain **72b,** the third domain **72c,** and the fourth domain **72d,** respectively. In the first domain **72a,** the branch portions **70c'** extend from the trunk portion **70a'** or **70b'** in the 45° direction. In the second domain **72b,** the branch portions **70d'** extend from the trunk portion **70a'** or **70b'** in the 135° direction. In the third domain **72c,** the branch portions **70c'** extend from the trunk portion **70a'** or **70b'** in the 225° direction. In the fourth domain **72d,** the branch portions **70d'** extend from the trunk portion **70a'** or **70b'** in the 315° direction.

[0068] All of the branch portions **70c'** and the branch portions **70d'** have equal widths (second line width) which are different from the first line width. The distance between any adjacent two of the branch portions **70c'** in each of the first domain **72a** and the third domain **72c** and the distance between any adjacent two of the branch portions **70d'** in each of the second domain **72b** and the fourth domain **72d** (second slit widths) are all equal. The second slit width is different from the first slit width.

[0069] In the third region **73,** the pixel electrode includes the trunk portions **70a"** and **70b"** that intersect each other at right angles in the central area of the third region **73,** and the plurality of branch portions **70c"** and the plurality of branch portions **70d"** that branch off from the trunk portion **70a"** or **70b".** Among divisional parts of the third region **73** separated by the trunk portion **70a"** and the trunk portion **70b",** the right upper part, the left upper part, the left lower part, and the right lower part in the drawing are referred to as the first domain **73a,** the second domain **73b,** the third domain **73c,** and the fourth domain **73d,** respectively. In the first domain **73a,** the branch portions **70c"** extend from the trunk portion **70a"** or **70b"** in the 45° direction. In the second domain **73b,** the branch portions **70d"** extend from the trunk portion **70a"** or **70b"** in the 135° direction. In the third domain **73c,** the branch portions **70c"** extend from the trunk portion **70a"** or **70b"** in the 225° direction. In the fourth domain **73d,** the branch portions **70d"** extend from the trunk portion **70a"** or **70b"** in the 315° direction.

[0070] All of the branch portions **70c"** and the branch portions **70d"** have equal widths (third line width) which are different from the first line width or the second line width. The distance between any adjacent two of the branch portions **70c"** in each of the first domain **73a** and the third domain **73c** and the distance between any adjacent two of the branch portions **70d"** in each of the second domain **73b** and the fourth domain **73d** (third slit widths) are all equal. The third slit width is different from the first slit width or the second slit width.

[0071] The first line width, the second line width, and the third line width are, for example, 1.5 μm, 2.5 μm, and 2.0 μm, respectively. The first slit width, the second slit width, and the third slit width are, for example, 4.0 μm, 3.5 μm, and 2.5 μm, respectively. The line widths and the slit widths are not limited to these values, but may desirably be set to 5.0 μm or less.

[0072] The pixel electrode **70** which has the above-described shape and the alignment films form a multidomain of 4D structure in each of the first region **71,** the second region **72,** and the third region **73.** When no voltage is applied, the azimuthal directions of the pretilt of the liquid crystal molecules in the respective domains are parallel to the branch portions in the respective domains, depending on the azimuthal directions memorized in the alignment films. When a voltage is applied, the liquid crystal molecules of the respective domains are oriented in a polar angle directions whose azimuthal directions are parallel to the branch portions in the domains (the azimuthal directions of the directors of the domains) and which are more parallel to the substrate surface. In this case, the azimuthal directions of the orientation are coincident with the azimuthal directions of the pretilt, and therefore, the orientation in correct azimuthal directions with an extremely high response rate is realized.

[0073] Since the liquid crystal display device **101** of example 2 has the pixel electrode **70** which has the above-described shape, the boundary between the domain formed by the branch portions **70c** and **70d** in the first region **71** and the domain formed by the branch portions **70c'** and **70d'** in the second region **72** lies on the boundary line **77a,** and the boundary between the domain formed by the branch portions **70c'** and **70d'** in the second region **72** and the domain formed by the branch portions **70c"** and **70d"** in the third region **73** lies on the boundary line **77b.** Thus, the respective domains do not include any region in which branch portions of different widths be adjacently positioned.

[0074] FIG. **8** is a graph illustrating the voltage dependence of the transmittance (VT characteristic) in the first region **71,** the second region **72,** and the third region **73** when the display surface is viewed from a position in front of the display surface (in the polar angle 0° direction). In FIG. **8,** lines a, b, and c represent the VT characteristics in the first region **71,** the second region **72,** and the third region **73,** respectively.

[0075] Among the first region **71,** the second region **72,** and the third region **73,** the width of the branch portions and the space between two branch portions are different. Accordingly, the liquid crystal alignment control force is also different among these three regions. Therefore, the different VT characteristics such as shown in FIG. **8** are obtained in the three regions. Note that the VT characteristic across the entire display surface is equal to the average of these three VT characteristics.

[0076] In the liquid crystal display device of example 2, three different VT characteristics can be obtained in one pixel, and the VT characteristic achieved across the entire display surface is equal to the average of the three VT characteristics. Therefore, ideal brightness and grayscale characteristics can be obtained by appropriately setting the line widths and the slit widths in the respective regions depending on the size, shape, or use of the liquid crystal display device.

[0077] FIG. **9** is a graph for illustrating the viewing angle characteristics of the liquid crystal display device **101** of example 2. In FIG. **9**, line m represents the viewing angle characteristic of the liquid crystal display device **101** of the present example which includes the pixel electrode **70.** Specifically, line m represents the average of the viewing angle characteristics obtained in the first region **71,** the second region **72,** and the third region **73.** Line n represents the average of the viewing angle characteristics obtained in two of the first region **71,** the second region **72,** and the third region **73** (for example, the average of the viewing angle characteristics of the first region **71** and the third region **73**). Line o represents the viewing angle characteristic obtained in any one of the first region **71,** the second region **72,** and the third region **73** (for example, the viewing angle characteristic of the first region **71**). Note that line 1 in FIG. **9** is a reference line on which the front transmittance and the diagonal transmittance are equal.

[0078] As seen from FIG. **9,** the liquid crystal display device of the present example achieves more excellent viewing angle characteristics than a liquid crystal display device in which the pixel electrode has a single line width and a single slit width. The liquid crystal display device of the present example also achieves more excellent viewing angle characteristics than a liquid crystal display device in which the pixel electrode has two line widths and two slit widths.

[0079] The domains formed in the first region **71,** the second region **72,** and the third region **73** do not include any region in which a wider branch portion and a narrower branch portion be adjacently positioned. Thus, according to example 2, the abnormal alignment of the liquid crystal is unlikely to occur, and display with high brightness can be achieved in which occurrence of a dark portion is prevented as in example 1.

[0080] Thus, the liquid crystal display device of example 2 is capable of high quality display with excellent grayscale characteristics and viewing angle characteristics and with high brightness. Note that the shape of the pixel electrode **70** of example 2 may be applied to the shape of the counter electrode in one pixel. In this case also, substantially the same effects as those described above can be obtained.

(Embodiment)

[0081] Hereinafter, a liquid crystal display device of an embodiment of the present invention is described. The liquid crystal display device of the embodiment has a different pretilt angle of the liquid crystal from that defined by the alignment films **26** and **44** of the liquid crystal display device of example 1, and the other elements are the same as those of example 1. Hereinafter, the differences from example 1 are mainly described.

[0082] FIG. **10** is a plan view schematically showing the structure of a pixel **10'** in a liquid crystal display device **102** of the embodiment . The pixel **10**' is constituted of a first region **31'** and a second region **32'** which are separated from each other by a boundary line **37.** The pixel **10'** includes a pixel electrode **30** that has the shape previously described in example 1. In the present embodiment, the tilt angle of the liquid crystal molecules in the first region **31'** in the absence of an applied voltage across the liquid crystal layer is different from the tilt angle of the liquid crystal molecules in the second region **32'.** The alignment films **26** and **44** in the first region **31'** are configured to provide the liquid crystal with a pretilt angle of 2°. The alignment films **26** and **44** in the second region **32'** are configured to provide the liquid crystal with a pretilt angle of 5°.

[0083] FIG. **11** is a graph illustrating the VT characteristic in the first region **31'** and the second region **32'** when the display surface is viewed from a position in front of the display surface (in the polar angle 0° direction). In the graph, lines a and c represent the VT characteristics in the first region **31'** and the second region **32',** while line b represents the VT characteristic in the second region **32** of example 1.

[0084] The pretilt angle in the first region **31'** is equal to the pretilt angle in the first region **31** of example 1, and therefore, these regions have equal VT characteristics. As seen from the VT characteristics represented by line c and line b, however, the transmittance in the second region **32'** is higher than the transmittance in the second region **32** of example 1. In the embodiment , the pretilt angle is different between the first region **31'** and the second region **32',** so that the difference in brightness between these regions is larger than that of example 1.

[0085] FIG. **12** is a graph for illustrating the viewing angle characteristics of the liquid crystal display device **102** of the present embodiment. In FIG. **12,** line o represents the viewing angle characteristic of the pixel **10'** of the embodiment . Specifically, line o represents the average of the above-described viewing angle characteristics respectively obtained in the first region **31'** and the second region **32'.** Line m represents the viewing angle characteristic of the pixel **10** of example 1, i.e., the viewing angle characteristic of a pixel which has the pixel electrode **30** but does not provide different pretilt angles. Line n represents the viewing angle characteristic obtained in any one of the first region **31'** and the second region **32'** (herein, the first region **31'**). Note that line l in FIG. **12** is a reference line representing that the front transmittance and the diagonal transmittance are equal.

[0086] As seen from FIG. **12,** by using the same pixel as that of example 1 and providing a plurality of pretilt angles in the pixel, more excellent viewing angle characteristics can be obtained than a liquid crystal display device in which the pixel electrode has a single line width and a single slit width, and than the liquid crystal display device of example 1 in which the pretilt angles in a pixel are all equal.

[0087] As described above, in the embodiment , the pretilt angle is modified depending on the difference in line width or slit width of the pixel electrode **30.** Therefore, display with higher brightness and more excellent viewing angle characteristics than embodiment 1 is possible. As seen from the comparison of example 1 and the embodiment, by modifying the pretilt angle depending on the difference in the line width or slit width of the pixel electrode **30,** the viewing angle characteristics across the entire display surface can be improved, while the brightness can be adjusted within a wider range over the entire display surface.

INDUSTRIAL APPLICABILITY

[0088] The present invention is applicable to a liquid crystal display device which has a relatively small pixel pitch, such as a liquid crystal display device for a mobile phone, and the like.

Claims

1. A vertical alignment type liquid crystal display device (100, 101, 102) which has a plurality of pixels (10), comprising:

   a pair of polarizing plates (60a, 60b) which have transmission axes orthogonal to each other;
   a first electrode (30, 70);
   a second electrode (43) provided so as to oppose the first electrode (30, 70); and
   a liquid crystal layer (50) interposed between the first electrode (30, 70) and the second electrode (43),
   wherein each of the plurality of pixels (10) includes a first region (31, 31'. 71) and a second region (32, 32', 72) which are separated by a line (37, 77a) parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates (60a, 60b), **characterized in that**
   the first electrode (30, 70) includes, in each of the first region (31, 31', 71) and the second region (32, 32'. 72), a plurality of first branch portions (30c, 30c', 70c, 70c', 70c") extending in a first direction and a plurality of second branch portions (30d, 30d', 70d, 70d', 70d") extending in a second direction that is different from the first direction;
   each of the plurality of first branch portions (30c, 70c) in the first region (31, 31', 71) has a first width, and each of the plurality of first branch portions (30c', 70c') in the second region (32, 32', 72) has a second width that is different from the first width
   an alignment film (26) causing a tilt angle of liquid crystal molecules in the first region (31, 31', 71) to be different from a tilt angle of liquid crystal molecules in the second region (32, 32', 72), when a voltage is not applied across the liquid crystal layer (50).

2. The liquid crystal display device (100, 101, 102) of claim 1, wherein
   each of the plurality of second branch portions (30d, 70d) in the first region (31, 31', 71) has the first width, and each of the plurality of second branch portions (30d, 70d) in the second region (32, 32'. 72) has the second width.

3. The liquid crystal display device (100, 101, 102) of claim 1 or 2, wherein
   any adjacent two of the plurality of first branch portions (30c. 70c) in the first region (31, 31', 71) are separated by a first space, and
   any adjacent two of the plurality of first branch portions (30c', 70c') in the second region (32, 32'. 72) are separated by a second space that is different from the first space.

4. The liquid crystal display device (100, 101, 102) of claim 3, wherein
   any adjacent two of the plurality of second branch portions (30d, 70d) in the first region (31, 31', 71) are separated by the first space, and
   any adjacent two of the plurality of second branch portions (30d, 70d) in the second region (32, 32', 72) are separated by the second space.

5. The liquid crystal display device (100, 101, 102) of any one of claims 1 to 4, wherein
   the first region (31, 31', 71) and the second region (32, 32', 72) respectively correspond to one region and the other region of a pixel which are separated by a scanning line (22) or CS line (24).

6. The liquid crystal display device (100, 101, 102) of any one of claims 1 to 4, wherein
   the first region (31, 31', 71) and the second region (32, 32', 72) respectively correspond to one region and the other region of a pixel which are separated by a line parallel to a signal line (23).

7. The liquid crystal display device (100, 101. 102) of any one of claims 1 to 6, wherein
   the first direction and the second direction are orthogonal to each other, and
   directions of the transmission axes of the pair of polarizing plates (60a, 60b) and the first direction are different by 45°, 135°, 225°, or 315°.

8. The liquid crystal display device (100, 101, 102) of any one of claims 1 to 7, wherein
   when a voltage is applied across the liquid crystal layer (50), four liquid crystal domains among which an alignment direction of liquid crystal molecules is different are formed in each of the first region (31, 31', 71) and the second region (32, 32'. 72).

9. The liquid crystal display device (100, 101, 102) of any one of claims 1 to 8, wherein
   each of the plurality of pixels (10) includes a third region (73) separated from the first region (31, 31', 71) or the

second region (32, 32', 72) by a line(77b) parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates (60a, 60b), wherein
the first electrode (30, 70) includes in the third region (73) a plurality of first branch portions (70c") extending in the first direction and a plurality of second branch portions (70d") extending in the second direction, and
each of the plurality of first branch portions (70c") and the plurality of second branch portions (70d") in the third region (73) has a third width that is different from the first width or the second width.

10. A vertical alignment type liquid crystal display device (100, 101, 102) which has a plurality of pixels (10), comprising:

a pair of polarizing plates (60a, 60b) which have transmission axes orthogonal to each other;
a first electrode (30, 70);
a second electrode (43) provided so as to oppose the first electrode (30, 70); and
a liquid crystal layer (50) interposed between the first electrode (30, 70) and the second electrode (43),
wherein each of the plurality of pixels (10) includes a first region (31, 31', 71) and a second region (32, 32', 72) which are separated by a line (37, 77a) parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates (60a, 60b), **characterized in that**
the first electrode (30, 70) includes, in each of the first region (31, 31', 71) and the second region (32. 32', 72), a plurality of first branch portions (30c, 30c'. 70c, 70c'. 70c") extending in a first direction and a plurality of second branch portions (30d, 30d', 70d, 70d', 70d") extending in a second direction that is different from the first direction;
any adjacent two of the plurality of first branch portions (30c. 70c) in the first region (31, 31', 71) are separated by a first space, and
any adjacent two of the plurality of first branch portions (30c', 70c') in the second region (32, 32', 72) are separated by a second space that is different from the first space.
an alignment film (26) causing a tilt angle of liquid crystal molecules in the first region (31, 31', 71) to be different from a tilt angle of liquid crystal molecules in the second region (32, 32', 72), when a voltage is not applied across the liquid crystal layer (50).

11. The liquid crystal display device (100, 101, 102) of claim 10, wherein
any adjacent two of the plurality of second branch portions (30d, 70d) in the first region (31, 31', 71) are separated by the first space, and
any adjacent two of the plurality of second branch portions (30d, 70d) in the second region (32, 32', 72) are separated by the second space.

12. The liquid crystal display device (100, 101, 102) of claim 10 or 11, wherein
each of the plurality of pixels (10) includes a third region (73) separated from the first region (31, 31', 71) or the second region (32, 32'. 72) by a line(77b) parallel to or perpendicular to the directions of the transmission axes of the pair of polarizing plates (60a, 60b), wherein
the first electrode (30, 70) includes in the third region (73) a plurality of first branch portions (70c") extending in the first direction and a plurality of second branch portions (70d") extending in the second direction, and
any adjacent two of the plurality of first branch portions (70c") in the third region (73) and any adjacent two of the plurality of second branch portions (70d") in the third region (73) are separated by a third space that is different from the first space or the second space.

Patentansprüche

1. Flüssigkristallanzeigevorrichtung (100, 101, 102) des Typs mit vertikaler Ausrichtung, die mehrere Pixel (10) besitzt, mit:

einem Paar Polarisationsplatten (60a, 60b), die zueinander senkrechte Durchlassachsen besitzen;
einer ersten Elektrode (30, 70);
einer zweiten Elektrode (43), die so vorgesehen ist, dass sie sich gegenüber der ersten Elektrode (30, 70) befindet; und
einer Flüssigkristallschicht (50), die zwischen die erste Elektrode (30, 70) und die zweite Elektrode (43) eingefügt ist,
wobei jedes der mehreren Pixel (10) einen ersten Bereich (31, 31', 71) und einen zweiten Bereich (32, 32', 72) aufweist, die durch eine Linie (37, 77a) parallel oder senkrecht zu den Richtungen der Durchlassachsen des

Paars Polarisationsplatten (60a, 60b) getrennt sind, **dadurch gekennzeichnet, dass**
die erste Elektrode (30, 70) in dem ersten Bereich (31, 31', 71) und in dem zweiten Bereich (32, 32', 72) mehrere erste Verzweigungsabschnitte (30c, 30c', 70c, 70c', 70c"), die sich in einer ersten Richtung erstrecken, und mehrere zweite Verzweigungsabschnitte (30d, 30d', 70d, 70d', 70d"), die sich in einer von der ersten Richtung verschiedenen zweiten Richtung erstrecken, aufweist;
jeder der mehreren ersten Verzweigungsabschnitte (30c, 70c) in dem ersten Bereich (31, 31', 71) eine erste Breite besitzt und
jeder der mehreren ersten Verzweigungsabschnitte (30c', 70c') in dem zweiten Bereich (32, 32', 72) eine von der ersten Breite verschiedene zweite Breite besitzt,
ein Ausrichtfilm (26) bewirkt, dass ein Neigungswinkel von Flüssigkristallmolekülen in dem ersten Bereich (31, 31', 71) von einem Neigungswinkel von Flüssigkristallmolekülen in dem zweiten Bereich (32, 32', 72) verschieden ist, wenn über die Flüssigkristallschicht (50) keine Spannung angelegt wird.

2. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach Anspruch 1, wobei
jeder der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem ersten Bereich (31, 31', 71) die erste Breite besitzt und
jeder der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem zweiten Bereich (32, 32', 72) die zweite Breite besitzt.

3. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach Anspruch 1 oder 2, wobei
irgendwelche zwei benachbarten Abschnitte der mehreren ersten Verzweigungsabschnitte (30c, 70c) in dem ersten Bereich (31, 31', 71) durch einen ersten Zwischenraum getrennt sind und
irgendwelche zwei benachbarten Abschnitte der mehreren ersten Verzweigungsabschnitte (30c', 70c') in dem zweiten Bereich (32, 32', 72) durch einen von dem ersten Zwischenraum verschiedenen zweiten Zwischenraum getrennt sind.

4. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach Anspruch 3, wobei
irgendwelche zwei benachbarten Abschnitte der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem ersten Bereich (31, 31', 71) durch den ersten Zwischenraum getrennt sind und
irgendwelche zwei benachbarten Abschnitte der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem zweiten Bereich (32, 32', 72) durch den zweiten Zwischenraum getrennt sind.

5. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach einem der Ansprüche 1 bis 4, wobei
der erste Bereich (31, 31', 71) und der zweite Bereich (32, 32', 72) einem Bereich bzw. dem anderen Bereich eines Pixels entsprechen, die durch eine Abtastlinie (22) oder CS-Linie (24) getrennt sind.

6. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach einem der Ansprüche 1 bis 4, wobei
der erste Bereich (30c, 30c', 70c, 70c', 70c") und der zweite Bereich (30d, 30d', 70d, 70d', 70d") dem einen Bereich bzw. dem anderen Bereich eines Pixels entsprechen, die durch eine zu einer Signalleitung parallele Linie (23) getrennt sind.

7. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach einem der Ansprüche 1 bis 6, wobei
die erste Richtung und die zweite Richtung zueinander senkrecht sind und
Richtungen der Durchlassachsen des Paars Polarisationsplatten (60a, 60b) und der ersten Richtung um 45°, 135°, 225° oder 315° verschieden sind.

8. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach einem der Ansprüche 1 bis 7, wobei
dann, wenn über die Flüssigkristallschicht (50) eine Spannung angelegt wird, vier Flüssigkristallgebiete, unter denen eine Ausrichtungsrichtung der Flüssigkristallmoleküle verschieden ist, in dem ersten Bereich (31, 31', 71) und in dem zweiten Bereich (32, 32', 72) gebildet werden.

9. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach einem der Ansprüche 1 bis 8, wobei
jedes der mehreren Pixel (10) einen dritten Bereich (73) enthält, der von dem ersten Bereich (31, 31', 71) oder von dem zweiten Bereich (32, 32', 72) durch eine Linie (77b) getrennt ist, die zu den Richtungen der Durchlassachsen des Paars Polarisationsplatten (60a, 60b) parallel oder senkrecht ist, wobei
die erste Elektrode (30, 70) in dem dritten Bereich (73) mehrere erste Verzweigungsabschnitte (70c"), die sich in der ersten Richtung erstrecken, und mehrere zweite Verzweigungsabschnitte (70d"), die sich in der zweiten Richtung erstrecken, enthält und

jeder der mehreren ersten Verzweigungsabschnitte (70c") und der mehreren zweiten Verzweigungsabschnitte (70d") in dem dritten Bereich (73) eine dritte Breite besitzt, die von der ersten Breite oder von der zweiten Breite verschieden ist.

10. Flüssigkristallanzeigevorrichtung (100, 101, 102) des Typs mit vertikaler Ausrichtung, die mehrere Pixel (10) besitzt, mit:

einem Paar Polarisationsplatten (60a, 60b), die zueinander senkrechte Durchlassachsen besitzen;
einer ersten Elektrode (30, 70);
einer zweiten Elektrode (43), die so vorgesehen ist, dass sie der ersten Elektrode (30, 70) gegenüberliegt; und
einer Flüssigkristallschicht (50), die zwischen die erste Elektrode (30, 70) und die zweite Elektrode (43) eingefügt ist,
wobei jedes der mehreren Pixel (10) einen ersten Bereich (31, 31', 71) und einen zweiten Bereich (32, 32', 72) enthält, die durch eine Linie (37, 77a) getrennt sind, die zu den Richtungen der Durchlassachsen des Paars Polarisationsplatten (60a, 60b) parallel oder senkrecht ist, **dadurch gekennzeichnet, dass**
die erste Elektrode (30, 70) in dem ersten Bereich (31, 31', 71) und in dem zweiten Bereich (32, 32', 72) mehrere erste Verzweigungsabschnitte (30c, 30c', 70c, 70c', 70c"), die sich in einer ersten Richtung erstrecken, und mehrere zweite Verzweigungsabschnitte (30d, 30d', 70d, 70d', 70d"), die sich in einer von der ersten Richtung verschiedenen zweiten Richtung erstrecken, aufweist;
irgendwelche zwei benachbarten Abschnitte der mehreren ersten Verzweigungsabschnitte (30c, 70c) in dem ersten Bereich (31, 31', 71) durch einen ersten Zwischenraum getrennt sind und
irgendwelche zwei benachbarten Abschnitte der mehreren ersten Verzweigungsabschnitte (30c', 70c') in dem zweiten Bereich (32, 32', 72) durch einen von dem ersten Zwischenraum verschiedenen zweiten Zwischenraum getrennt sind,
ein Ausrichtfilm (26) bewirkt, dass ein Neigungswinkel von Flüssigkristallmolekülen in dem ersten Bereich (31, 31', 71) von einem Neigungswinkel von Flüssigkristallmolekülen in dem zweiten Bereich (32, 32', 72) verschieden ist, wenn über die Flüssigkristallschicht (50) keine Spannung angelegt wird.

11. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach Anspruch 10, wobei
irgendwelche zwei benachbarten Abschnitte der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem ersten Bereich (31, 31', 71) durch den ersten Zwischenraum getrennt sind und
irgendwelche zwei benachbarten Abschnitte der mehreren zweiten Verzweigungsabschnitte (30d, 70d) in dem zweiten Bereich (32, 32', 72) durch den zweiten Zwischenraum getrennt sind.

12. Flüssigkristallanzeigevorrichtung (100, 101, 102) nach Anspruch 10 oder 11, wobei
jedes der mehreren Pixel (10) einen dritten Bereich (73) enthält, der von dem ersten Bereich (31, 31', 71) oder von dem zweiten Bereich (32, 32', 72) durch eine Linie (77b) getrennt ist, die zu den Richtungen der Durchlassachsen des Paars Polarisationsplatten (60a, 60b) parallel oder senkrecht ist, wobei
die erste Elektrode (30, 70) in dem dritten Bereich (73) mehrere erste Verzweigungsabschnitte (70c"), die sich in der ersten Richtung erstrecken, und mehrere zweite Verzweigungsabschnitte (70d"), die sich in der zweiten Richtung erstrecken, aufweist und
irgendwelche zwei benachbarten Abschnitte der mehreren ersten Verzweigungsabschnitte (70c") in dem dritten Bereich (73) und irgendwelche zwei benachbarten Abschnitte der mehreren zweiten Verzweigungsabschnitte (70d") in dem dritten Bereich (73) durch einen dritten Zwischenraum getrennt sind, der von dem ersten Zwischenraum oder von dem zweiten Zwischenraum verschieden ist.

Revendications

1. Dispositif d'affichage à cristaux liquides de type à alignement vertical (100, 101, 102) qui comporte une pluralité de pixels (10), comprenant :

une paire de plaques de polarisation (60a, 60b) qui ont des axes de transmission orthogonaux l'un à l'autre ;
une première électrode (30, 70) ;
une deuxième électrode (43) disposée de façon à s'opposer à la première électrode (30, 70) ; et
une couche de cristaux liquides (50) intercalée entre la première électrode (30, 70) et la deuxième électrode (43),
dans lequel chacun de la pluralité de pixels (10) comprend une première région (31, 31', 71) et une deuxième région (32, 32', 72) qui sont séparées par une ligne (37, 77a) parallèle ou perpendiculaire aux directions des

axes de transmission de la paire de plaques de polarisation (60a, 60b), **caractérisé en ce que** la première électrode (30, 70) comprend, dans chacune de la première région (31, 31', 71) et de la deuxième région (32, 32', 72), une pluralité de premières parties de dérivation (30c, 30c', 70c, 70c', 70c'') s'étendant dans une première direction et une pluralité de deuxièmes parties de dérivation (30d, 30d', 70d, 70d', 70d") s'étendant dans une deuxième direction qui est différente de la première direction ;
chacune de la pluralité de premières parties dérivation (30c, 70c) dans la première région (31, 31', 71) a une première largeur, et
chacune de la pluralité de premières parties dérivation (30c', 70c') dans la deuxième région (32, 32', 72) a une deuxième largeur qui est différente de la première largeur,
un film d'alignement (26) amenant un angle d'inclinaison de molécules de cristaux liquides dans la première région (31, 31', 71) à être différent d'un angle d'inclinaison de molécules de cristaux liquides dans la deuxième région (32, 32', 72), lorsqu'aucune tension n'est appliquée à travers la couche de cristaux liquides (50).

2. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon la revendication 1, dans lequel
chacune de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la première région (31, 31', 71) a la première largeur, et
chacune de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la deuxième région (32, 32', 72) a la deuxième largeur.

3. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon la revendication 1 ou 2, dans lequel
deux parties adjacentes quelconques de la pluralité de premières parties de dérivation (30c, 70c) dans la première région (31, 31', 71) sont séparées par un premier espace, et
deux parties adjacentes quelconques de la pluralité de premières parties de dérivation (30c', 70c') dans la deuxième région (32, 32', 72) sont séparées par un deuxième espace qui est différent du premier espace.

4. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon la revendication 3, dans lequel
deux parties adjacentes quelconques de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la première région (31, 31', 71) sont séparées par le premier espace, et
deux parties adjacentes quelconques de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la deuxième région (32, 32', 72) sont séparées par le deuxième espace.

5. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon l'une quelconque des revendications 1 à 4, dans lequel la première région (31, 31', 71) et la deuxième région (32, 32', 72) correspondent respectivement à une région et à l'autre région d'un pixel qui sont séparées par une ligne de balayage (22) ou une ligne CS (24).

6. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon l'une quelconque des revendications 1 à 4, dans lequel la première région (31, 31', 71) et la deuxième région (32, 32', 72) correspondent respectivement à une région et à l'autre région d'un pixel qui sont séparées par une ligne parallèle à une ligne de signaux (23).

7. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon l'une quelconque des revendications 1 à 6, dans lequel
la première direction et la deuxième direction sont orthogonales l'une à l'autre, et
les directions des axes de transmission de la paire de plaques de polarisation (60a, 60b) et la première direction sont différentes de 45°, 135°, 225° ou 315°.

8. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon l'une quelconque des revendications 1 à 7, dans lequel lorsqu'une tension est appliquée à travers la couche de cristaux liquides (50), quatre domaines de cristaux liquides parmi lesquels une direction d'alignement de molécules de cristaux liquides est différente sont formés dans chacune de la première région (31, 31', 71) et de la deuxième région (32, 32', 72).

9. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon l'une quelconque des revendications 1 à 8, dans lequel chacun de la pluralité de pixels (10) comprend une troisième région (73) séparée de la première région (31, 31', 71) ou de la deuxième région (32, 32', 72) par une ligne (77b) parallèle ou perpendiculaire aux directions des axes de transmission de la paire de plaques de polarisation (60a, 60b), dans lequel
la première électrode (30, 70) comprend dans la troisième région (73) une pluralité de premières parties de dérivation (70c'') s'étendant dans la première direction et une pluralité de deuxièmes parties de dérivation (70d'') s'étendant dans la deuxième direction, et
chacune de la pluralité de premières parties de dérivation (70c'') et de la pluralité de deuxièmes parties de dérivation (70d'') dans la troisième région (73) a une troisième largeur qui est différente de la première largeur ou de la deuxième

largeur.

10. Dispositif d'affichage à cristaux liquides de type à alignement vertical (100, 101, 102) qui comporte une pluralité de pixels (10), comprenant :

une paire de plaques de polarisation (60a, 60b) qui ont des axes de transmission orthogonaux l'un à l'autre ;
une première électrode (30, 70) ;
une deuxième électrode (43) disposée de façon à s'opposer à la première électrode (30, 70) ; et
une couche de cristaux liquides (50) intercalée entre la première électrode (30, 70) et la deuxième électrode (43), dans lequel chacun de la pluralité de pixels (10) comprend une première région (31, 31', 71) et une deuxième région (32, 32', 72) qui sont séparées par une ligne (37, 77a) parallèle ou perpendiculaire aux directions des axes de transmission de la paire de plaques de polarisation (60a, 60b), **caractérisé en ce que**
la première électrode (30, 70) comprend, dans chacune de la première région (31, 31', 71) et de la deuxième région (32, 32', 72), une pluralité de premières parties de dérivation (30c, 30c', 70c, 70c', 70c'') s'étendant dans une première direction et une pluralité de deuxièmes parties de dérivation (30d, 30d', 70d, 70d', 70d'') s'étendant dans une deuxième direction qui est différente de la première direction ;
deux parties adjacentes quelconques de la pluralité de premières parties de dérivation (30c, 70c) dans la première région (31, 31', 71) sont séparées par un premier espace, et
deux parties adjacentes quelconques de la pluralité de premières parties de dérivation (30c', 70c') dans la deuxième région (32, 32', 72) sont séparées par un deuxième espace qui est différent du premier espace,
un film d'alignement (26) amenant un angle d'inclinaison de molécules de cristaux liquides dans la première région (31, 31', 71) à être différent d'un angle d'inclinaison de molécules de cristaux liquides dans la deuxième région (32, 32', 72), lorsqu'aucune tension n'est appliquée à travers la couche de cristaux liquides (50).

11. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon la revendication 10, dans lequel
deux parties adjacentes quelconques de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la première région (31, 31', 71) sont séparées par le premier espace, et
deux parties adjacentes quelconques de la pluralité de deuxièmes parties de dérivation (30d, 70d) dans la deuxième région (32, 32', 72) sont séparées par le deuxième espace 12. Dispositif d'affichage à cristaux liquides (100, 101, 102) selon la revendication 10 ou 11, dans lequel
chacun de la pluralité de pixels (10) comprend une troisième région (73) séparée de la première région (31, 31', 71) ou de la deuxième région (32, 32', 72) par une ligne (77b) parallèle ou perpendiculaire aux directions des axes de transmission de la paire de plaques de polarisation (60a, 60b), dans lequel
la première électrode (30, 70) comprend dans la troisième région (73) une pluralité de premières parties de dérivation (70c'') s'étendant dans la première direction et une pluralité de deuxièmes parties de dérivation (70d'') s'étendant dans la deuxième direction, et
deux parties adjacentes quelconques de la pluralité de premières parties de dérivation (70c'') dans la troisième région (73) et deux parties adjacentes quelconques de la pluralité de deuxièmes parties de dérivation (70d'') dans la troisième région (73) sont séparées par un troisième espace qui est différent du premier espace ou du deuxième espace.

FIG. 1

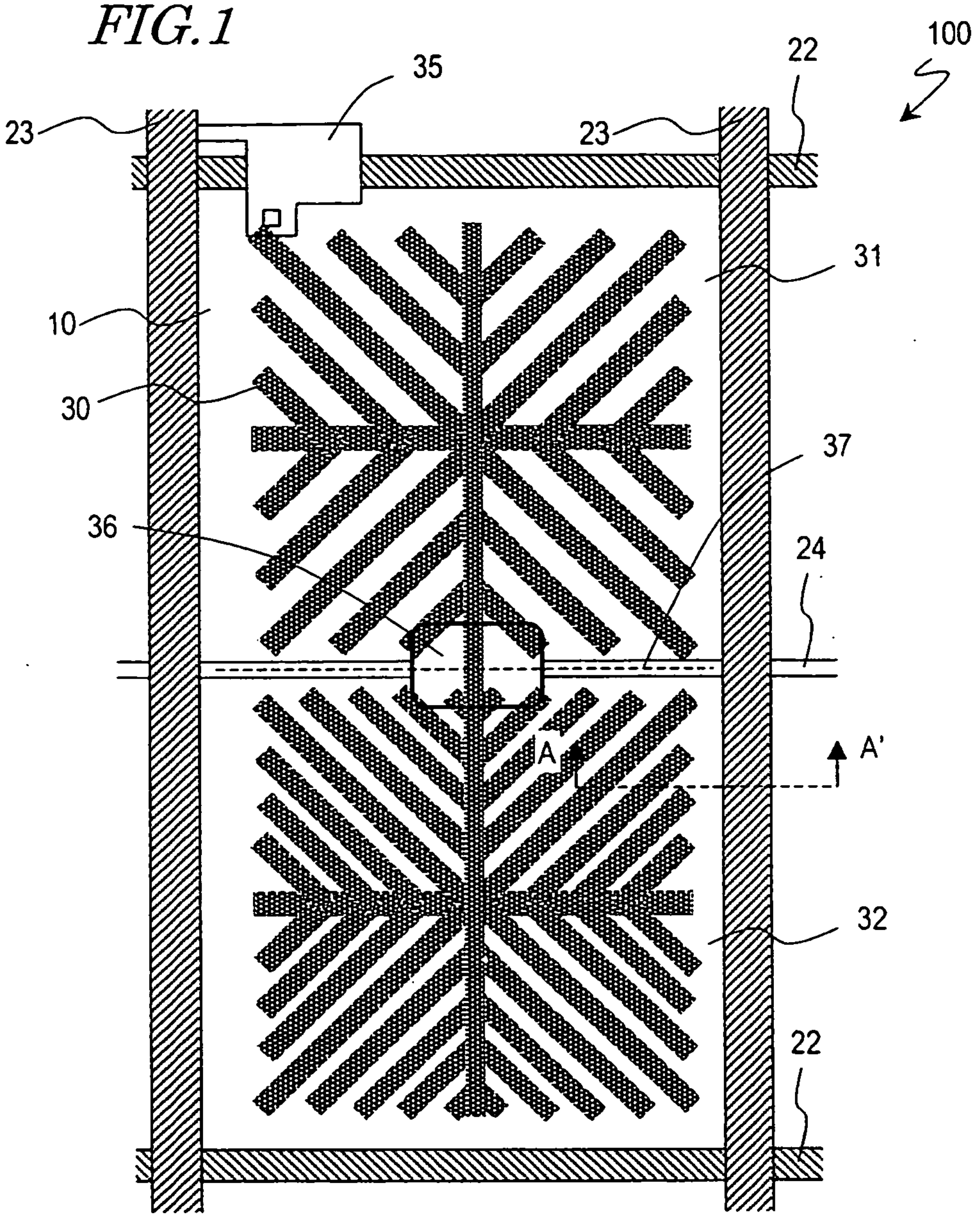


FIG.2

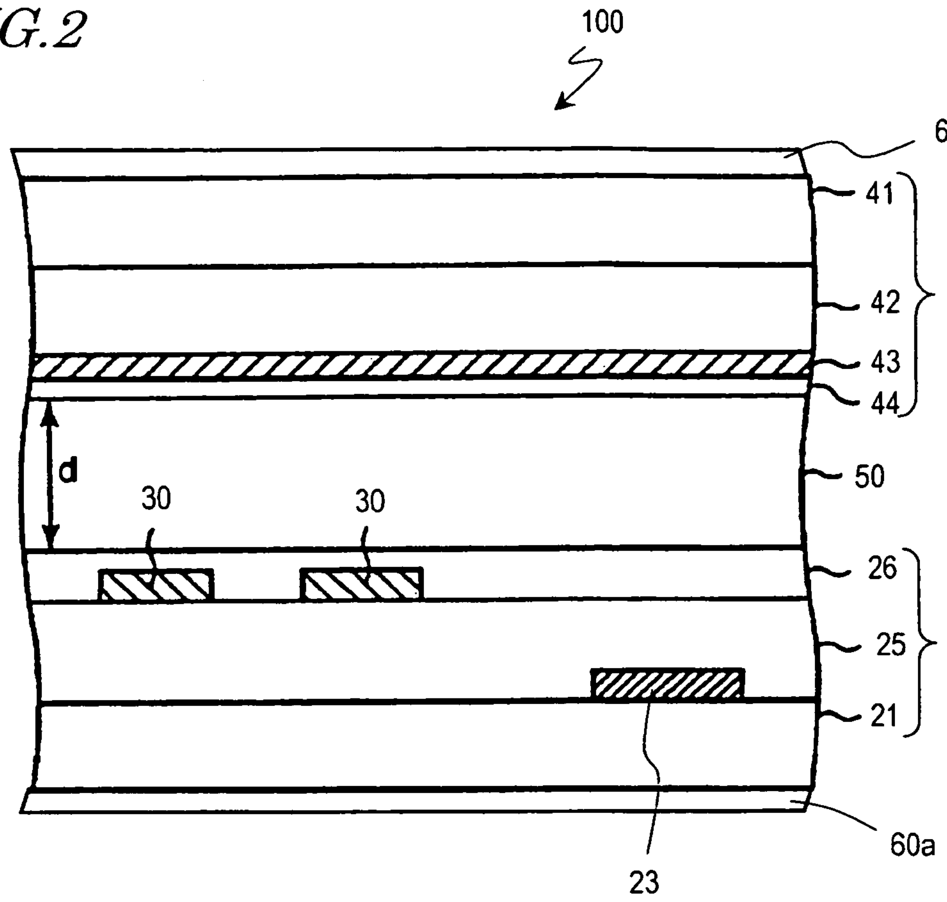


FIG.3

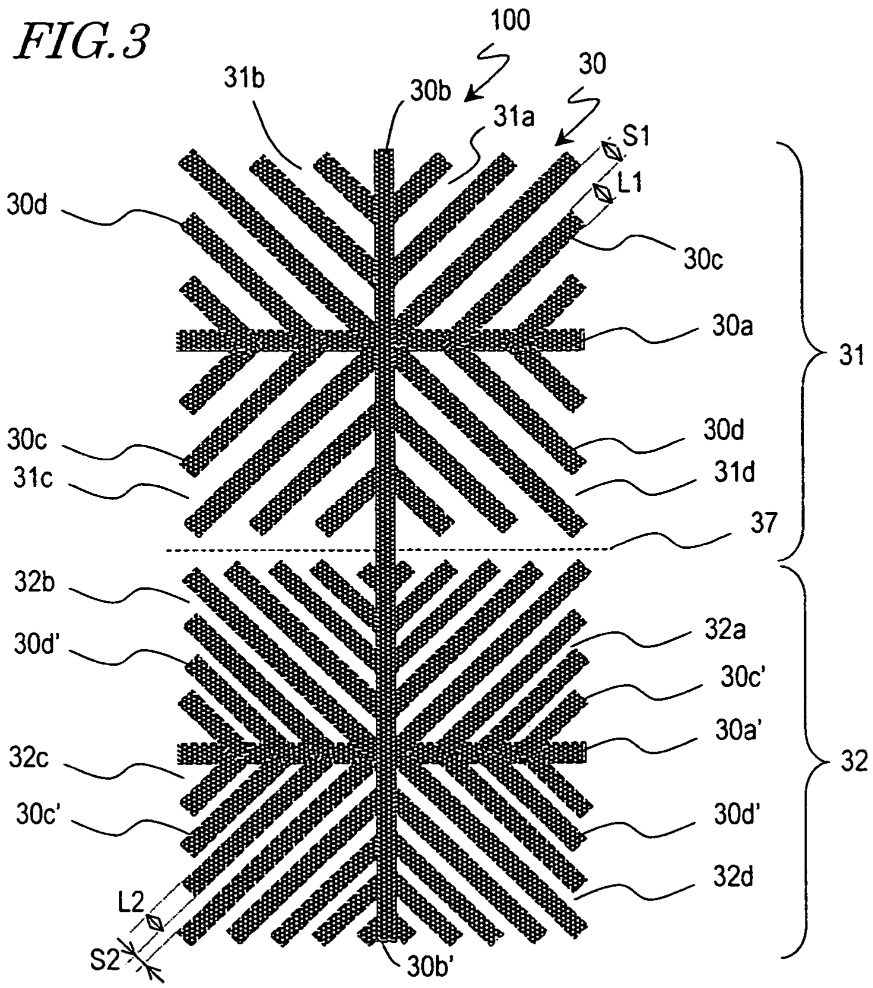

100
30
31b
30b
31a
S1
L1
30d
30c
30a
31
30c
30d
31c
31d
37
32b
32a
30d'
30c'
30a'
32c
32
30c'
30d'
32d
L2
S2
30b'

FIG.4

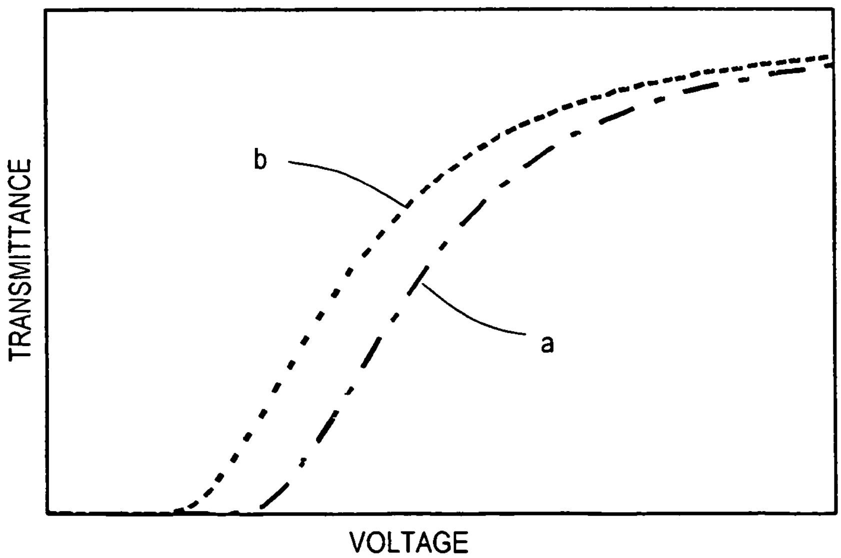

TRANSMITTANCE
VOLTAGE
b
a

FIG.5

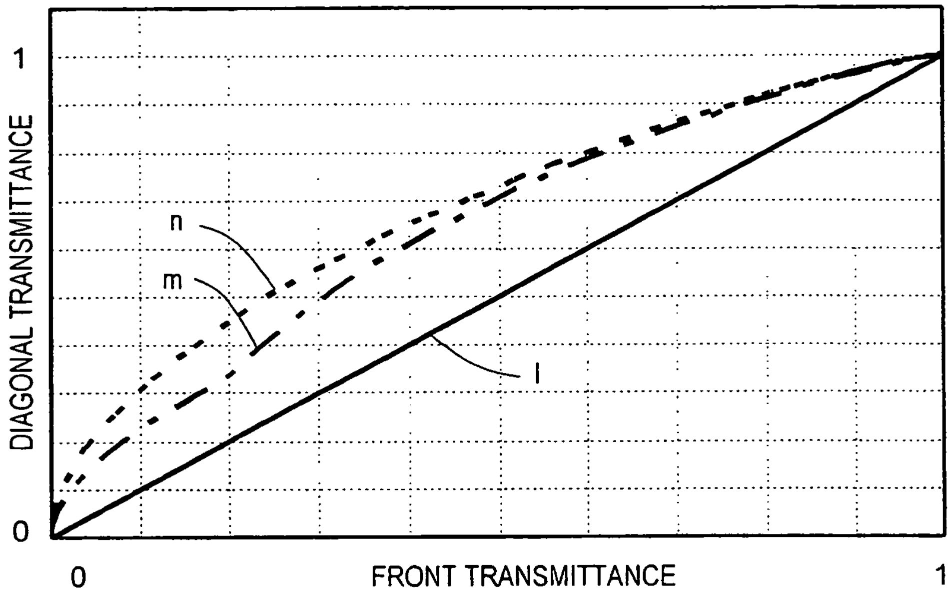

1
0
DIAGONAL TRANSMITTANCE
n
m
l
0
FRONT TRANSMITTANCE
1

FIG.6

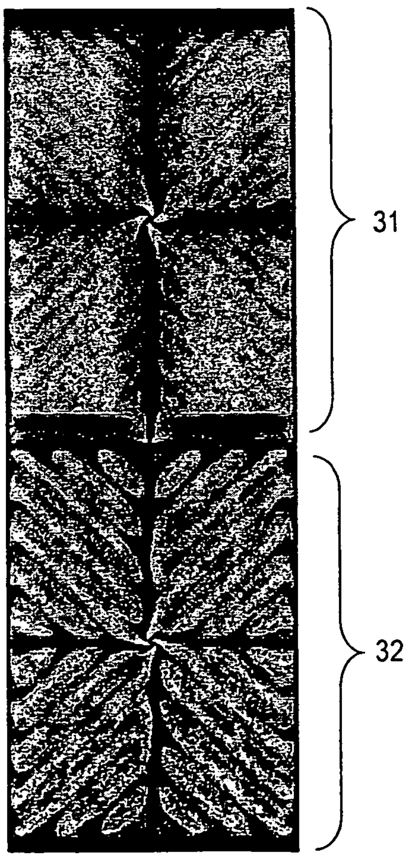
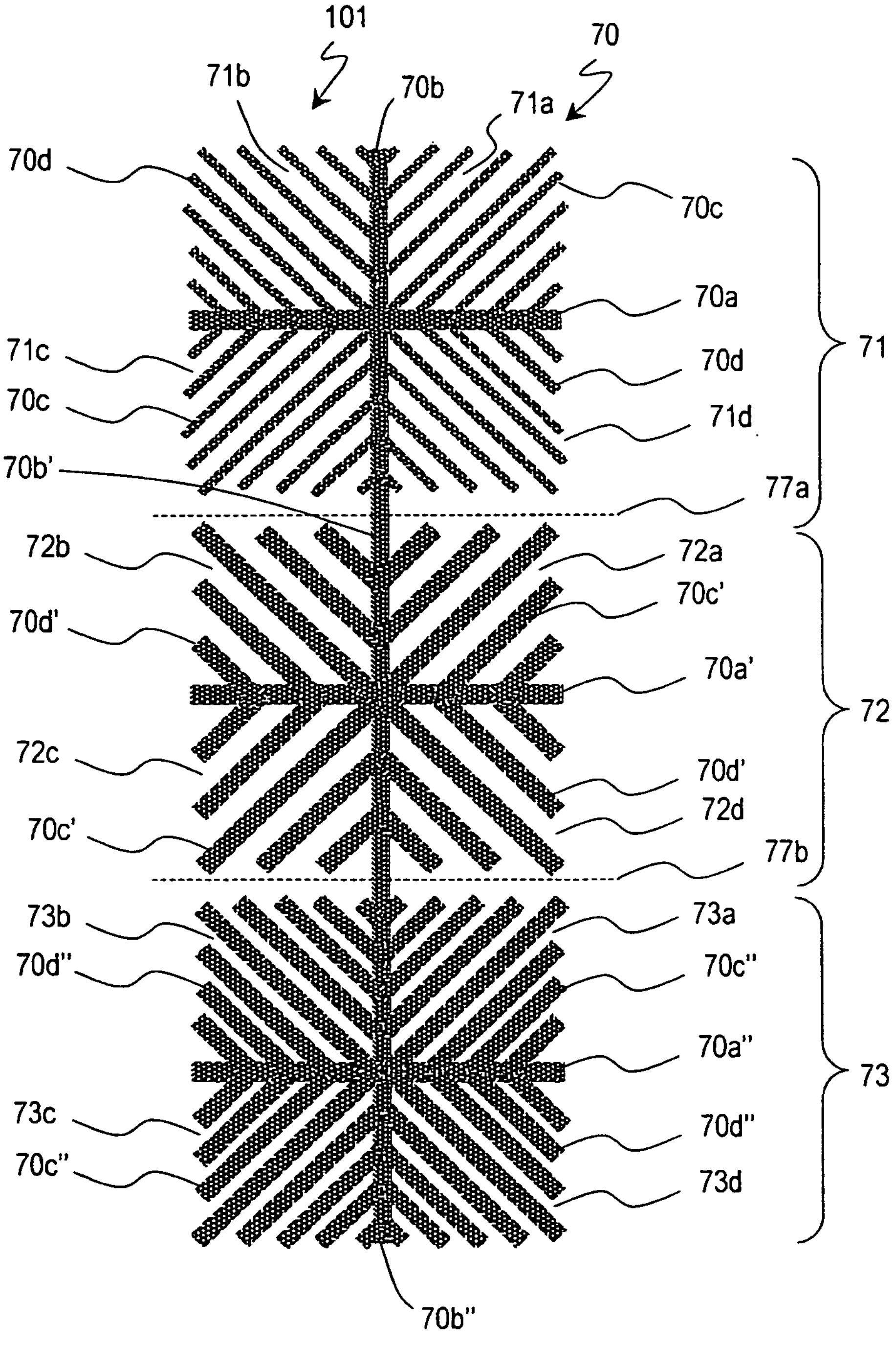

31
32

FIG. 7


101
70
71b
70b
71a
70d
70c
70a
71c
70d
70c
71d
70b'
77a
71
72b
72a
70c'
70d'
70a'
72
72c
70d'
72d
70c'
77b
73b
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70d"
70c"
70a"
73
73c
70d"
70c"
73d
70b"

FIG.8

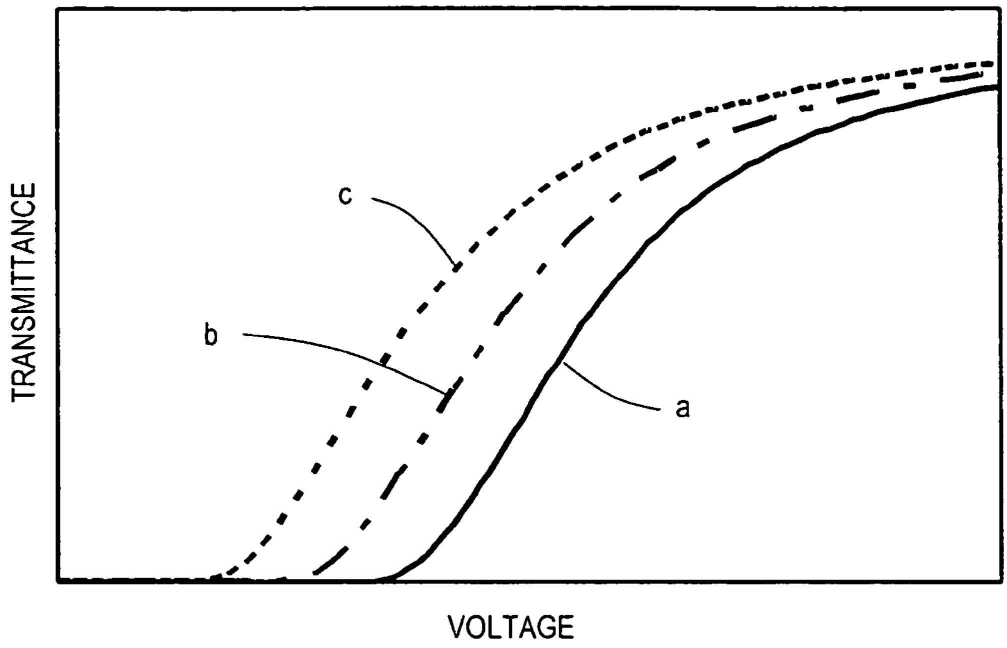

TRANSMITTANCE
c
b
a
VOLTAGE

FIG.9

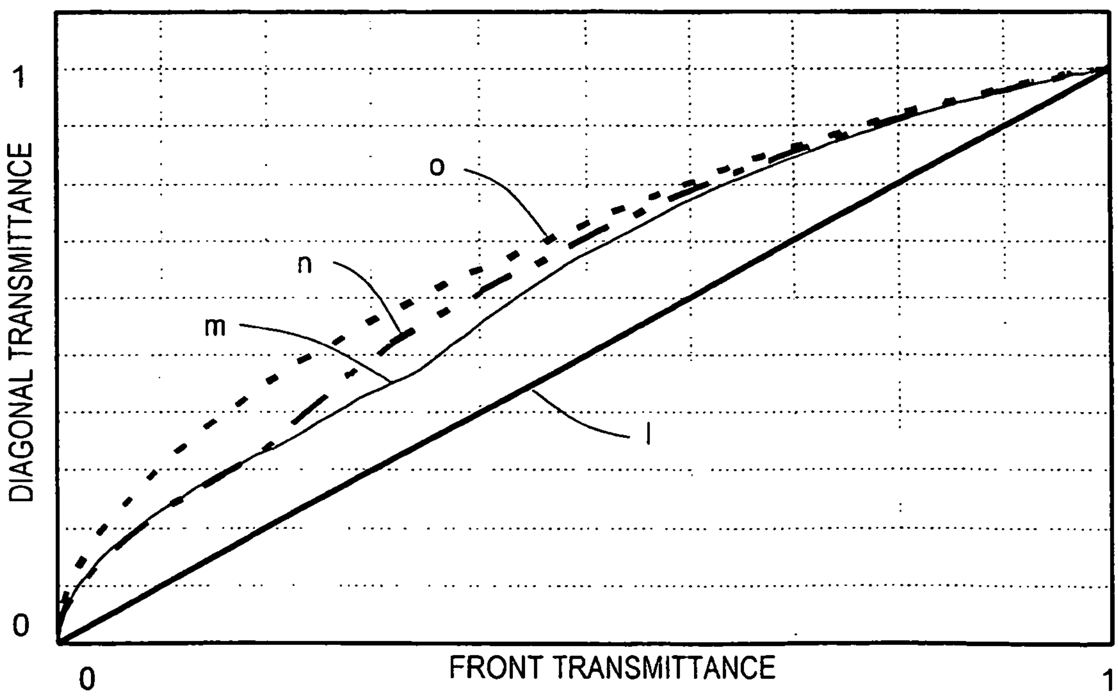

1
0
DIAGONAL TRANSMITTANCE
o
n
m
l
0
FRONT TRANSMITTANCE
1

FIG.10

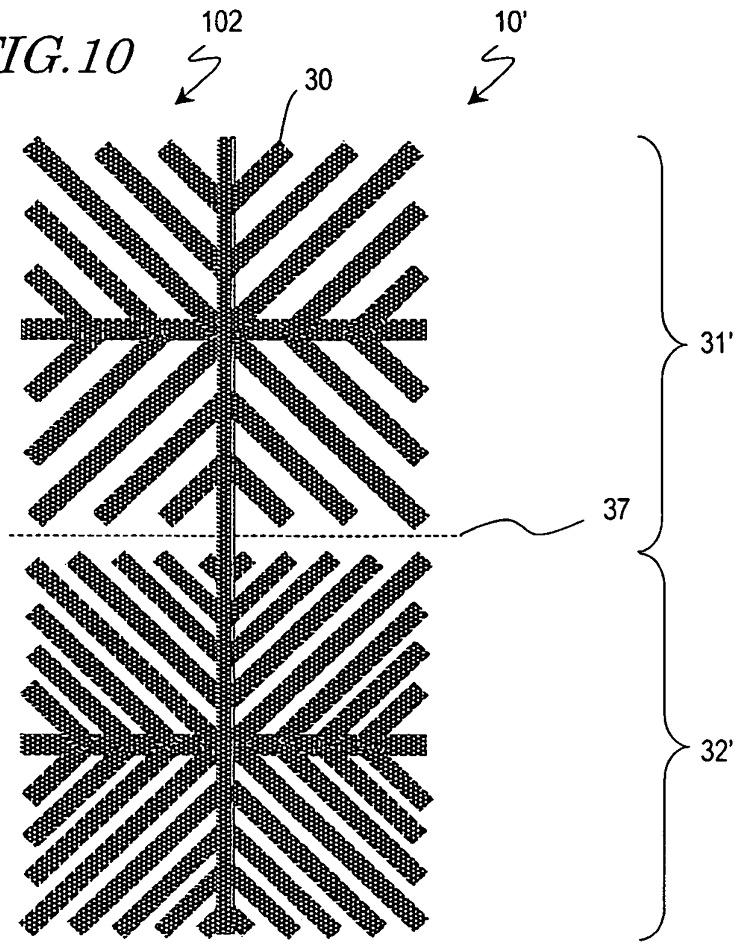


FIG.11

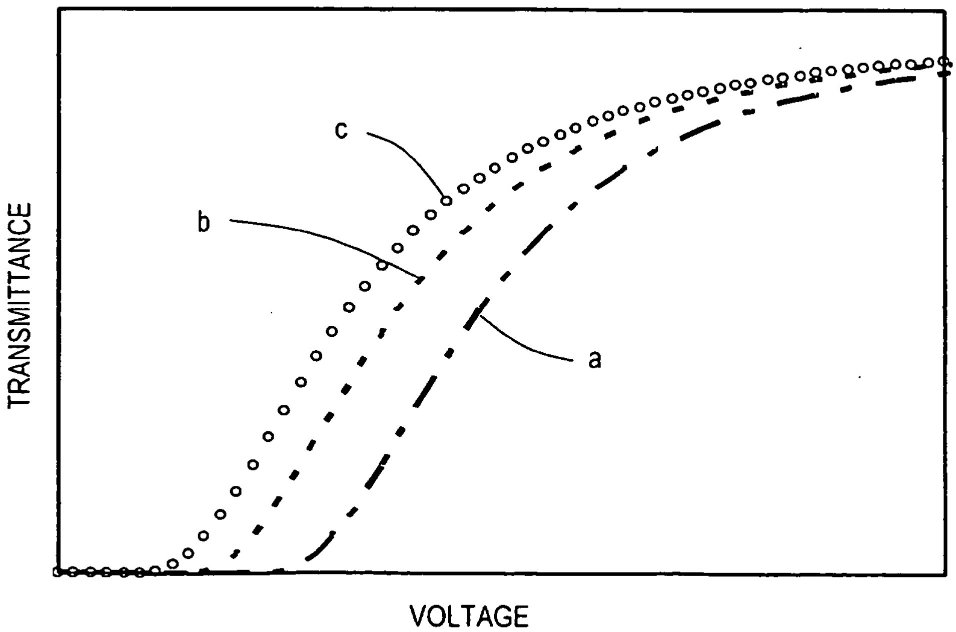


FIG.12

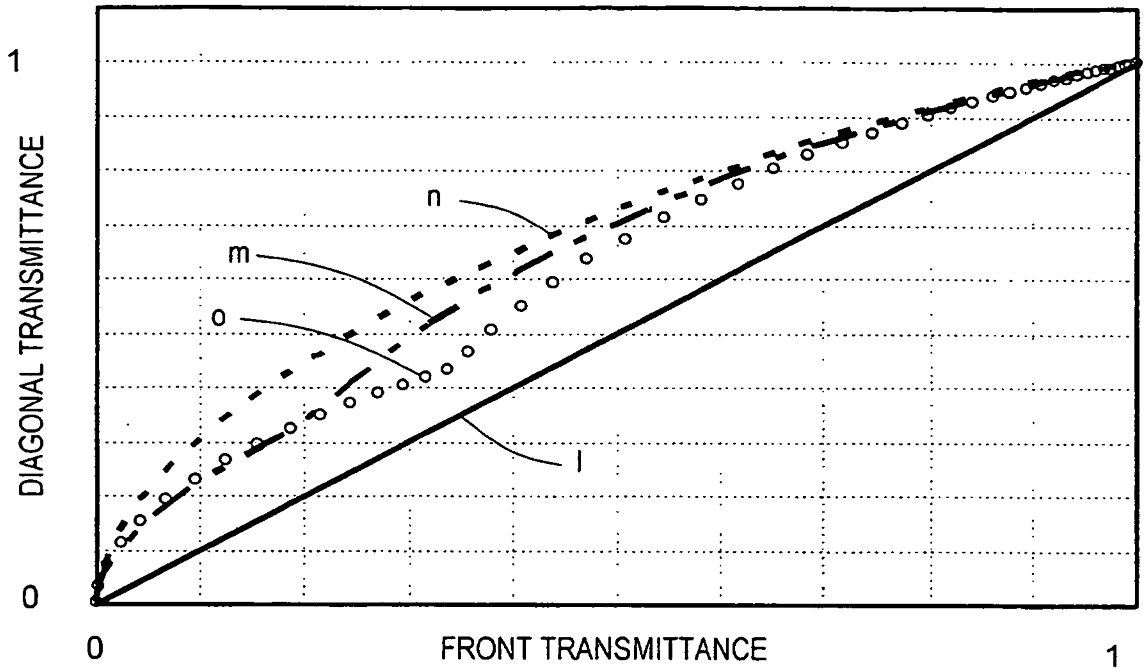


FIG. 13

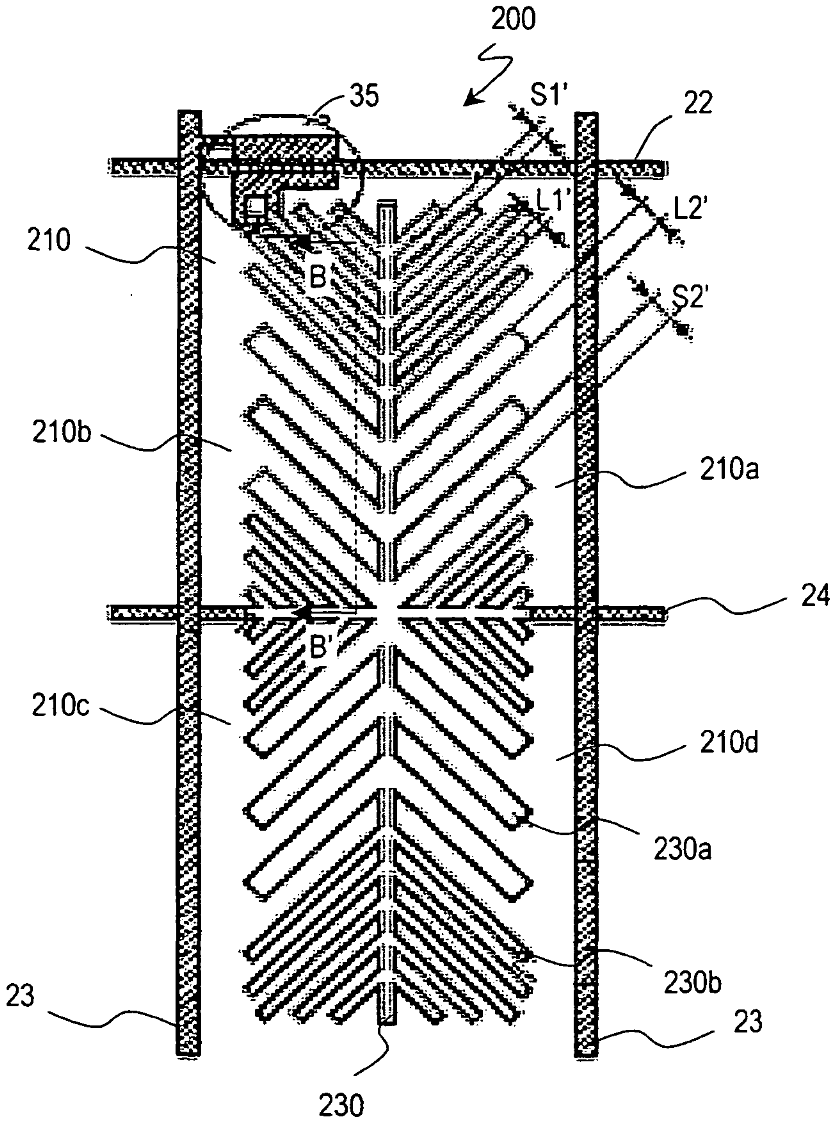

200
35
S1'
22
L1'
L2'
210
B
S2'
210b
210a
24
B'
210c
210d
230a
230b
23
23
230

FIG. 14

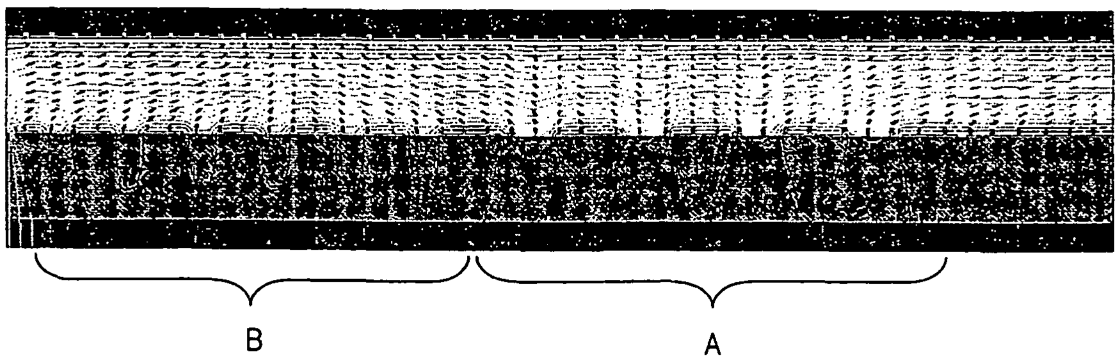

B
A

FIG.15

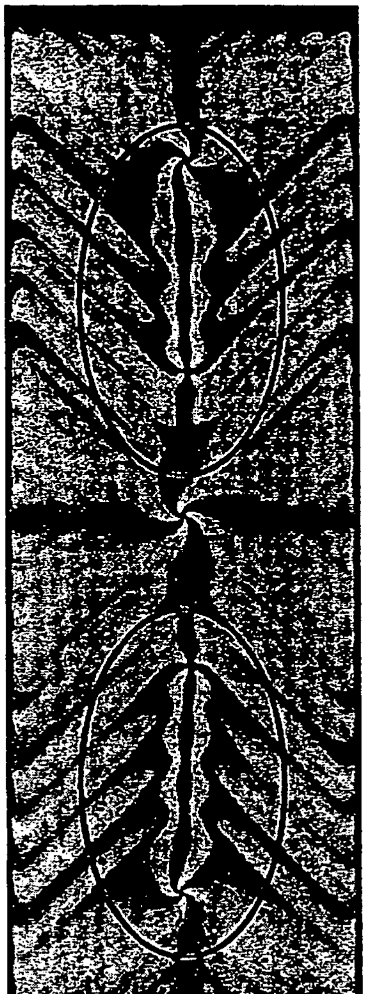
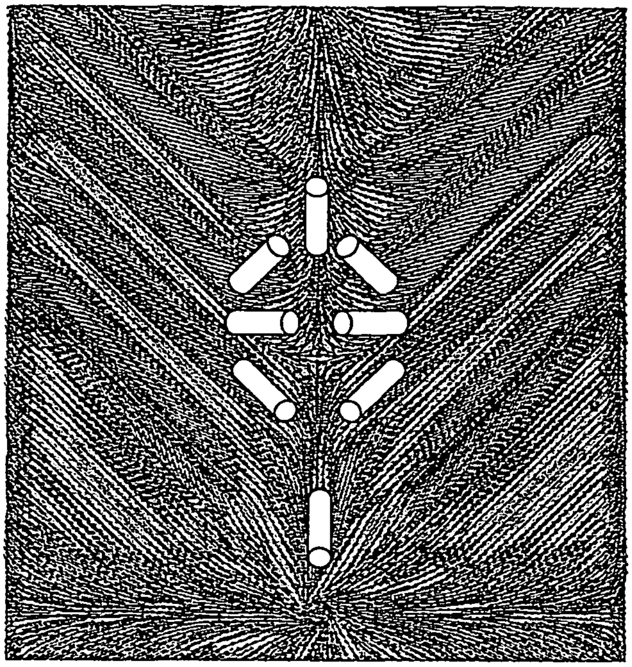


FIG.16



REFERENCES CITED IN THE DESCRIPTION

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申请(专利权)人(译)	夏普株式会社		
当前申请(专利权)人(译)	夏普株式会社		
[标]发明人	HASHIMOTO YOSHITO OHGAMI HIROYUKI SHIBASAKI MASAKAZU KUBO MASUMI IYAMA YUICHI SOGA MASAYUKI		
发明人	HASHIMOTO, YOSHITO OHGAMI, HIROYUKI SHIBASAKI, MASAKAZU KUBO, MASUMI IYAMA, YUICHI SOGA, MASAYUKI		
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CPC分类号	G02F1/134309 G02F1/133707 G02F1/133753 G02F1/1393		
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外部链接	Espacenet		

摘要(译)

本发明提供一种高图像质量的液晶显示装置，其具有高亮度和优异的视角特性。本发明的液晶显示装置包括一对偏振片，第一电极，设置成与第一电极相对的第二电极，以及插入在第一电极和第二电极之间的液晶层。多个像素中的每一个包括第一区域和第二区域，第一区域和第二区域由平行于或垂直于该对偏振板的透射轴的方向的线分开。第一电极在第一区域和第二区域中的每一个中包括沿第一方向延伸的多个第一分支部分和沿不同于第一方向的第二方向延伸的多个第二分支部分。第一区域中的多个第一分支部分中的每一个具有第一宽度。第二区域中的多个第一分支部分中的每一个具有不同于第一宽度的第二宽度。

FIG. 1