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Kim et al.

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(45) **Date of Patent:** **Jul. 20, 2010**

(54) **VERTICALLY ALIGNED LIQUID CRYSTAL DISPLAY DEVICE HAVING AN OPTIMIZED VIEWING ANGLE**

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(22) Filed: **Feb. 9, 2006**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.** **349/119**; 349/118; 349/120; 349/130

(58) **Field of Classification Search** 349/117, 349/130, 118, 119, 120, 121
See application file for complete search history.

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Primary Examiner—David Nelms
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(57) **ABSTRACT**

A method of improving the viewing angle of a vertically-aligned liquid crystal display device is presented. The method involves designing a uniaxial compensation film to provide a retardation value of 200 nm or less for light having a wavelength of about 550 nm. Using this uniaxial compensation film, a display device can be built by obtaining a liquid crystal panel with liquid crystal molecules contained between glass substrates, coupling the uniaxial compensation film to at least one of the glass substrates, and coupling a polarization film and electrodes to the compensation film. Preferably, the uniaxial compensation film has a thickness less than or equal to 50 microns. Where there are multiple compensation films, the total thickness and the total retardation values should be considered.

5 Claims, 17 Drawing Sheets

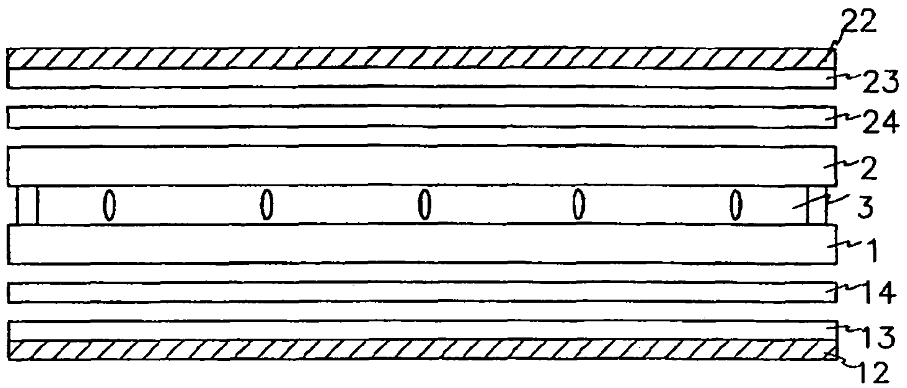

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FIG.1

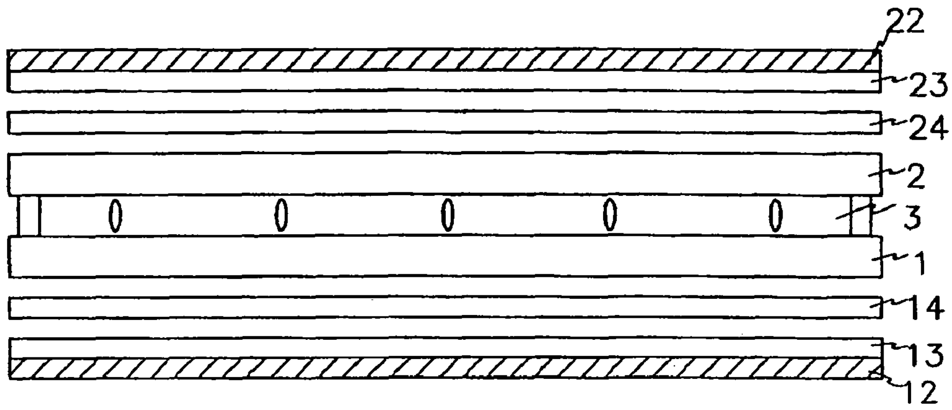
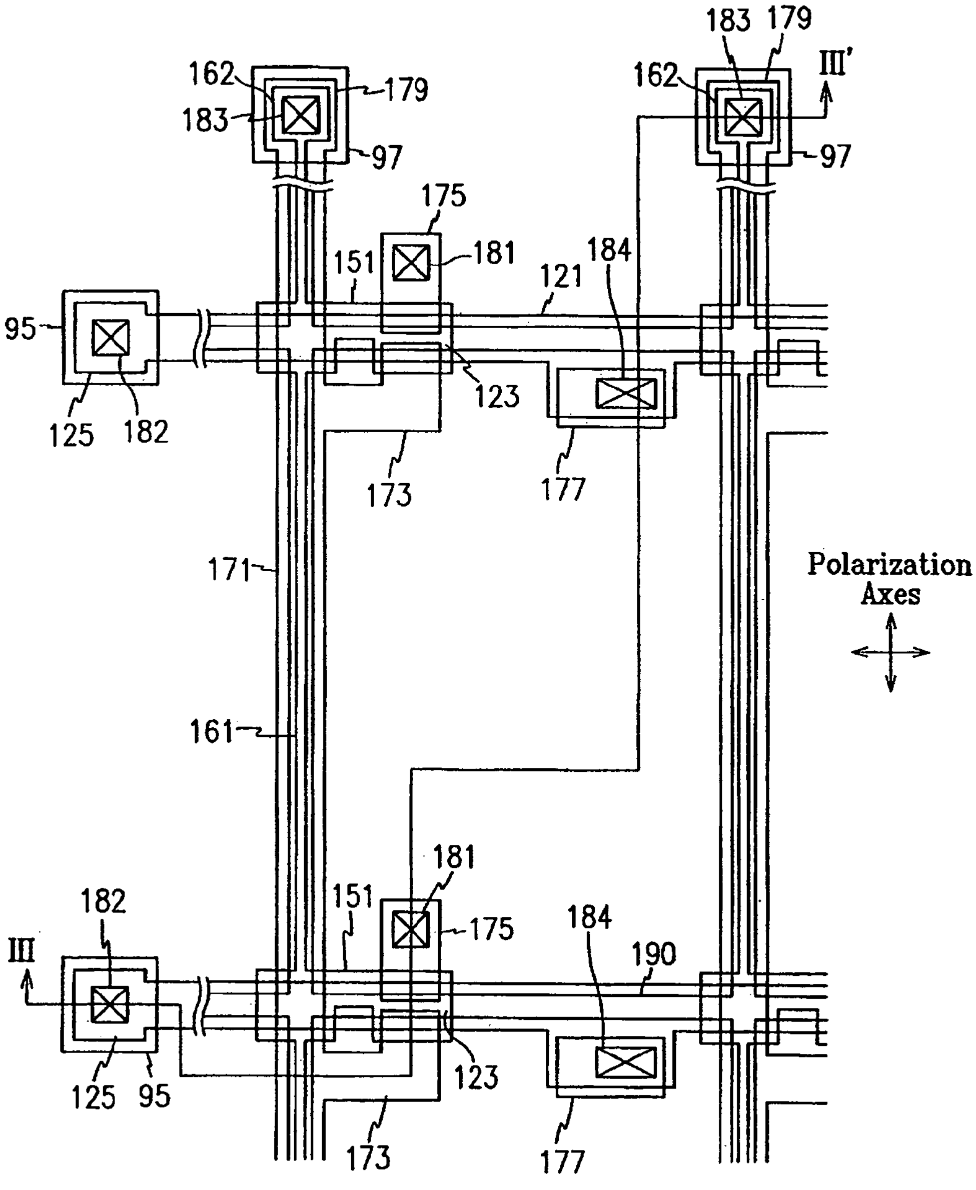


FIG.2



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III'
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Polarization
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FIG.3

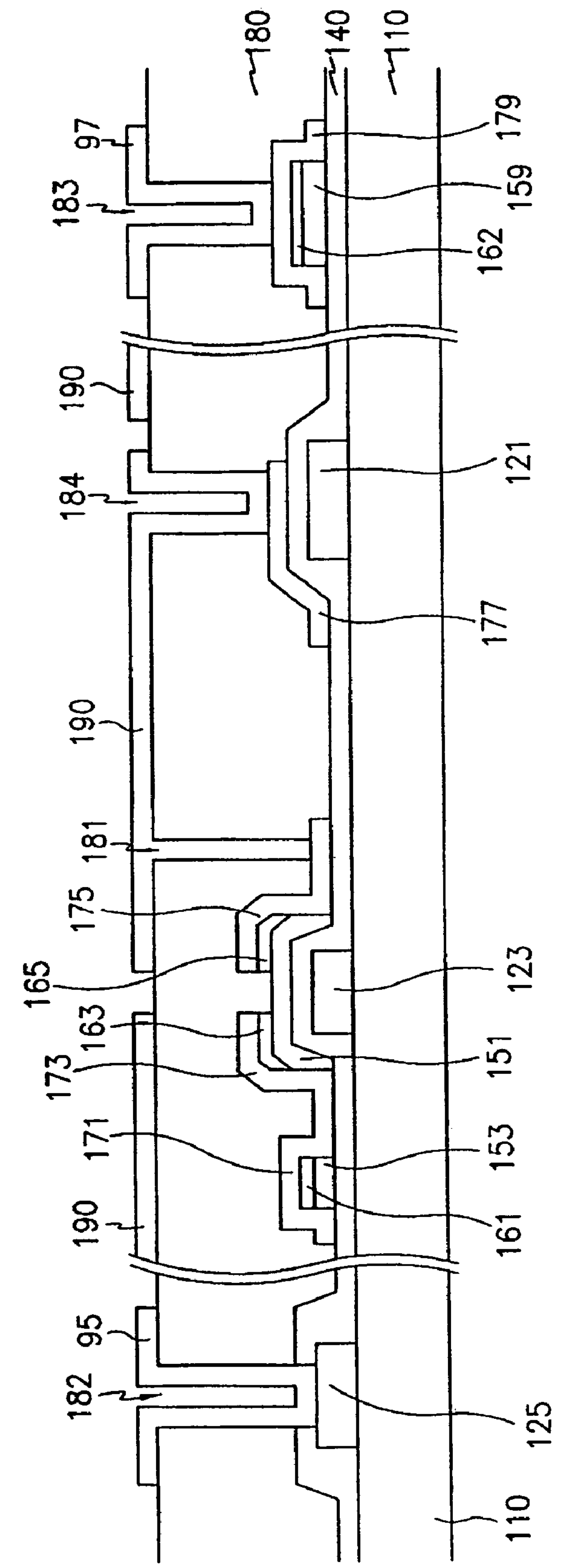
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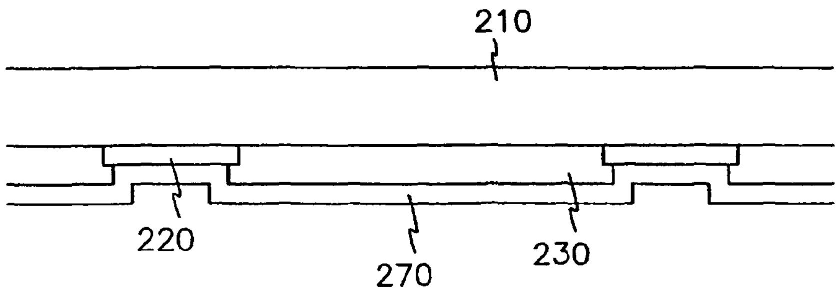
FIG.4



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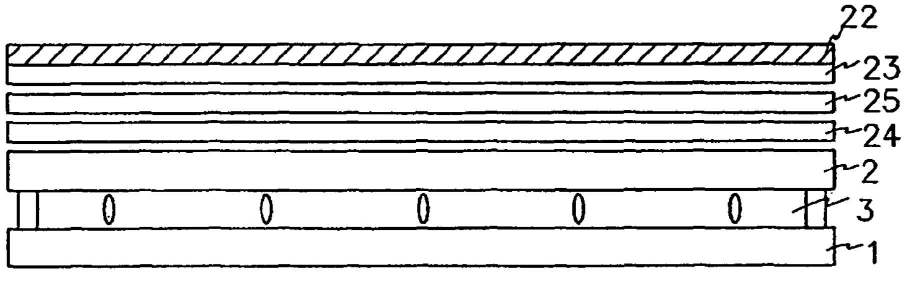

FIG.6

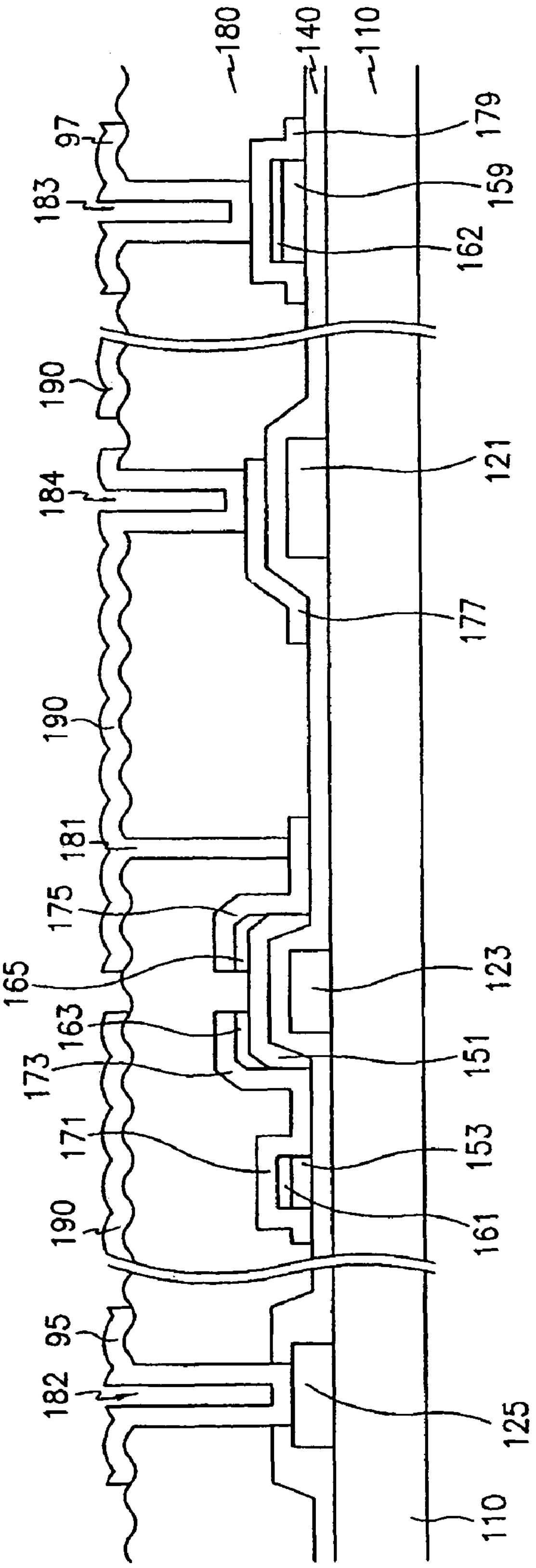
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FIG.7

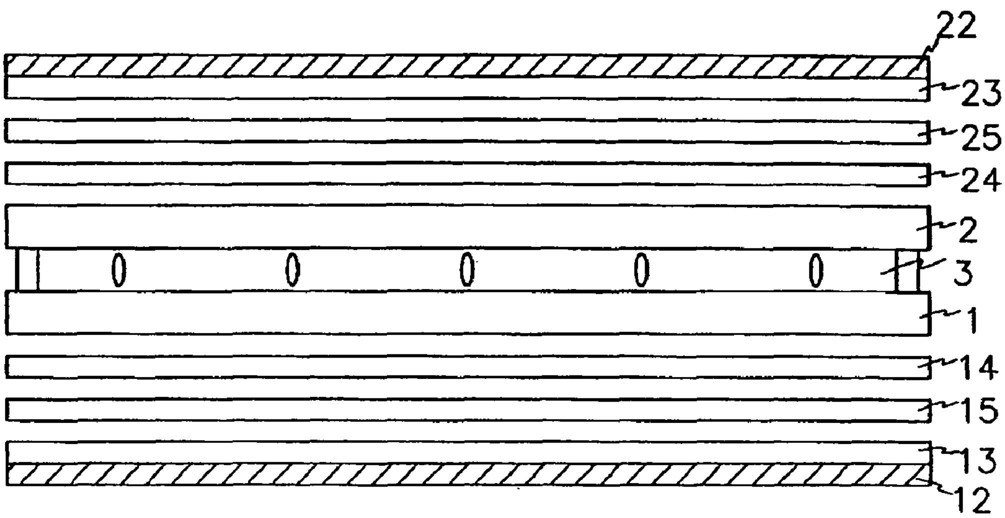
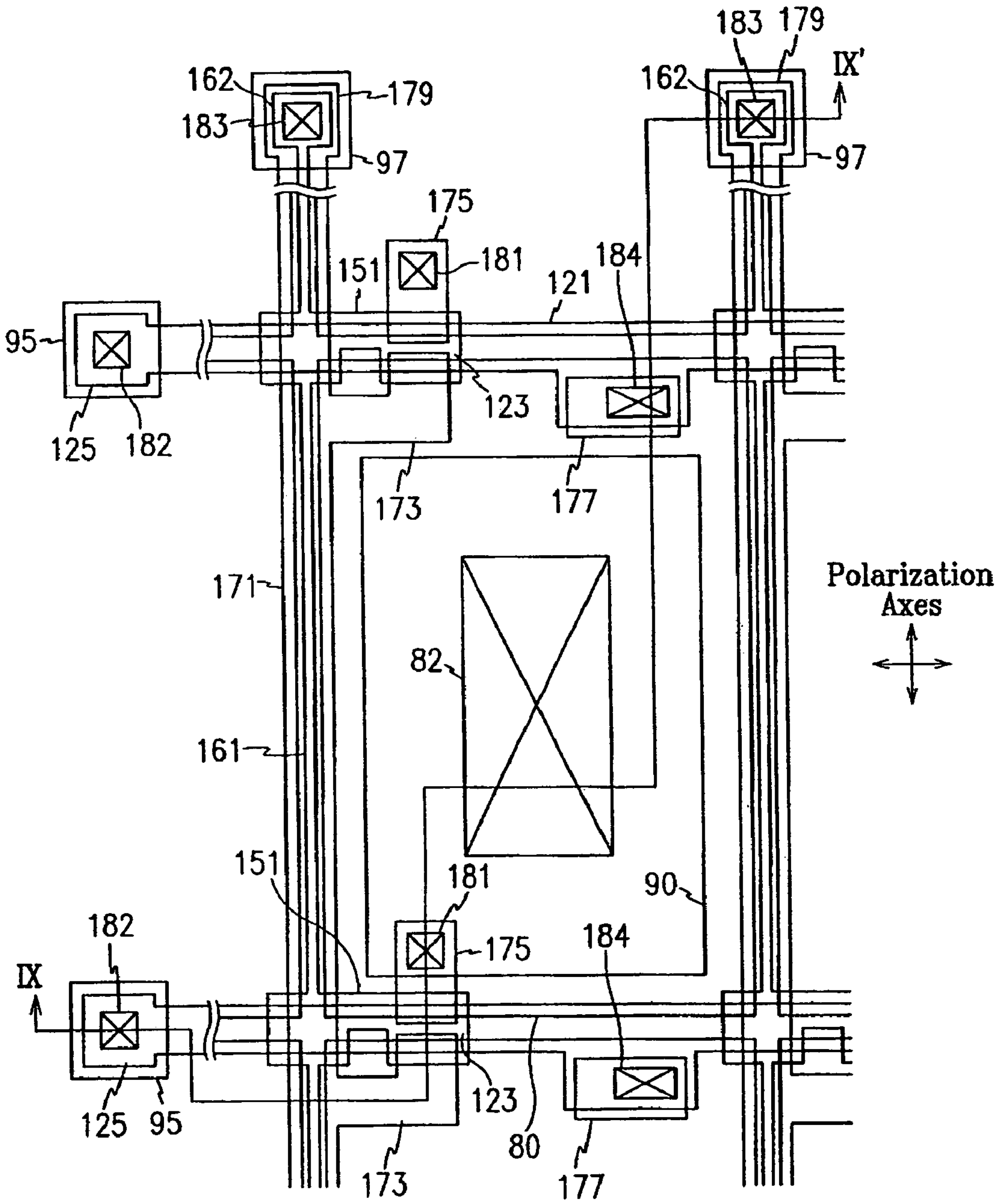


FIG.8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Polarization
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FIG.9

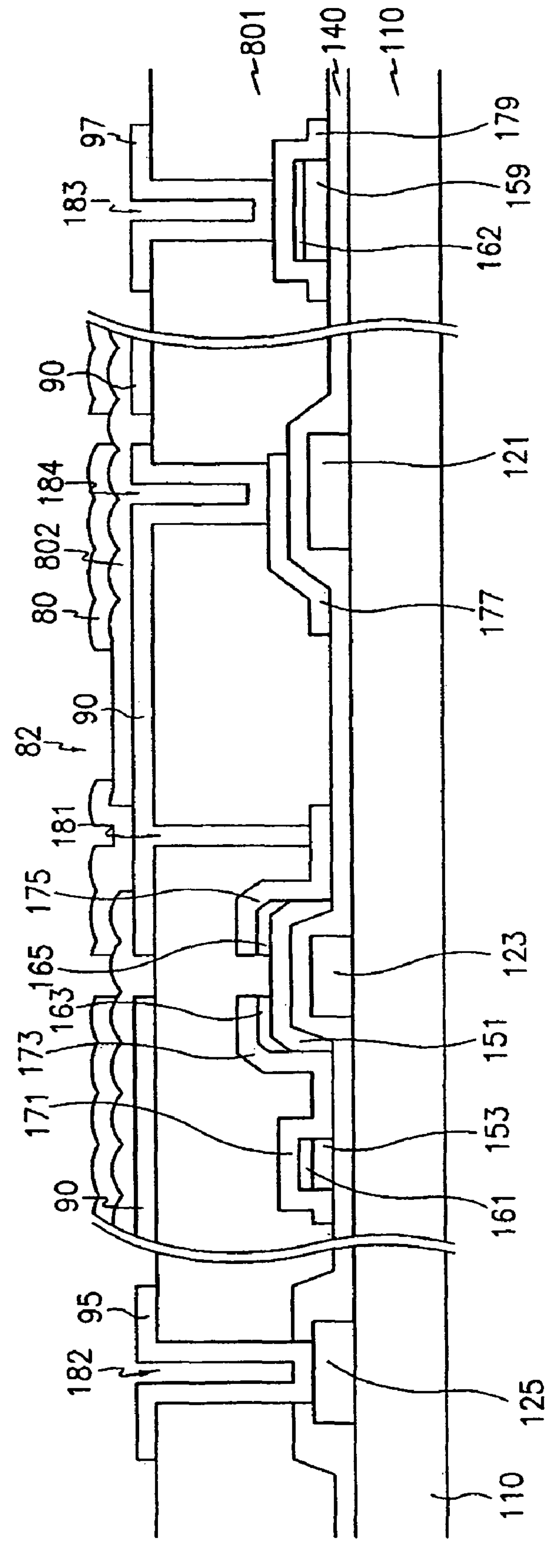

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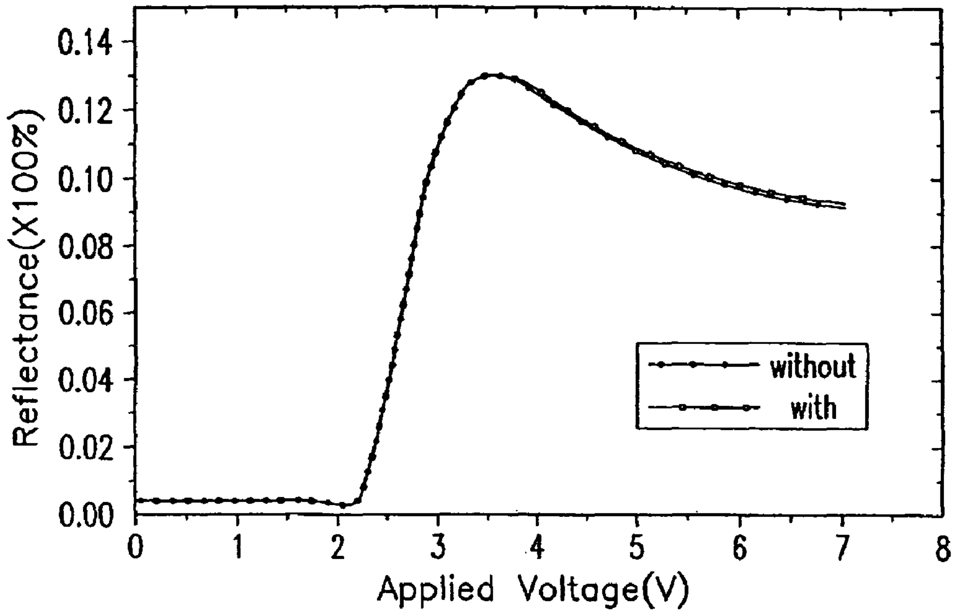
FIG.10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0.12
0.10
0.08
0.06
0.04
0.02
0.00
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1
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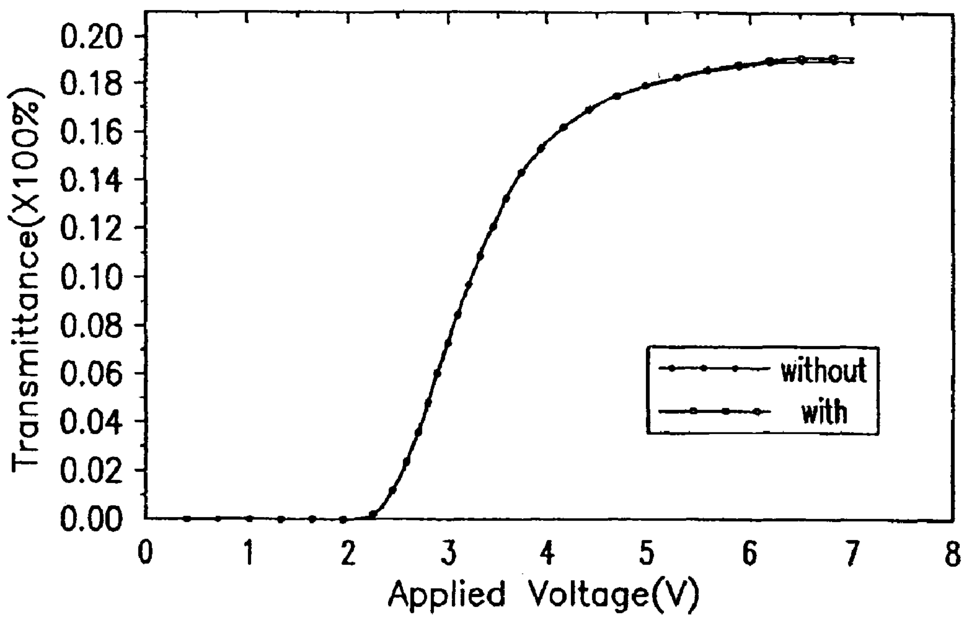
3
4
5
6
7
8
Applied Voltage(V)
without
with

FIG.11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0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Transmittance(X100%)
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1
2
3
4
5
6
7
8
Applied Voltage(V)
without
with

FIG.12A

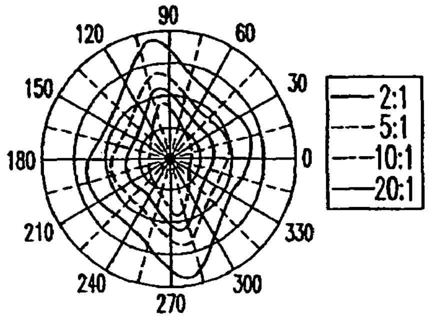

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FIG.12B

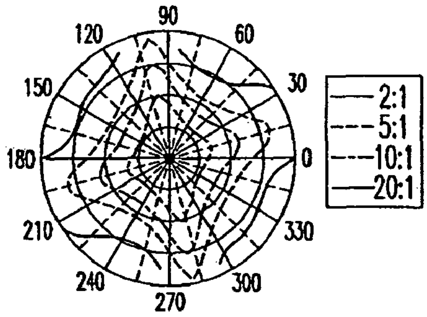

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FIG.12C

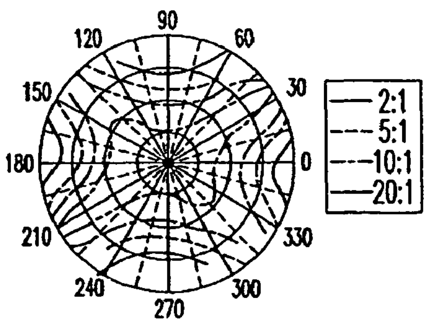

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FIG.12D

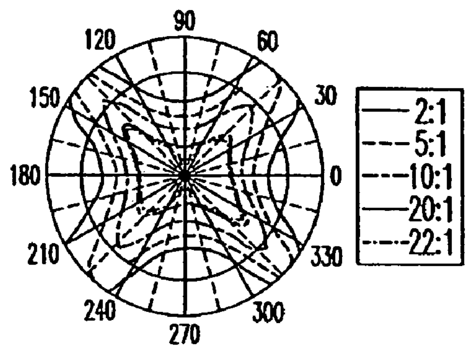

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FIG.12E

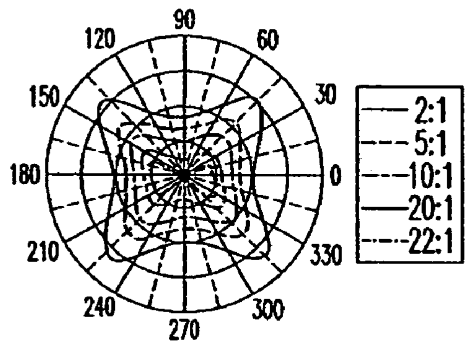

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FIG.12F

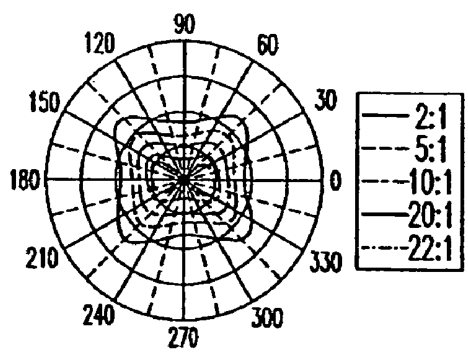

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FIG.13A

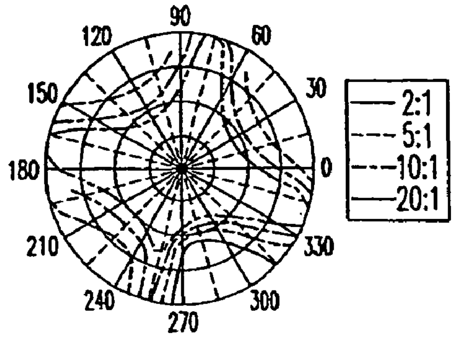

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FIG.13B

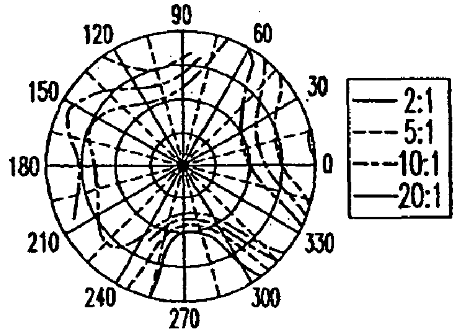

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FIG.13C

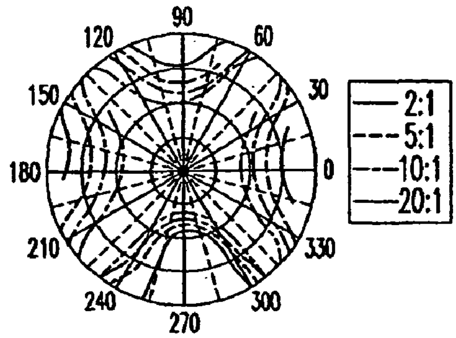

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FIG.13D

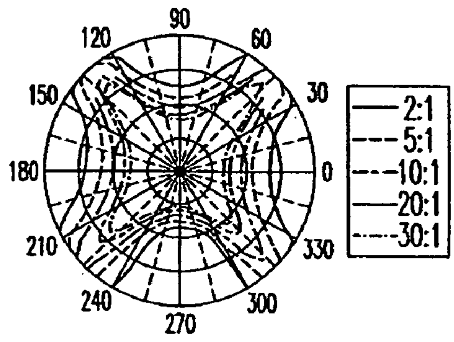

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FIG.13E

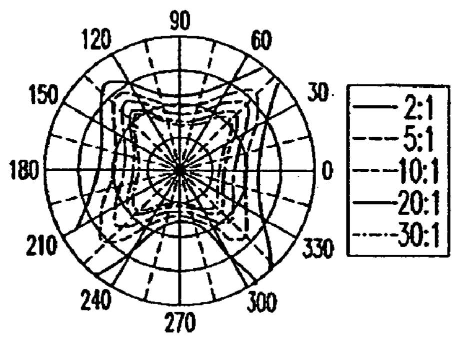

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FIG.13F

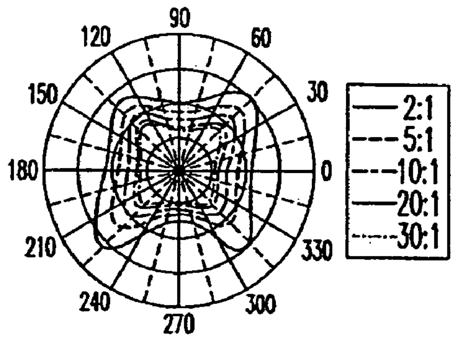

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FIG.14A

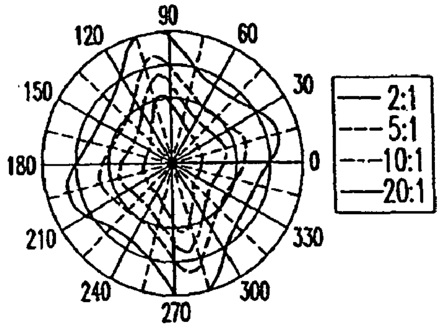

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FIG.14B

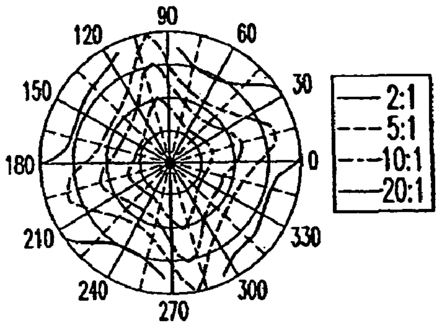

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FIG.14C

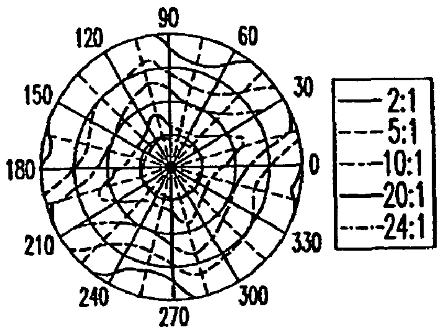

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FIG.14D

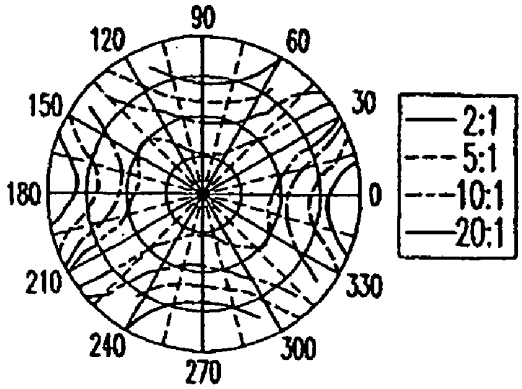

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FIG.14E

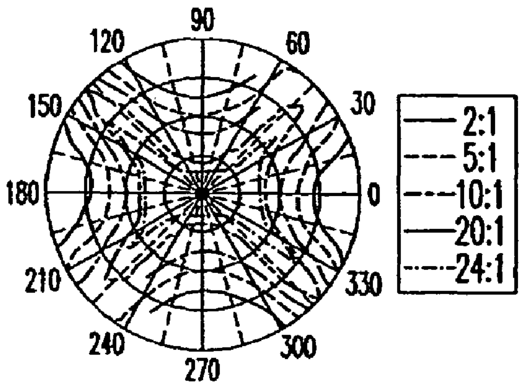

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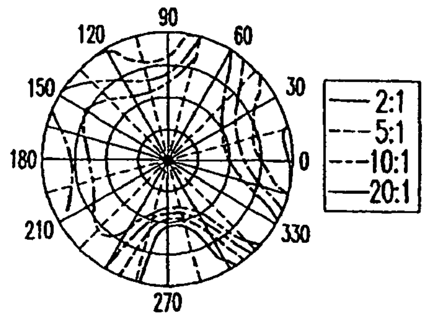
FIG.15A



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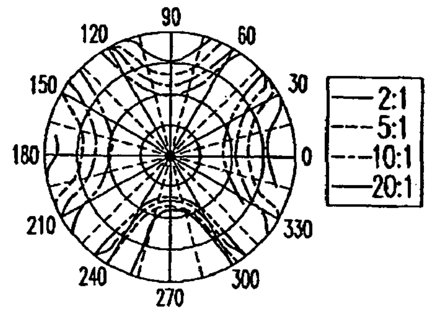

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FIG.15C

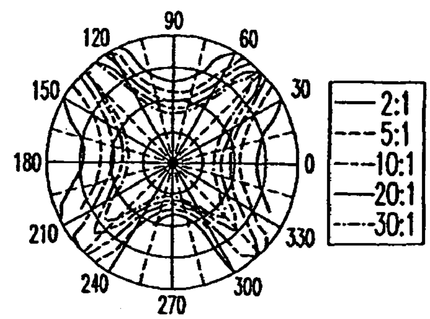

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FIG.15D

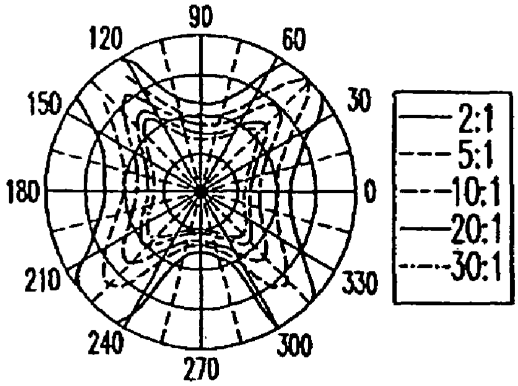

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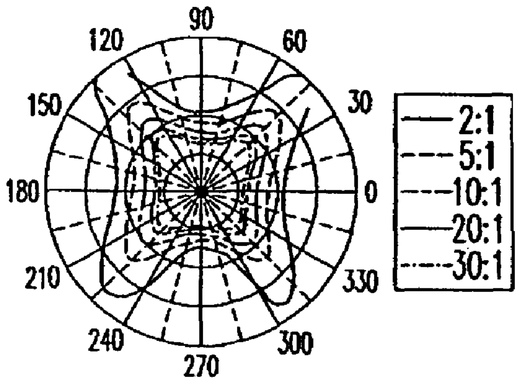
FIG.15E



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VERTICALLY ALIGNED LIQUID CRYSTAL DISPLAY DEVICE HAVING AN OPTIMIZED VIEWING ANGLE

RELATED APPLICATION

This application is a Continuation of U.S. application Ser. No. 10/618,142 filed on Jul. 10, 2003, now U.S. Pat. No. 7,079,208, which claims priority, under 35 U.S.C. 119, from Korean Patent Application No. 2002-0040857 filed on Jul. 12, 2002, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal display devices.

2. Description of Related Art

A liquid crystal display ("LCD") device includes upper and lower panels provided with field-generating electrodes thereon, a liquid crystal layer interposed therebetween, a pair of a polarizer and an analyzer, compensation films, etc. The LCD generates electric field in the liquid crystal layer by applying electric voltages to the field-generating electrodes and adjusts the intensity of the electric field to control the transmittance of light passing through the liquid crystal layer, thereby displaying desired images.

One of the most widely used types of LCD has a common electrode and a plurality of pixel electrodes provided on respective panels and a plurality of thin film transistors ("TFT") for switching voltages applied to the pixel electrodes, which is provided on the panel having the pixel electrodes.

LCDs may operate in one of several modes. An LCD operating in a vertically-aligned ("VA") mode contains liquid crystal molecules aligned perpendicular to two panels. VA-mode LCDs are sometimes preferred for their high contrast ratio and wide viewing angle.

LCDs often suffer from light leakage, the severity of which increases with viewing angle. The light leakage, which causes poor visibility from the sides and a narrow viewing angle, is caused by variations in light path and in the effective angle made by the polarizer and the analyzer depending on the viewing directions.

Compensation films are sometimes used to neutralize the effect of these variations. However, use of compensation films usually significantly increases the cost of the LCD because they are expensive and there is no efficient way to select the compensation film that yields optimal results. A method of determining the optimal parameters of a compensation film without the costly trial-and-error process is needed in order to allow more LCD applications to take advantage of compensation films.

SUMMARY

The invention is a display device that includes a first substrate and a second substrate positioned parallel to each other and a liquid crystal layer interposed between the first glass substrate and the second glass substrate. The liquid crystal layer includes liquid crystal molecules whose long axes are oriented substantially orthogonal to the first and second substrates in the absence of an electrical field in the liquid crystal layer. A first compensation film is coupled to the first substrate. The first compensation film has a retardation value of less than or equal to 200 nm for light having a wavelength of about 550 nm and is negatively birefringent. A polarization film is coupled to the first compensation film, and a first electrode is formed on one of the first and second substrates.

In another aspect, the invention is a display device that includes a first substrate and a second substrate positioned parallel to each other and a liquid crystal layer interposed between the first substrate and the second substrate. A polarization film is coupled to the first substrate, and a reverse-dispersion phase difference film is positioned between the first substrate and the polarization film. An electrode is formed on one of the first and second substrates.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other advantages of the present invention will-become more apparent by describing preferred embodiments thereof in detail with reference to the accompanying drawings in which:

FIG. **1** is a sectional view of an LCD according to an embodiment of the present invention;

FIG. **2** is a layout view of a TFT array panel of an LCD according to an embodiment of the present invention;

FIG. **3** is a sectional view of the TFT array panel shown in FIG. **2** taken along the line III-III';

FIG. **4** is a layout view of a color filter array panel of an LCD according to an embodiment of the present invention;

FIG. **5** is a sectional view of an LCD according to another embodiment of the present invention;

FIG. **6** is a sectional view of a TFT array panel of an LCD according to another embodiment of the present invention;

FIG. **7** is a sectional view of an LCD according to another embodiment of the present invention;

FIG. **8** is a layout view of a TFT array panel of an LCD according to another embodiment of the present invention;

FIG. **9** is a sectional view of the TFT array panel shown FIG. **8** taken along the line IX-IX';

FIG. **10** is a graph showing reflectance as function of applied voltage for a transflective LCD with and without uniaxial (C-plate) compensation films;

FIG. **11** is a graph showing transmittance as function of applied voltage for a transflective LCD with and without uniaxial (C-plate) compensation films;

FIGS. **12**A to **12**F are graphs showing isocontrast curves of a reflective type LCD without and with one C-plate attached to the upper panel;

FIGS. **13**A to **13**F are graphs showing isocontrast curves of a transmissive type LCD without and with one C-plate attached to the upper panel;

FIGS. **14**A to **14**E are graphs showing isocontrast curves of a reflective type LCD with C-plates attached to both upper and lower panels; and

FIGS. **15**A to **15**E are graphs showing isocontrast curves of a transmissive type LCD with C-plates attached to both upper and lower panels.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

In the drawings, the thickness of layers and regions are exaggerated for clarity. Like numerals refer to like elements throughout. It will be understood that when an element such as a layer, film, region, substrate or panel is referred to as being "on" another element, it can be directly on the other element or on one or more intervening elements. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

Then, LCDs according to embodiments of the present invention will be described in detail with reference to the drawings.

FIG. **1** is a sectional view of a transmissive type LCD according to an embodiment of the present invention.

An LCD according to this embodiment includes a TFT array panel **1** and a color filter array panel **2** facing each other, and a liquid crystal layer **3** interposed between the two panels **1** and **2**. The LCD also includes first and second polarization films **12** and **22** having nonparallel polarization axes, and first and second protective films **13** and **23** preferably made of TAC (triacetate cellulose) films and attached on the first and the second polarization films **12** and **22** for protecting the polarization films **12** and **22**, respectively. The LCD further includes a first uniaxial (C-plate) compensation film **14** inserted between the TFT array panel **1** and the first protective film **13**, and a second uniaxial compensation film **24** inserted between the color filter array panel **2** and the second protective film **23**.

The LCD is in a vertically-aligned (VA) mode. That is, the liquid crystal layer **3** of the LCD includes liquid crystal molecules aligned to make their long axes substantially perpendicular to the two panels **1** and **2**.

The first and the second protective films **13** and **23** generate slight retardation. In addition, the uniaxial compensation films **14** and **24** have negativity and generate retardation in a range between about 0 nm and about 200 nm for the light having a wavelength of 550 nm. Here, the uniaxiality means that $nx=ny\neq nz$ and the negativity means that $nx=ny>nz$, where nx, ny and nz denote the refractive indices of x, y and z directions, respectively.

The first uniaxial compensation film **14** may be omitted.

Now, a TFT array panel and a color filter array panel of an LCD according to embodiments are described in more detail.

FIG. **2** is a layout view of a TFT array panel for an LCD according to an embodiment of the present invention, and FIG. **3** is a sectional view of the TFT array panel shown in FIG. **2** taken along the line III-III'.

As shown in FIGS. **2** and **3**, a gate wire **121**, **123** and **125** preferably made of a metal having low resistivity such as aluminum, silver, etc. is formed on a transparent insulating substrate **110**. The gate wire **121**, **123** and **125** includes a plurality of gate lines **121** extending in a transverse direction and a plurality of gate electrodes **123** connected to the gate lines **121**. An end portion **125** of each gate line **121** is widened for connection with an external circuit.

A gate insulating layer **140** is formed on the entire surface of the substrate including the gate wire **121**, **123** and **125**.

A plurality of semiconductor stripes **151**, **153** and **159** preferably made of amorphous silicon are formed on the gate insulating layer **140**, and a plurality of ohmic contacts **161**, **162**, **163** and **165** preferably made of amorphous silicon heavily doped with n-type impurity are formed on the semiconductor stripes **151**, **153** and **159**.

A data wire **171**, **173**, **175**, **177** and **179** preferably made of a metal having low resistivity such as aluminum, silver, etc. is formed on the ohmic contacts **161**, **162**, **163** and **165** and the gate insulating layer **140**.

The data wire **171**, **173**, **175**, **177** and **179** includes a plurality of data lines **171** intersecting the gate lines **121** to define a plurality of pixel areas, a plurality of source electrodes **173** which are branches of the data lines **171** and connected to the ohmic contacts **163**, a plurality of drain electrode **175** separated from the source electrodes **173** and formed on the ohmic contacts **165** opposite to the source electrodes **173** with respect to the gate electrodes **123**, and a plurality of storage electrodes **177** overlapping the gate lines **121** to form storage capacitors. An end portion **179** of each data line **171** is widened for connection with an external circuit.

A passivation layer **180** is formed on the data wire **171**, **173**, **175**, **177** and **179**. The passivation layer **180** has a plurality of first contact holes **181** exposing the drain electrodes **175**, a plurality of second contact holes **182** exposing the end portions **125** of the gate lines, a plurality of third contact holes **183** exposing the end portions **179** of the data lines **171**, and a plurality of fourth contact holes **184** exposing the storage electrodes **177**.

A plurality of pixel electrodes **190** and a plurality of contact assistants **95** and **97** are formed on the passivation layer **180**. The pixel electrodes **190** are connected to the drain electrodes **175** and the storage electrodes **177** via the first and the fourth contact holes **181** and **184**, respectively, and the contact assistants **95** and **97** are connected to the exposed end portions **125** of the gate lines **121** and the exposed end portions **179** of the data lines **171** via the second and the third contact holes **182** and **183**, respectively. The pixel electrodes **190** and the contact assistants **95** and **97** are preferably made of transparent material such as ITO (indium tin oxide) or IZO (indium zinc oxide).

FIG. **4** is a layout view of a color filter array panel of an LCD according to an embodiment of the present invention.

A black matrix **220** is formed on an insulating substrate **210**, a plurality of color filters **230** are formed on the black matrix **220**, and a common electrode **270** is formed on the color filters **230**. The common electrode **270** is preferably made of a transparent conductive material such as ITO or IZO.

FIG. **5** is a sectional view of a reflective type LCD without separate light source according to another embodiment of the present invention.

An LCD according to this embodiment includes a TFT array panel **1** and a color filter array panel **2** facing each other, and a liquid crystal layer **3** interposed between the two panels **1** and **2**. The LCD further includes a polarization film **22** and a protective film **23** attached on the polarization film **22** for protecting the polarization film **22**. The LCD also includes a uniaxial compensation film **24** and a reverse dispersion phase difference film **25** inserted between the color filter array panel **2** and the protective film **23**.

The LCD is in a VA mode. The protective film **23** generates slight retardation, and the uniaxial compensation film **24** has negativity and generates retardation ranging 0 nm to 200 nm for the light with 550 nm wavelength.

FIG. **6** is a sectional view of a TFT array panel of an LCD according to another embodiment of the present invention.

Referring to FIG. **6**, a gate wire **121**, **123** and **125**, a gate insulating layer **140**, a plurality of semiconductor stripes **151** and **153**, a plurality of ohmic contacts **161**, **162**, **163** and **165**, a data wire **171**, **173**, **175**, **177** and **179**, a passivation layer **180**, a plurality of pixel electrodes **190**, and a plurality of contact assistants **95** and **97** are formed on a substrate **110**.

The surface of the passivation layer **180** has embossment including prominences/protrusions and depressions, and the pixel electrodes **190** are preferably made of a metal having good reflectance such as aluminum.

FIG. **7** is a sectional view of a transflective LCD according to another embodiment of the present invention.

An LCD according to this embodiment includes a TFT array panel **1** and a color filter array panel **2** facing each other, and a liquid crystal layer **3** interposed between the two panels

1 and **2**. The LCD also includes a pair of first and second polarization films **12** and **22**, and a pair of first and second protective films **13** and **23** attached on the polarization films **12** and **22**, respectively. The LCD further includes a first uniaxial (C-plate) compensation film **14** and a first reverse dispersion phase difference film **15** inserted between the TFT array panel **1** and the first protective film **13**, and a second uniaxial (C-plate) compensation film **24** and a second reverse dispersion phase difference film **25** inserted between the color filter array panel **2** and the second protective film **23**.

The LCD is in a VA mode. The first and the second protective films **13** and **23** generate slight retardation, and the first and the second uniaxial compensation films **14** and **24** have negativity and generate retardation in a range from 0 nm to 200 nm for the light with 550 nm wavelength. The first uniaxial compensation film **14** may be omitted.

FIG. **8** is a layout view of a TFT array panel of an LCD according to an embodiment of the present invention, and FIG. **9** is a sectional view of the TFT array panel shown in FIG. **8** taken along the line IX-IX'.

Referring to FIG. **8**, a gate wire **121**, **123** and **125**, a gate insulating layer **140**, a plurality of semiconductor stripes **151** and **153**, a plurality of ohmic contacts **161**, **162**, **163** and **165**, a data wire **171**, **173**, **175**, **177** and **179**, and a passivation layer **801** are formed on a substrate **110**.

A plurality of transparent electrodes **90** and a plurality of contact assistants **95** and **97** preferably made of ITO or IZO are formed on the passivation layer **801**. An interlayer insulating layer **802** having an embossed surface is formed on the transparent electrodes **90**. A plurality of reflecting electrodes **80** are formed on the interlayer insulating layer **802**, and each reflecting electrodes **80** has a window **82** for light transmission.

Various characteristics of various types of LCDs with various types of compensation films were measured.

The LCDs used for the measurement have conditions shown in TABLE 1 and TABLE 2.

TABLE 1

Mode	VA
Dopant	natural pitch of 67 microns
Twist Angle	90 degrees
Pretilt Angle	89 degrees
K11	13.0 pN
K22	5.1 pN
K33	14.7 pN
ϵ||	3.6
$\epsilon\perp$	7.4
Cell Gap	2.89 microns

Here, K11, K22 and K33 are elastic coefficients of spreading, twisting and bending measured in pico-newton (pN) and $\epsilon||$ and $\epsilon\perp$ are permittivity parallel to and perpendicular to the director, respectively.

TABLE 2

			n_∞	$A(nm^{-2})$	Thickness (microns)	Δnd for 550 nm wavelength
Liquid	VA	ne	1.5369	7651.0	2.89	240 nm
Crystal		no	1.4607	5569.0		
Reverse	ne		1.5934	−268.8	52.14	142.86 nm
dispersionλ/4 plate	no		1.59	0		
TAC	nx 1.4800		ny 1.4798	nz 1.4791	80	—
C-Plate	nx 1.504		ny 1.504	nz 1.500	20	80 nm

Here, ne is the refractive index parallel to the director (i.e. for extraordinary ray) and no is the refractive index perpendicular to the director (i.e. for ordinary ray), while Δn=ne−no. In addition, the dispersion relation is given by:

$$n(\lambda) = n_\infty + \frac{A}{\lambda^2},$$

where n_∞ is the refractive index for infinite wavelength and A is a constant.

FIGS. **10** and **11** are graphs respectively showing reflectance and transmittance as function of applied voltage for a transflective LCD with and without uniaxial (C-plate) compensation films.

The curves show that the presence of the uniaxial compensation films hardly affects the reflectance and the transmittance of the LCD.

FIGS. **12**A to **12**F are graphs showing isocontrast curves of a reflective type LCD without and with one C-plate attached to the upper panel. FIGS. **12**A to **12**F show the isocontrast curves for the cases 2 to 7 in the TABLE 3, respectively.

TABLE 3

		Number/	Reflective Type			
Case	Mode	Thickness (um)/ Δnd of C plate	Reflectance (%)	Front view CR	Viewing Angle up/down/ (left/right) CR 2:1	Areal Isocontrast Ratio (CR 10:1)
1	TN	None	11.7	19.9	47/34/80/66	0.861
2	VA	None	16.9	26.0	68/68/51/51	0.757
3	VA	One/ 20/80 nm	16.9	25.8	80/80/79/79	1
4	VA	One/ 40/160 nm	16.9	24.0	55/55/68/68	1.324
5	VA	One/ 60/240 nm	16.9	22.1	42/42/50/50	0.987
6	VA	One/ 80/320 nm	16.9	26.6	35/35/42/42	0.723
7	VA	One/ 100/400 nm	16.9	26.6	31/31/36/36	0.603

FIGS. **13**A to **13**F are graphs showing isocontrast curves of a transmissive type LCD without and with one C-plate attached to the upper panel. FIGS. **13**A to **13**F show the isocontrast curves for the cases 2 to 7 in TABLE 4, respectively.

TABLE 4

		Number/	Transmissive type			
Case	Mode	Thickness (um)/ Δnd of C plate	Transmittance (%)	Front View CR	Viewing Angle (up/down/ left/right) CR 2:1	Areal Isocontrast Ratio (CR 10:1)
1	TN	None	7.4	378.4	59/59/80/80	1.065
2	VA	None	13.0	881.6	80/47/80/80	1.404
3	VA	One/ 20/ 80 nm	13.0	880.3	80/40/80/79	1.55
4	VA	One/ 40/ 160 nm	13.0	881.9	60/34/70/63	1.410
5	VA	One/ 60/ 240 nm	13.0	880.7	50/31/57/54	1.177

TABLE 4-continued

Case	Mode	Number/ Thickness (um)/ Δnd of C plate	Transmissive type Transmittance (%)	Front View CR	Viewing Angle (up/down/ left/right) CR 2:1	Areal Isocontrast Ratio (CR 10:1)
6	VA	One/ 80/ 320 nm	13.0	881.0	44/30/50/49	0.925
7	VA	One/ 100/ 400 nm	13.0	882.0	39/27/45/44	0.797

FIGS. **14**A to **14**E are graphs showing isocontrast curves of a reflective type LCD with two C-plates respectively attached to upper and lower panels. FIGS. **14**A to **14**E show the isocontrast curves for Cases 8 to 12, respectively.

TABLE 5

Case	Mode	Thickness (um)/ Δnd of C plate	Reflective type Reflectivity (%)	Front view CR	Viewing Angle (up/down/ left/right) CR 2:1	Areal Isocontrast Ratio (CR 10:1)
8	VA	10/ 40 nm × 2	16.9	23.2	75/78/62/62	0.861
9	VA	20/ 80 nm × 2	16.9	25.8	80/80/79/79	1
10	VA	30/ 120 nm × 2	16.9	24.3	69/69/80/80	1.209
11	VA	40/ 160 nm × 2	16.9	24.0	55/55/68/68	1.324
12	VA	50/ 200 nm × 2	16.9	24.3	47/47/58/58	1.242

FIGS. **15**A to **15**E are graphs showing isocontrast curves of a transmissive type LCD with two C-plates respective attached to upper and lower panels. FIGS. **15**A to **15**E show the isocontrast curves for Cases 8 to 12 in TABLE 6, respectively.

TABLE 6

Case	Mode	Thickness (um)/ Δnd of C plate	Transmissive Type Transmittance (%)	Front View CR	Viewing Angle (up/down/ left/right) CR 2:1	Areal Isocontrast Ratio (CR 10:1)
8	VA	10/ 40 nm × 2	13.0	881.0	80/39/80/78	1.565
9	VA	20/ 80 nm × 2	13.0	881.8	59/34/75/63	1.430
10	VA	30/ 120 nm × 2	13.0	881.2	49/31/58/54	1.215
11	VA	40/ 160 nm × 2	13.0	881.6	43/29/51/48	0.958
12	VA	50/ 200 nm × 2	13.0	882.1	38/27/46/44	0.817

In TABLES 3 to 6, the areal isocontrast ratio is an isocontrast area for the contrast ratio of 10:1 divided by that in Case 3 of the reflective type LCD. White and black voltages in VA mode are 3.5V and 1.8V for the reflective type and 4.5V and 1.8V for transmissive type, respectively. The abbreviation "CR" stands for contrast ratio.

The ratios such as 2:1, 5:1, 10:1, 20:1 and 22:1 in the legends of FIGS. **12**A to **15**E indicate contrast ratios and the values (for example, 68/68/51/51 in FIG. **12**A) at the bottom of FIGS. **12**A to **15**E indicate upper/lower/left/right side viewing angles giving the contrast ratio of 2:1.

The measurement values of TABLES 3 to 6 shown in FIGS. **12**A to **12**F, **13**A to **13**F, and **14**A to **15**E can be summarized as follows.

Without uniaxial compensation film (C-plate), the transmittance, the reflectance, the contrast ration at the front view, and the viewing angle of the VA mode are superior to those of the TN mode.

Compared with Case 2, which does not include a uniaxial compensation film, Cases 3 and 4 of the VA mode show both improved viewing angle and improved isocontrast curve, and Cases 3 and 4 of the transmissive mode show improved isocontrast curves. In contrast, Cases 5, 6 and 7, each of which includes a compensation film causing a retardation greater than 160 nm, show deteriorated viewing angle and deteriorated isocontrast curves. Data indicates that a uniaxial compensation film providing a retardation value larger than 160 nm has a detrimental effect on the LCD device.

With uniaxial compensation films attached to both upper and lower panels, the isocontrast curves for the transmissive-type LCDs are improved until the sum of the retardation values of the two compensation films equals to 160 nm. When the combined retardation value exceeds 160 nm, both the isocontrast curves and the viewing angles become worse. For the reflective-type LCDs, only one of the two compensation films contributes to the total retardation since light is not transmitted through both of films. Therefore, the actual retardation values of the compensation films for the cases 8 to 11 are equal to or smaller than 160 nm. This explains why case 12 for the reflective-type LCD shows improved isocontrast curves in spite of having a retardation value of 200 nm. For the transmissive-type LCD, although there is no experimental example for the case of 200 nm retardation, the results shown in TABLES 3 to 6 suggest that the isocontrast curves will be improved where retardation values are equal to or less than 200 nm.

The above-described experimental results show a correlation between the total thickness of the uniaxial compensation film(s) and the viewing angle and/or the contrast ratio. It appears that the total thickness of the uniaxial compensation film(s) affects the viewing angle and/or the contrast ratio more than the number or the physical arrangement of the uniaxial compensation film(s).

Of the cases above, Case 3 has optimal characteristics both for the transmissive type and the reflective type LCDs. Although some cases show better contrast ratio at the front view than Case 3, the difference is small. Overall, Case 3 resulted in a better viewing angle than the other cases. Therefore, it can be said that Case 3 is optimized.

In conclusion, the total retardation of the uniaxial compensation film(s) equal to or under 200 nm improves the isocontrast curve and/or the viewing angle. This improvement is irrelevant to the number of uniaxial compensation films used and the type (reflective or the transmissive) of LCD.

According to the present invention, uniaxial compensation film(s) generating a predetermined retardation is used to improve the viewing angle of the LCD.

What is claimed is:

1. A display device of a reflective type, the display device comprising:

a first substrate comprising a color filter array panel;

a second substrate comprising a TFT array panel, the second substrate positioned parallel to the first substrate;

a liquid crystal layer interposed between the first and second substrates;

a single compensation film coupled only to the first substrate;

a polarization film coupled to the compensation film; and

a reverse dispersion phase difference film located between the compensation film and the polarization film,

wherein the compensation film has refractive indices nx, ny, and nz that satisfy the relation nx=ny>nz.

2. The display device of claim **1**, wherein the liquid crystal layer comprises liquid crystal molecules whose long axes are oriented substantially orthogonal to the first and second substrates in the absence of an electric field in the liquid crystal layer.

3. The display device of claim **1**, wherein the compensation film has a retardation value less than or equal to 200 nm for light having a wavelength of about 550 nm.

4. The display device of claim **1**, wherein the compensation film is negatively birefringent.

5. The display device of claim **1**, wherein the reverse dispersion phase difference film is a λ/4.

* * * * *

专利名称(译)	具有优化视角的垂直排列的液晶显示装置		
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[标]申请(专利权)人(译)	三星电子株式会社		
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摘要(译)

提出了一种改善垂直配向的液晶显示装置的视角的方法。该方法涉及设计单轴补偿膜以对波长为约550nm的光提供200nm或更小的延迟值。使用这种单轴补偿膜，可以通过获得液晶面板来构建显示装置，该液晶面板包含在玻璃基板之间的液晶分子，将单轴补偿膜耦合到至少一个玻璃基板，并将偏振膜和电极耦合到补偿片。优选地，单轴补偿膜的厚度小于或等于50微米。如果有多个补偿膜，则应考虑总厚度和总延迟值。