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(54) **LIQUID CRYSTAL DISPLAY WITH A WIDE VIEWING ANGLE USING A COMPENSATION FILM**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

Jun. 13, 2000 (KR) 2000-32506

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

(52) **U.S. Cl.** **349/121**; 349/120

(58) **Field of Classification Search** 349/119, 349/121, 118, 181, 120
See application file for complete search history.

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(57) **ABSTRACT**

Disclosed is a liquid crystal display comprising a liquid crystal cell including a pair of transparent substrates, with orientation layers deposited on inner surfaces thereof, and a liquid crystal layer of liquid crystal material injected between the substrates; biaxial compensation films provided on outer surfaces of the liquid crystal cell, the biaxial compensation films including an optical dielectric material layer; and polarization plates provided on outer surfaces of the biaxial compensation films, wherein if "d" is set as a cell gap of the liquid crystal cell, "R_{LC}" is set as a phase retardation value of the liquid crystal layer, an axis perpendicular to planes made by the substrates is set as a z-axis, x-axis and y-axis are formed on a planar surface of the substrates, and refractive indices of molecules comprising the biaxial compensation films in the x, y and z directions are denoted by nx, ny and nz, retardation values (ny−nx)*d and (nz−nx)*d of the biaxial compensation films being respectively within ranges of −30±5 nm and $-R_{LC}/4\pm15$ nm.

14 Claims, 12 Drawing Sheets

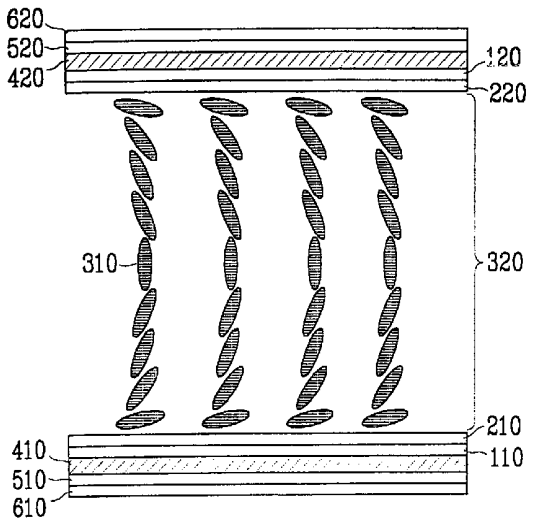


FIG.1

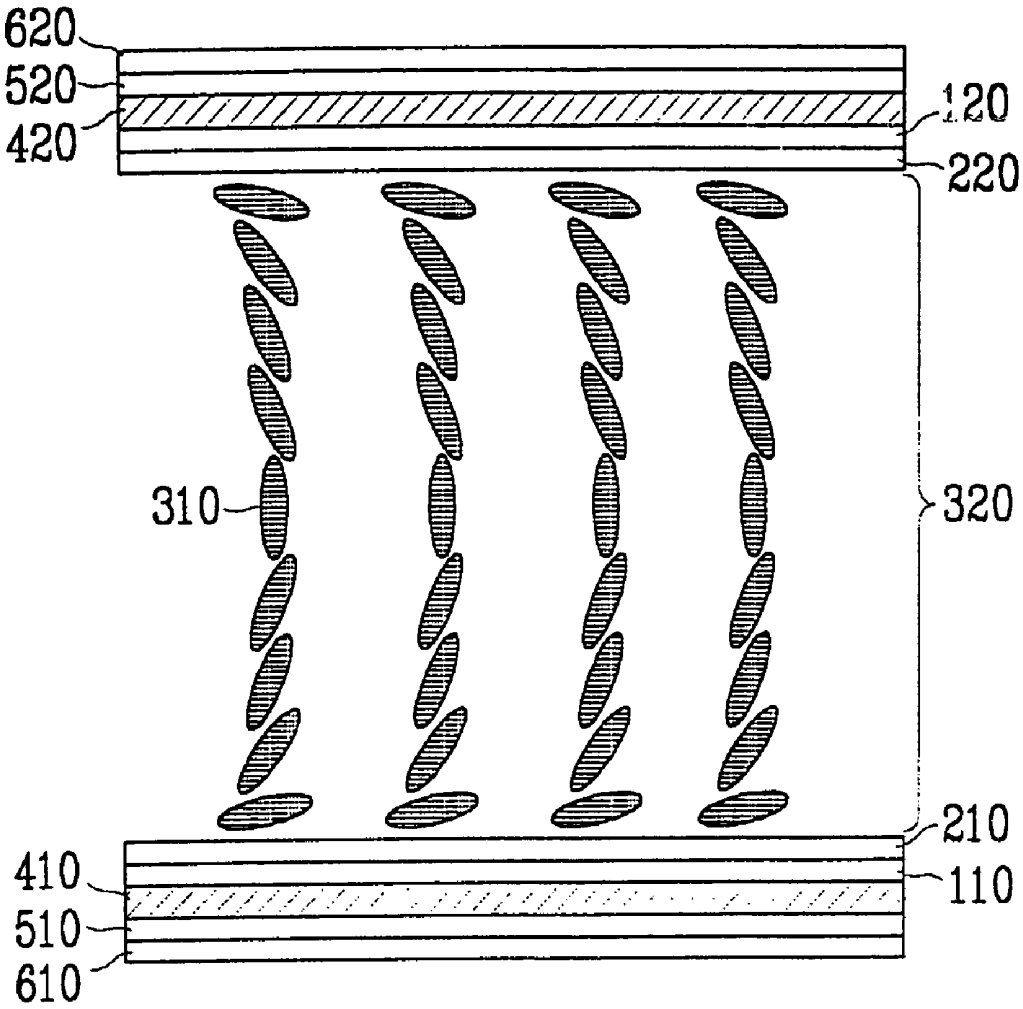
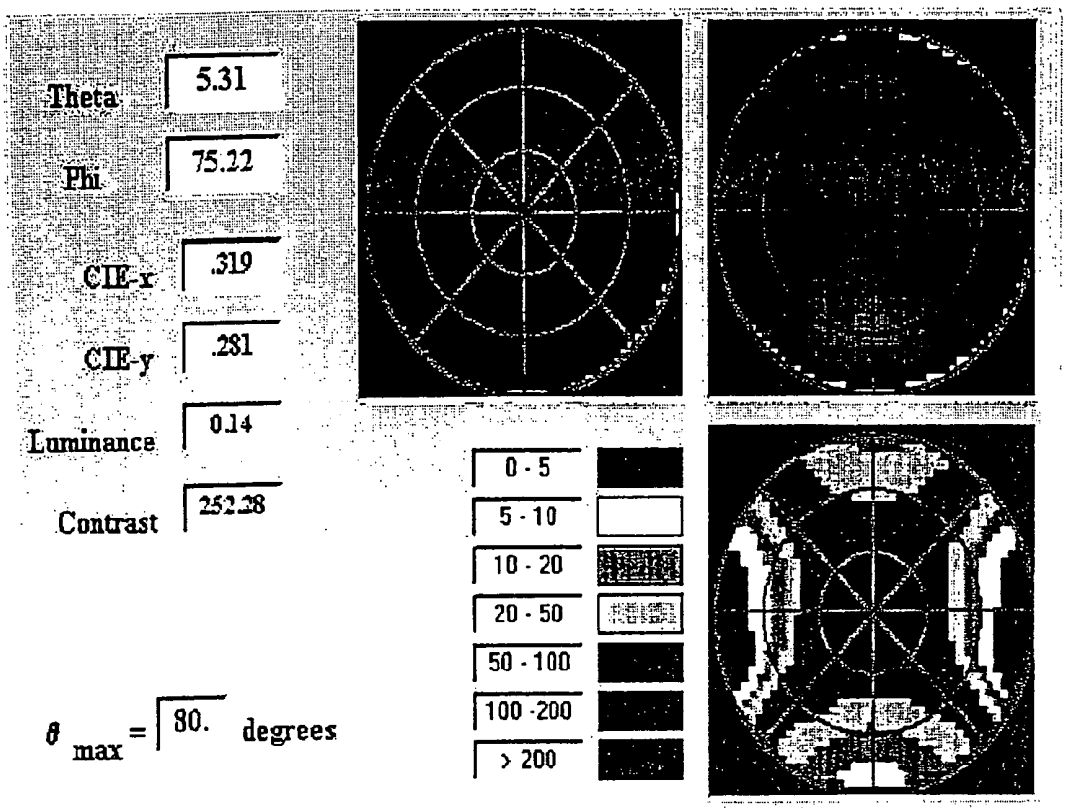


FIG.2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CIE-x .319
CIE-y .281
Luminance 0.14
Contrast 252.28
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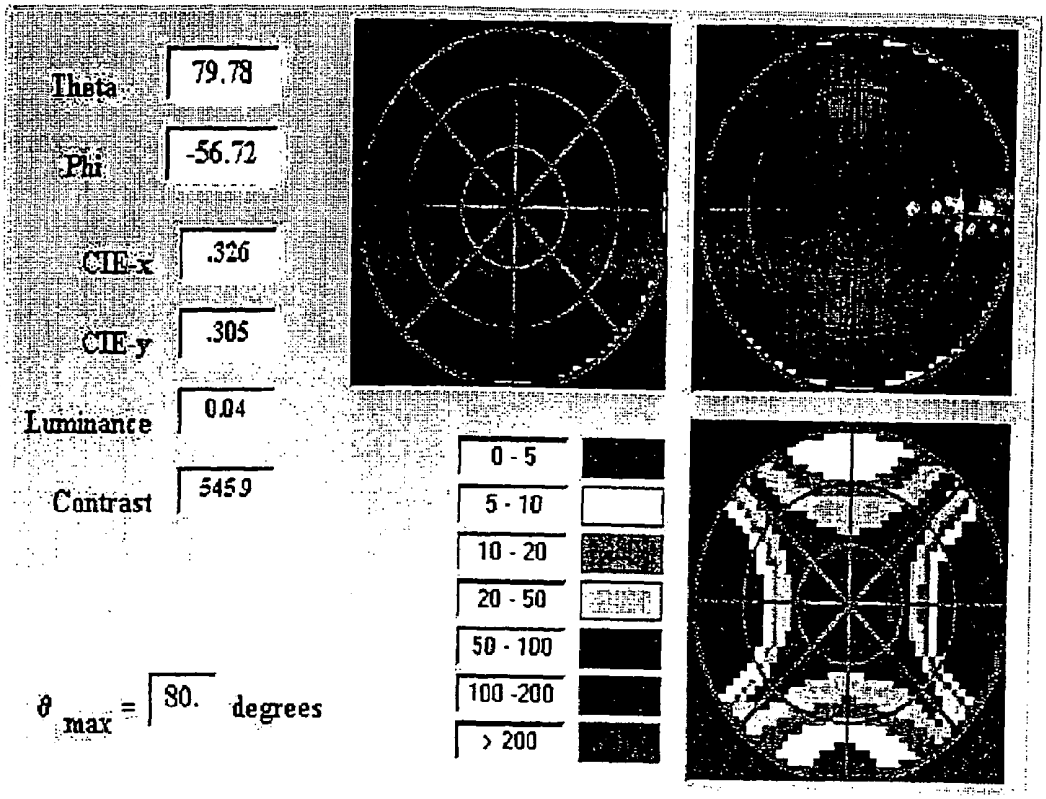
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200
θ max = 80. degrees

FIG.3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CIE-y
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Contrast
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5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200
θ max = 80. degrees

FIG.4A

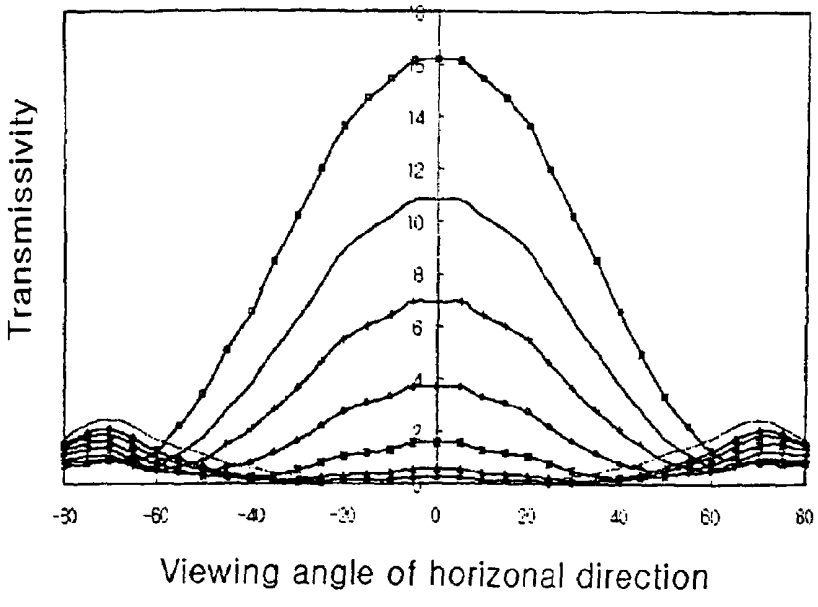
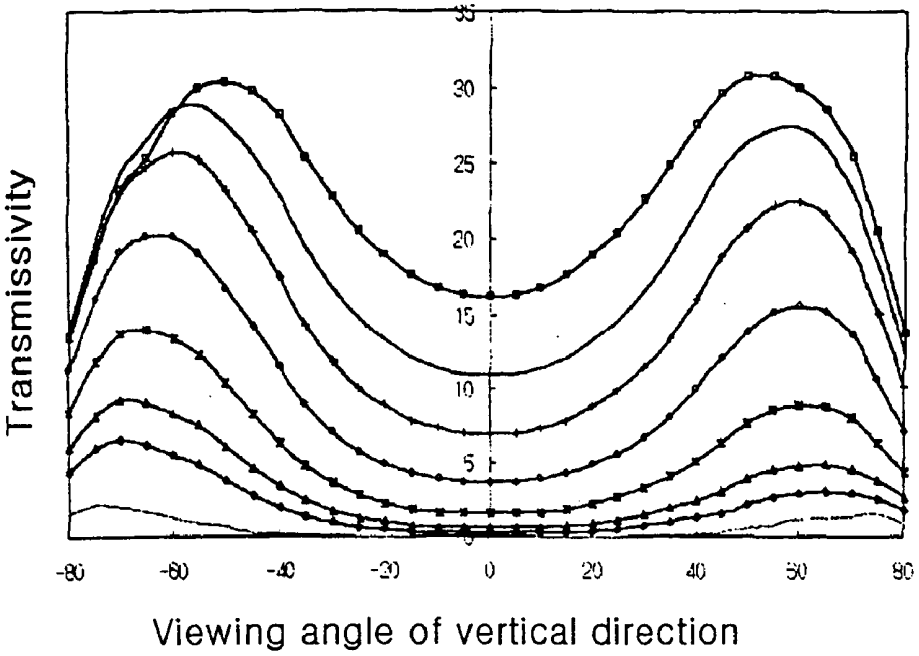

Transmissivity
16
14
12
10
8
6
4
2
0
-80
-60
-40
-20
0
20
40
60
80
Viewing angle of horizonal direction

FIG.4B


Transmissivity
35
30
25
20
15
10
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0
-80
-60
-40
-20
0
20
40
60
80
Viewing angle of vertical direction

FIG.4C

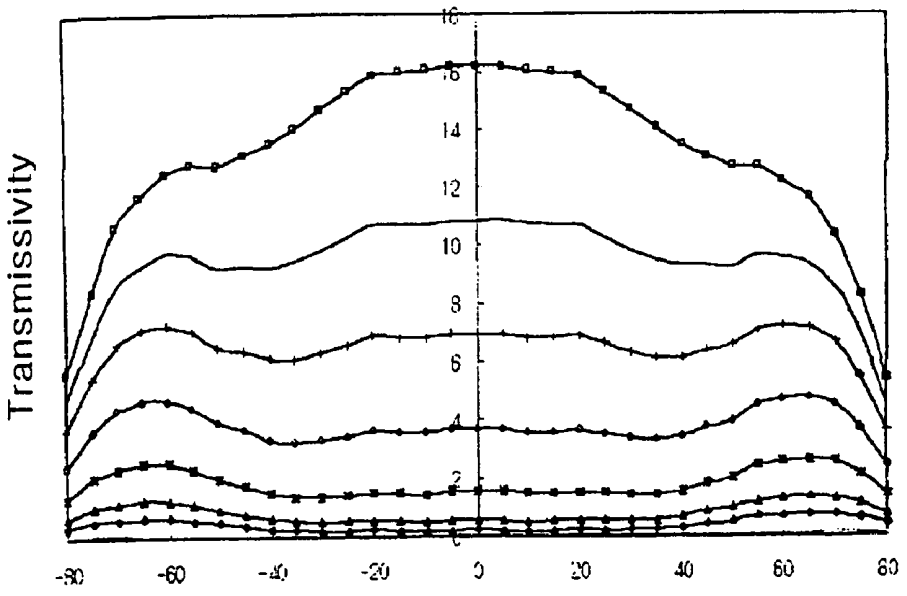
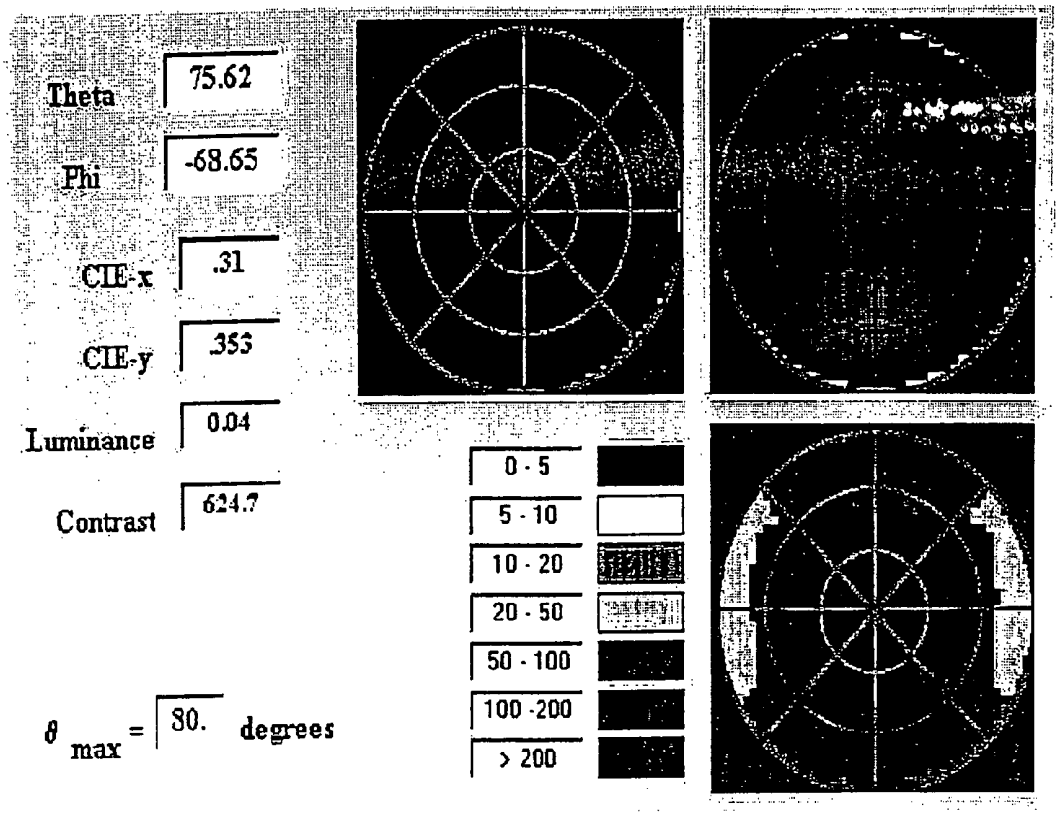

Transmissivity
16
14
12
10
8
6
4
2
0
-80
-60
-40
-20
0
20
40
60
80
Viewing angle of diagonal direction

FIG.5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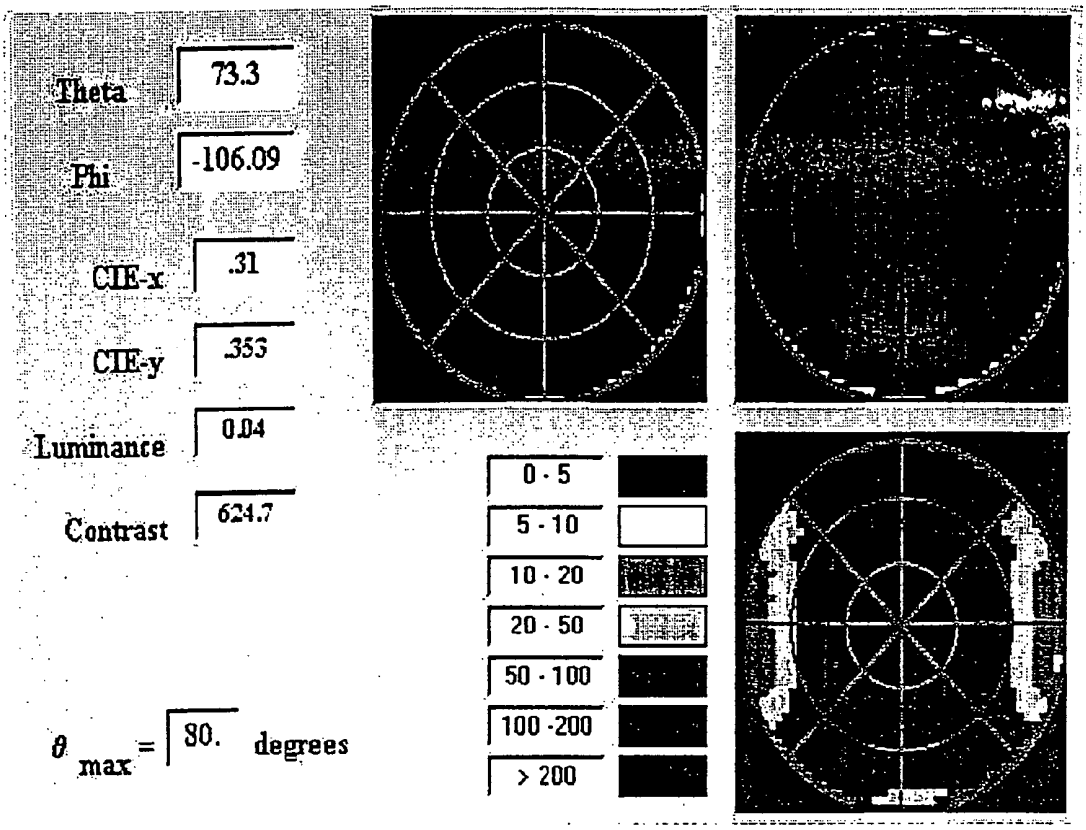
Phi
-68.65
CIE-x
.31
CIE-y
.353
Luminance
0.04
Contrast
624.7
θ max = 80. degrees
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.6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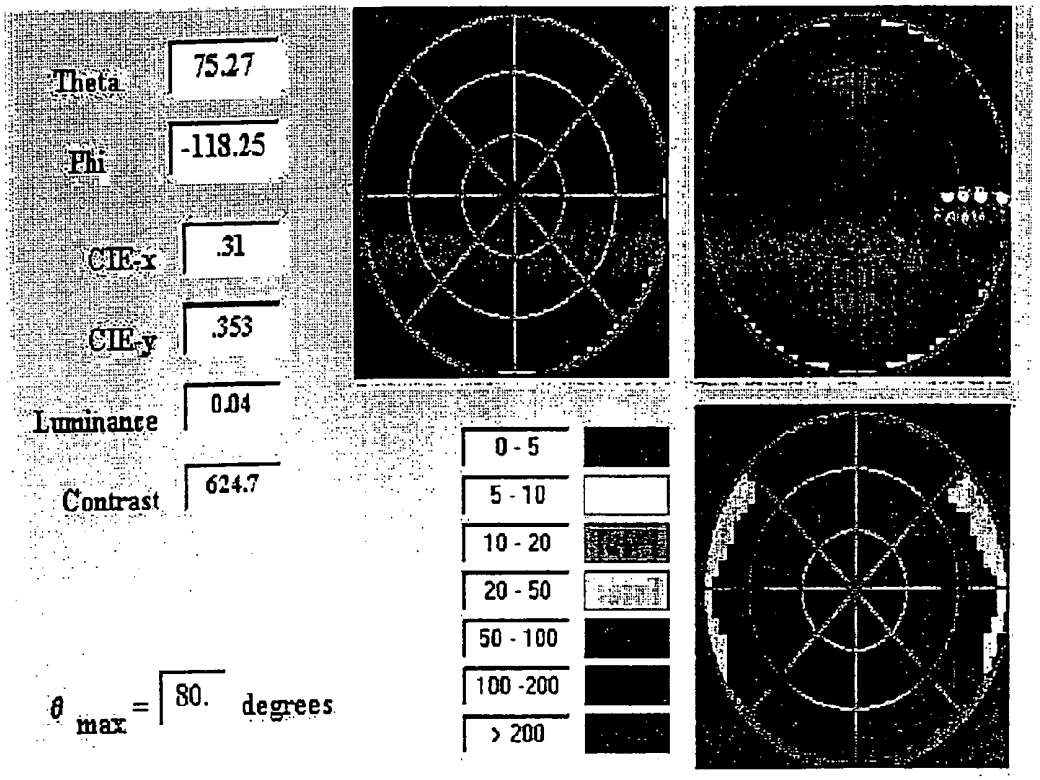
CIE-y
.353
Luminance
0.04
Contrast
624.7
θ max = 80. degrees
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.7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75.27
Phi
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CIE-x
.31
CIE-y
.353
Luminance
0.04
Contrast
624.7
θ max = 80. degrees
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.8A

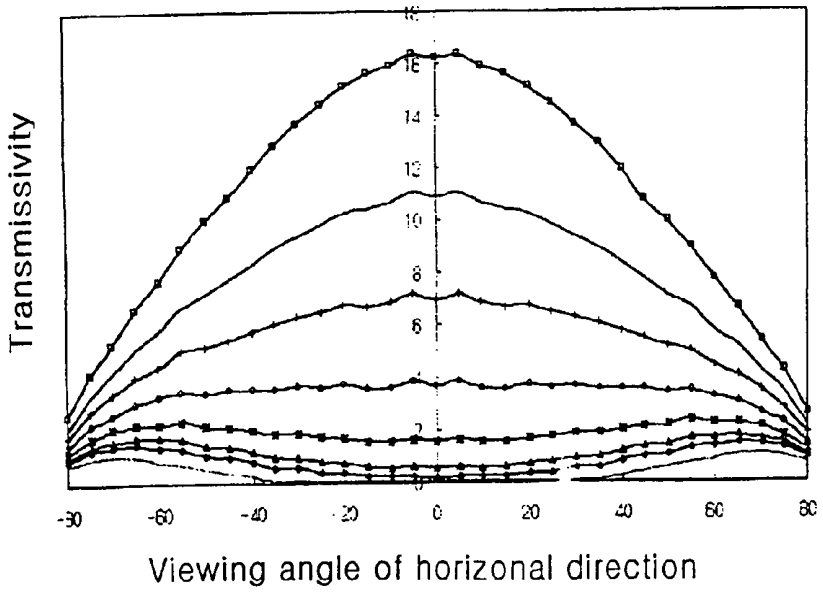

Transmissivity
14
12
10
8
6
-30
-60
-40
-20
0
20
40
60
80
Viewing angle of horizonal direction

FIG.8B

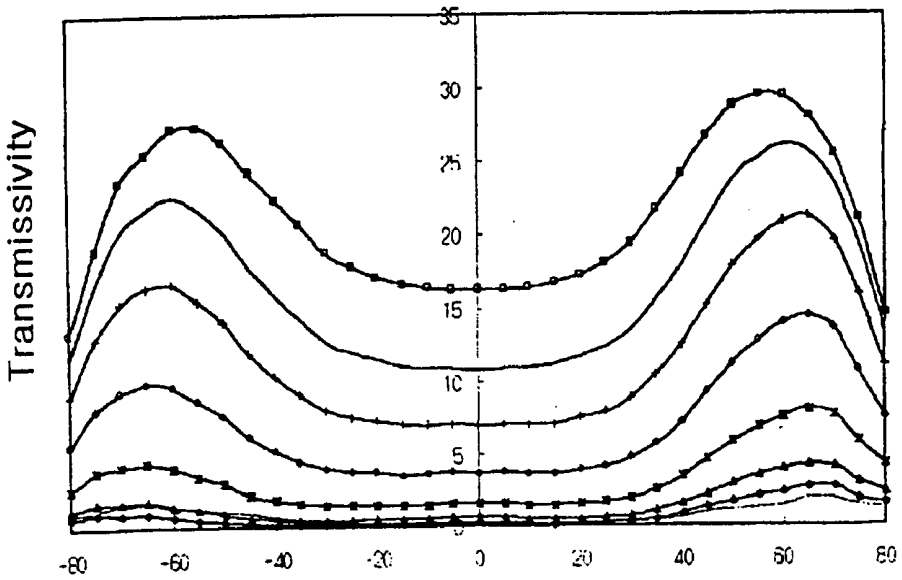

Transmissivity
35
30
25
20
15
10
5
0
-80
-60
-40
-20
0
20
40
60
80
Viewing angle of vertical direction

FIG.8C

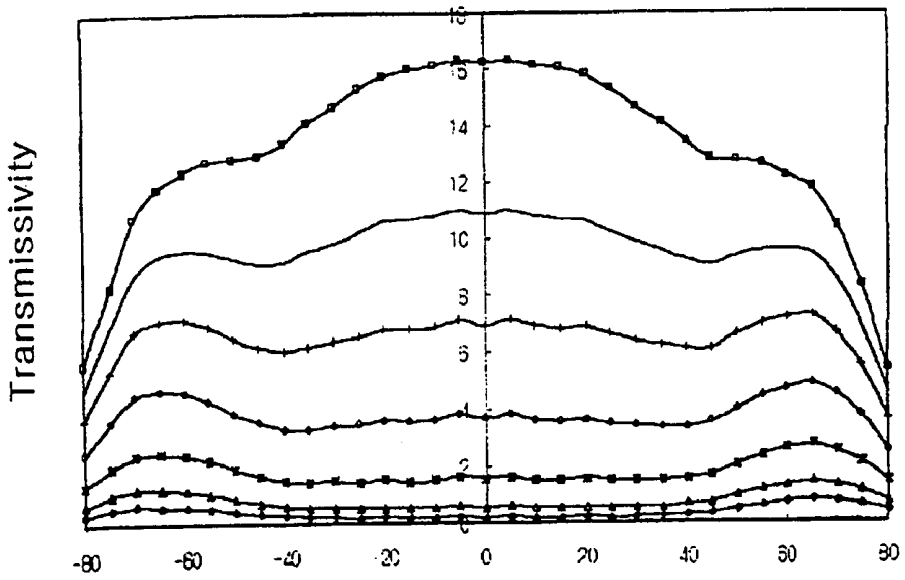
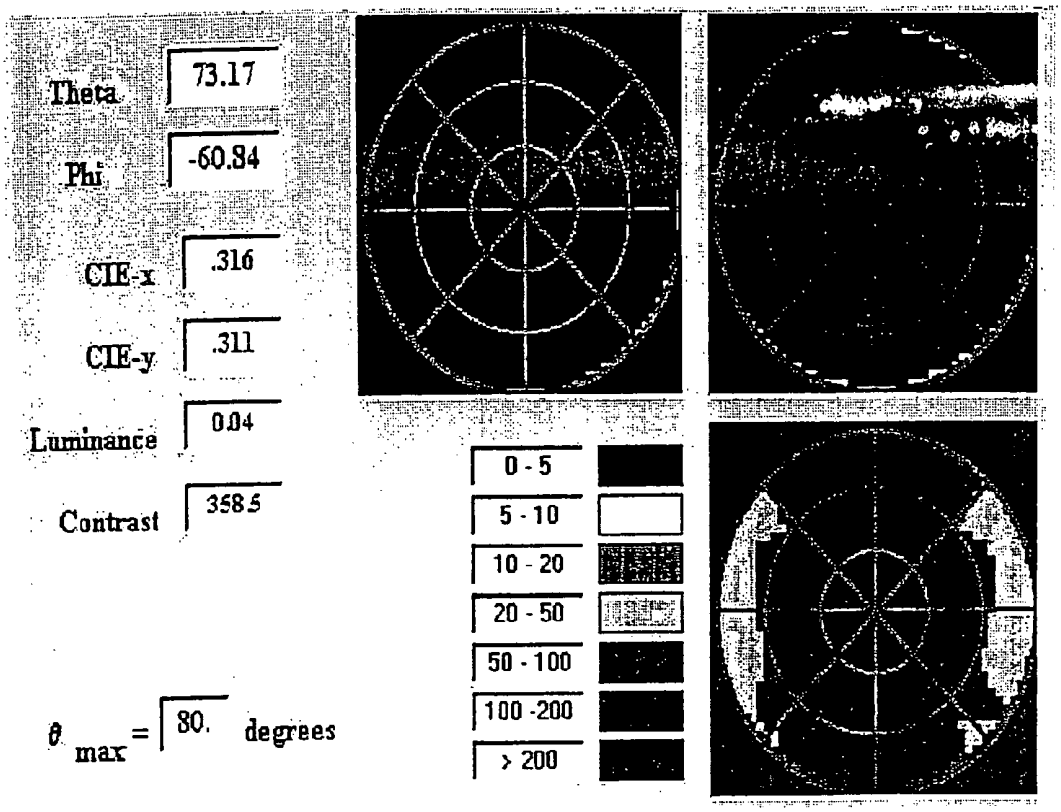

Transmissivity
16
14
12
10
8
6
4
2
0
-80
-60
-40
-20
0
20
40
60
80
Viewing angle of vertical direction

FIG.9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73.17
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CIE-x
.316
CIE-y
.311
Luminance
0.04
Contrast
358.5
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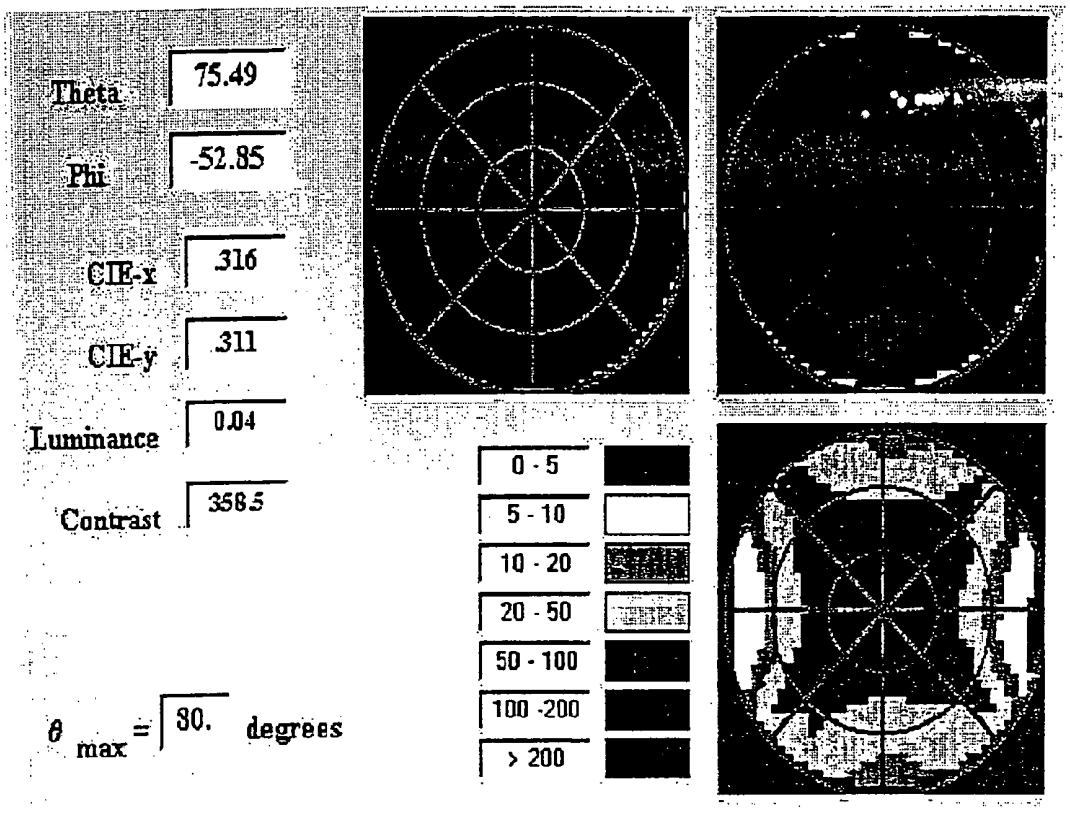
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.10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CIE-x
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CIE-y
.311
Luminance
0.04
Contrast
358.5
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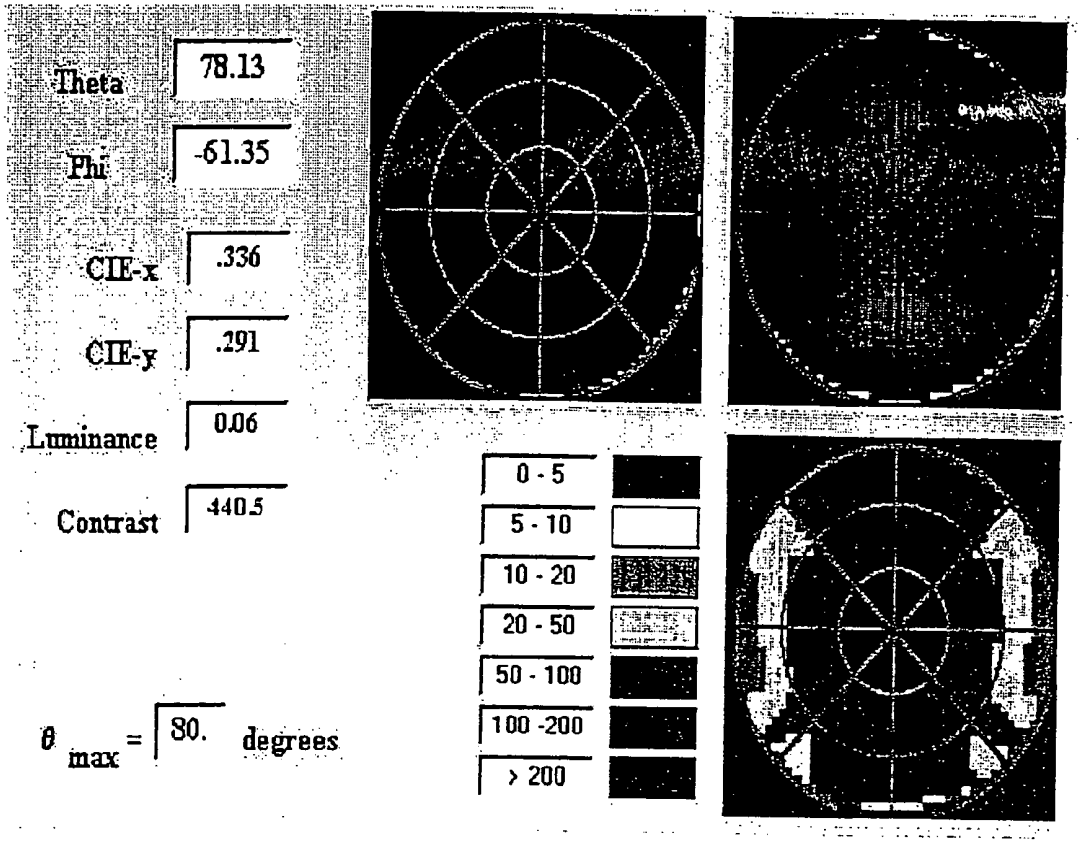
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.11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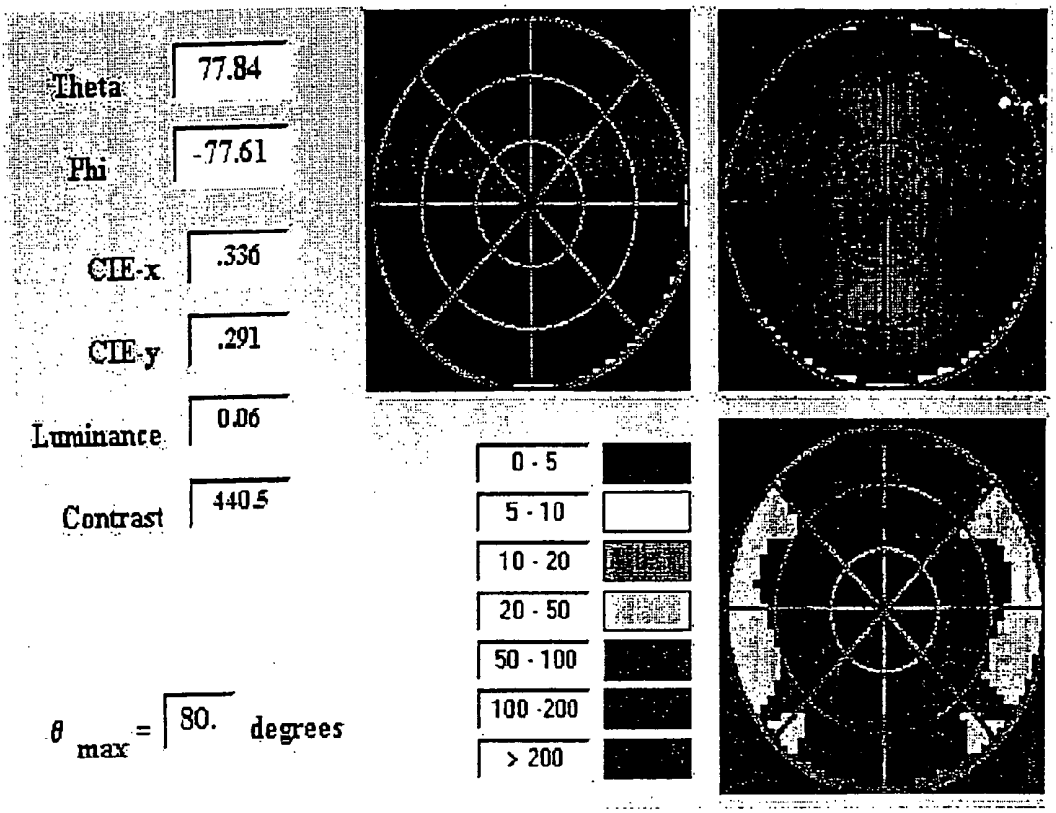
78.13
Phi
-61.35
CIE-x
.336
CIE-y
.291
Luminance
0.06
Contrast
440.5
θ max = 80. degrees
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

FIG.12


Theta
77.84
Phi
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CIE-x
.336
CIE-y
.291
Luminance
0.06
Contrast
440.5
θ max = 80. degrees
0 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 -200
> 200

LIQUID CRYSTAL DISPLAY WITH A WIDE VIEWING ANGLE USING A COMPENSATION FILM

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation application of the U.S. patent application Ser. No. 09/879,119 filed on Jun. 13, 2001 now U.S. Pat. No. 6,671,017.

This application claims the benefit of Korean Patent Application No. 2000-32506, filed on Jun. 13, 2000, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a liquid crystal display having a wide viewing angle and using a compensation film.

(b) Description of the Related Art

Liquid crystal displays are typically structured including two substrates provided substantially in parallel with a predetermined gap therebetween, and liquid crystal material is injected between the opposing substrates. Each substrate includes an electrode. and an electric field is formed between the substrates by applying a voltage of a different potential to the electrodes. Accordingly, the alignment of liquid crystal molecules of the liquid crystal material changes to control the transmittance of incident light, thereby showing images.

Various types of liquid crystal displays have been developed to improve response times and viewing angle. They include the HAN (hybrid aligned nematic) mode liquid crystal display and the OCB (optically compensated bend) mode liquid crystal display. The OCB mode LCD is arranged symmetrically about an imaginary center plane between the two substrates and parallel to the same. That is, the liquid crystal molecules are aligned substantially parallel to the substrates, then are increasingly slanted until reaching this center plane where the liquid crystal molecules are substantially perpendicular to the two substrates. A wide viewing angle is achieved as a result. To obtain such a bent alignment of the liquid crystal molecules, a horizontal orientation agent that is oriented in the same direction is used and a, high voltage is initially applied. Also, the move of liquid crystal molecules in the same orientation when operating, realizes a wide viewing angle as well as fast response times.

However, since liquid crystal material has a birefringence where a refraction index of long axes of the liquid crystal molecules is different from that of short axes of the liquid crystal molecules, a different viewing angle may generate a different refraction index. Accordingly, the ratio of polarization becomes different when the linearly polarized light passes through the liquid crystals. Thus, the amount and color characteristics of the light vary depending on the viewing angle. Hence, color shifting, gray inversion and variations in a contrast ratio happen in the LCD as the viewing angle changes.

An OCB mode LCD is disclosed in U.S. Pat. Nos. 5,410,422 and 5,805,253, in which a compensation film is used to compensate for a phase difference in liquid crystal cells. In these applications, a change in phase of light in liquid crystals is compensated in an opposite direction by the compensation film to solve the viewing angle problem. Here, a uniaxial or biaxial compensation film is used. In U.S. Pat. No. 5,410,422, a retardation value of the uniaxial compensation film is limited to 60–85% of a retardation value of the liquid crystal cells, while a phase difference value of the biaxial compensation film of U.S. Pat. No. 5,805,253 is limited to 0–100 nm.

SUMMARY OF THE INVENTION

The present invention has been made in an effort to solve the above problems.

It is an object of the present invention to provide a liquid crystal display having a wide viewing angle that uses a compensation film, which minimizes color shifting and prevents gray inversion.

To achieve the above object, the present invention provides a liquid crystal display comprising a liquid crystal cell including a pair of transparent substrates with orientation layers deposited on inner surfaces thereof, and a liquid crystal layer realized through liquid crystal material injected between the substrates; biaxial compensation films provided on outer surfaces of the liquid crystal cell, the biaxial compensation films including an optical dielectric material layer; and polarization plates provided on outer surfaces of the biaxial compensation films, wherein if "d" is set as a cell gap of the liquid crystal cell, "R_{LC}" is set as a phase retardation value of the liquid crystal layer, an axis perpendicular to planes made by the substrates is set as a z-axis, x-axis and y-axis are formed on a planar surface of the substrates, and refractive indexes of molecules comprising the biaxial compensation films in the x, y and z directions are denoted by nx, ny and nz, retardation values (ny−nx)*d and (nz−nx)*d of the biaxial compensation films being respectively within ranges of −30±5 nm and $-R_{LC}/4\pm15$ nm.

According to a feature of the present invention, liquid crystal molecules of the liquid crystal layer have a symmetrically bent alignment about an imaginary axis parallel and equidistant to the pair of substrates.

According to another feature of the present invention, the material layer of the biaxial compensation films is an optical dielectric material having a negative anisotropy.

According to yet another feature of the present invention, the liquid crystal display further comprises hybrid C plate compensation films provided between the liquid crystal cell and the biaxial compensation films.

In another aspect, the present invention provides a liquid crystal display comprising a liquid crystal cell including a pair of transparent substrates with orientation layers deposited on inner surfaces thereof, and a liquid crystal layer realized through liquid crystal material injected between the substrates; biaxial compensation films provided on at least one outer surface of the liquid crystal cell, the biaxial compensation films including an optical dielectric material layer; and polarization plates provided on outer surfaces of the biaxial compensation films, wherein if "d" is set as a cell gap of the liquid crystal cell, "R_{LC}" is set as a phase retardation value of the liquid crystal layer, an axis perpendicular to planes made by the substrates is set as a z-axis, x-axis and y-axis are formed on a planar surface of the substrates, and refractive indexes of molecules comprising the biaxial compensation films in the x, y and z directions are denoted by nx, ny and nz, retardation values (ny−nx)*d and (nz−nx)*d of the biaxial compensation films being respectively within ranges of -60 ± 10 nm and $-R_{LC}/2\pm30$ nm.

According to a feature of the present invention, liquid crystal molecules of the liquid crystal layer have a symmetrically bent alignment about an imaginary axis parallel and equidistant to the pair of substrates.

According to another feature of the present invention, the material layer of the biaxial compensation films is an optical dielectric material having a negative anisotropy.

According to yet another feature-of the present invention, the liquid crystal display further comprises hybrid C plate compensation films provided between the liquid crystal cell and the biaxial compensation films.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, serve to explain the principles of the invention:

FIG. **1** is a partial sectional view of a liquid crystal display having a bent alignment of liquid crystal molecules according to a preferred embodiment of the present invention; and

FIGS. **2**, **3**, **4**A, **4**B, **4**C, **5**, **6**, **7**, **8**A, **8**B, **8**C, **9**, **10**, **11** and **12** describe viewing angle characteristics of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. **1** shows a partial sectional view of a liquid crystal display having a bent alignment of liquid crystal molecules according to a preferred embodiment of the present invention.

As shown in the drawing, a liquid crystal display of the present invention includes a pair of opposing transparent insulating substrates **110** and **120**; orientation layers **210** and **220** formed on inner surfaces of the substrates **110** and **120**, respectively; a liquid crystal layer **320** formed of liquid crystal material injected between the substrates **110** and **120**, the liquid crystal material being comprised of liquid crystal molecules **310**; hybrid C plate compensation films **410** and **420** formed on outer surfaces of the substrates **110** and **120**, respectively; biaxial compensation films **510** and **520** provided on outer surfaces of the hybrid C plate compensation films **410** and **420**, respectively; and polarization plates **610** and **620** provided on outer surfaces of the biaxial compensation films **510** and **520**, respectively.

The liquid crystal layer **320** has a positive dielectric anisotropy. If a critical voltage is applied to the liquid crystal layer **320**, the liquid crystal molecules **310** adjacent to the substrates **110** and **120** are aligned to a pretilt angle with respect to the substrates **110** and **120** as a result of properties of the liquid crystal molecules **310** and an orientation force of the orientation layers **210** and **220**. Further, as approaching an imaginary plane, which is positioned parallel to the substrates **110** and **120** at a center thereof, the liquid crystal molecules **310** are increasingly bent by the decreasing influence of the orientation force and the increasing influence of an electric field vertical to the substrates **110** and **120**. Accordingly, a symmetrical arrangement about the imaginary plane is formed by the liquid crystal molecules **310**, resulting in two distinct regions. As a result of this alignment, a phase retardation of light passing through the liquid crystal layer **320** is compensated symmetrically about the imaginary plane such that a wide viewing angle is obtained.

The orientation layers **210** and **220** are horizontal orientation layers that provide an orientation force to the liquid crystal molecules **310** in a direction horizontal to the substrates **110** and **120**. The orientation layers **210** and **220** undergo an orientation process such that they provide an orientation force in the same direction, thereby obtaining the symmetrical arrangement of the liquid crystal molecules **310** about the imaginary plane.

The hybrid C plate compensation films **410** and **420** are made of a compound material having a negative dielectric anisotropy such as the WV film made by Fuji Film. The hybrid C plate compensation films **410** and **420** align short axes of molecules having a discotic molecule structure such that they have an increasingly larger angle with respect to a line normal to the substrates **110** and **120**.

If an axis perpendicular to planes made by the substrates **110** and **120** is set as a z-axis, x-axis and y-axis are formed on a planar surface of the substrates **110** and **120**, and refractive indexes of molecules comprising the compensation films **510** and **520** in the x, y and z directions are denoted by nx, ny and nz, the biaxial compensation films **510** and **520** are structured such that nx>ny>nz. Retardation values (ny−nx)*d and (nz−nx)*d of the biaxial compensation films **510** and **520** are respectively within ranges of −30±5 nm and $-R_{LC}/4\pm15$ nm. And when only one of the two biaxial compensation films **510** and **520** is used, retardation values (ny−nx)*d and (nz−nx)*d are respectively in the ranges of −60±10 nm and $-R_{LC}/2\pm30$ nm. This will be described in more detail hereinafter using results of an experiment as an example. Here, "d" refers to a cell gap of liquid crystal cells and "$-R_{LC}$" refers to a phase retardation value of the liquid crystal layer **320**.

The polarization plates **610** and **620** act to polarize light only in the direction of a transmission axis of the polarizing plates **610** and **620**. The transmission axis of the polarizing plates **610** and **620** can be either in a vertical or planar direction, with respect to the substrates **110** and **120**.

FIGS. **2**, **3**, **4**A, **4**B, **4**C, **5**, **6**, **7**, **8**A, **8**B, **8**C, **9**, **10**, **11** and **12** are views used to describe viewing angle characteristics of the present invention. In the drawings, Theta and Phi refer respectively to an azimuth angle and a polar angle. Also, CIE_{-x} and CIE_{-y} refer to positions of a bright state in the CIE1976 standard color chart. Luminance and Contrast in the drawings have their normal meanings, and θ_{max} refers to a maximum viewing angle.

In Experiments 1 through 3, the hybrid C plate compensation films **410** and **420** include a liquid crystal layer containing liquid crystal molecules having a discotic molecular structure and a negative anisotropic dielectric value, and a base film containing liquid crystal material. At this time, an angle made by the liquid crystal molecules from the body to an adjacent substrate **110** or **120** slowly increases from 4° to 68°. A direction to which an absolute value of a phase difference is at a minimum is a direction slanted 21° from a vertical surface of the base film. Here, a phase difference of the liquid crystal layer of the hybrid C plate compensation films **410** and **420** is 117 nm, and a phase difference of the base film is 40 nm. Further, a drive voltage used to display a bright state is 2V, while a drive voltage used to display a dark state is 6V.

EXPERIMENT 1

FIGS. **2**, **3**, **5**, **6** and **7** show pictures of a dark state, bright state and contrast ratio of Experiment 1. FIGS. **4**A, **4**B and **4**C illustrate a gray inversion of the Experiment of FIG. **3** according to angle variations with respect to a horizontal direction, vertical direction and a diagonal direction. FIGS. **8**A, **8**B and **8**C illustrate a gray inversion of the experiment

of FIG. **5** according to angle variations with respect to a horizontal direction, vertical direction and a diagonal direction.

In Experiment 1, a dark state, a bright state and a contrast ratio are measured as a phase difference of the biaxial compensation films **510** and **520** (FIG. **1**) is varied in the case where a liquid crystal cell gap is 6.0 μm and a refractive index dielectric value of the liquid crystal layer **320** (FIG. **1**) is 0.15.

FIG. **2** shows pictures of viewing angle characteristics when a planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −4 μm and a phase difference (nz−nx)*d in a normal direction is −228 μm. As shown in the drawing, in the dark state, light leaks a lot and a contrast ratio is measured less than 10 at a viewing angle of 80°.

FIG. **3** shows pictures of viewing angle characteristics when the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −10 μm and the phase difference (nz−nx)*d in a normal direction is −300 μm. As shown in the drawing, in the bright state, light leaks a lot and a contrast ratio is measured less than 10 at a viewing angle of 80°. Further, with reference to FIG. **4**A, it is evident from transmissivity measurements that gray inversion occurs.

FIG. **5** shows pictures of viewing angle characteristics when the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −30 μm at −30±5 nm and the phase difference (nz−nx)*d in a normal direction is −228 m in the range of $-R_{LC}/4\pm15$ nm. As shown in the drawing, the leakage of light in the dark and bright states is reduced, and a contrast ratio of greater than 20 is obtained at a viewing angle of 80°. Further, with reference to FIG. **8**A, it is evident that gray inversion does not occur.

FIGS. **6** and **7** show pictures of viewing angle characteristics when the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −30 cm and the phase difference (nz−nx)*d in a normal direction is −218 μm and −238 μm. As shown in the drawings, the leakage of light in the dark and bright states is reduced when compared to FIGS. **2** and **3**, and a contrast ratio of greater than 10 and 20 is obtained at a viewing angle of 80°.

EXPERIMENT 2

FIGS. **9** and **10** show pictures of a dark state, bright state and contrast ratio of Experiment 2. In Experiment 2, a dark state, a bright state and a contrast ratio are measured as the phase difference of the biaxial compensation films **510** and **520** (FIG. **1**) is varied in the case where a liquid crystal cell gap is 6.0 μm and a refractive index dielectric value of the liquid crystal layer **320** (FIG. **1**) is 0.12. The hybrid C plate compensation films **410** and **420** (FIG. **1**) are identical to Experiment 1.

FIG. **9** shows pictures of viewing angle characteristics in the case where the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −35 μm at −30±5 nm and the phase difference (nz−nx)*d in a normal direction is −180 μm in the range of $-R_{LC}/4\pm15$ nm. As shown in the drawing, the leakage of light in the dark and bright states is reduced, and a contrast ratio of greater than 20 is obtained at a viewing angle of 80°.

FIG. **10** shows pictures of viewing angle characteristics in the case where the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −35 μm at −30±5 nm and the phase difference (nz−nx)*d in a normal direction is −148 μm in the range of $-R_{LC}/4\pm15$ nm. As shown in the drawing, an extremely poor contrast ratio is obtained at a viewing angle of 80°.

EXPERIMENT 3

FIGS. **11** and **12** show pictures of a dark state, bright state and contrast ratio of Experiment 3. In Experiment 3, a dark state, a bright state and a contrast ratio are measured as the phase difference of the biaxial compensation films **510** and **520** (FIG. **1**) varies when a liquid crystal cell gap is 6.0 μm and a refractive index dielectric value of the liquid crystal layer **320** (FIG. **1**) is 0.167. The hybrid C plate compensation films **410** and **420** (FIG. **1**) are identical to Experiments 1 and 2.

FIGS. **11** and **12** show pictures of viewing angle characteristics in the case where the planar phase difference (ny−nx)*d of the biaxial compensation films **510** and **520** (FIG. **1**) is −30 μm at −30±5 nm and the phase difference (nz−nx)*d in a normal direction is −255 μm and −265 μm in the range of $-R_{LC}/4\pm15$ nm. As shown in the drawings, the leakage of light in the dark and bright states is reduced, and a contrast ratio of greater than 10 and 20 is obtained at a viewing angle of 80°.

In the liquid crystal display of the present invention described above, with the use of the biaxial compensation films of a planar phase difference (ny−nx)*d in the range of −60±10 nm and a phase difference (nz−nx)*d in a normal direction in the range of $-R_{LC}/2\pm30$ nm, a wide viewing angle and a high contrast ratio are obtained. Further, color shifting is minimized and gray inversion is prevented.

Although preferred embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the spirit and scope of the present invention, as defined in the appended claims.

What is claimed is:

1. A liquid crystal display, comprising:

a first insulating substrate;

a first horizontal orientation layer formed on the first insulating substrate;

a first hybrid C plate compensation film formed on the first insulating substrate;

a first biaxial compensation film formed on the first insulating substrate, wherein the first compensation film has a retardation value of about $-R_{LC}/2\pm30$ nm, wherein R_{LC} is a phase retardation value of the liquid crystal layer;

a first polarizer formed on the first insulating substrate;

a second insulating substrate facing the first insulating substrate;

a second horizontal orientation layer formed on the second insulating substrate;

a second compensation film formed on the second insulating substrate;

a second biaxial compensation film formed on the second insulating substrate;

a second polarizer formed on the second insulating substrate; and

a liquid crystal layer arranged between the first horizontal orientation layer and second horizontal orientation layer, wherein a cell gap of a predetermined distance is formed between the first insulating substrate and second insulating substrate.

2. The liquid crystal display of claim 1, wherein the second compensation film is a hybrid C plate compensation film.

3. The liquid crystal display of claim 1, wherein the predetermined distance is about 6 μm.

4. The liquid crystal display of claim 1, wherein the liquid crystal layer comprises liquid crystal molecules having a discotic molecular structure.

5. The liquid crystal display of claim 1, wherein the second biaxial compensation film has a retardation value of about −60+10 nm.

6. The liquid crystal display of claim 1, wherein the liquid crystal layer comprises liquid crystals having a discotic molecular structure and a negative anisotropic dielectric value.

7. A liquid crystal display (LCD), comprising:

a first substrate having an inner surface and an outer surface;

a first orientation layer provided on the inner surface of the first substrate;

a first polarizing plate formed on the first biaxial compensation film;

a second substrate having an inner surface and an outer surface;

a second orientation layer provided on the inner surface of the second substrate;

a second polarization plate formed on the second biaxial compensation film;

at least one biaxial compensation film provided on at least one of the outer surfaces of the first and second substrates;

a liquid crystal cell formed between the inner surfaces of the first and second substrates; and

a liquid crystal layer provided in the liquid crystal cell,

wherein the biaxial compensation film has a retardation value (ny−nx)*d of about −60±10 nm or a retardation value (nz−nx)*d of about $-R_{LC}/2\pm30$ nm,

where "d" is a cell gap of the liquid crystal cell, "R_{LC}" is a phase retardation value of the liquid crystal layer, and "nx", "ny" and "nz" are refractive indices of molecules of the biaxial compensation film in x, y and z directions, the x and y directions being parallel to the inner surfaces of the first and second substrates and the z direction being perpendicular to the inner surfaces of first and second substrate.

8. The LCD of claim 7, wherein the liquid crystal layer has a symmetrically bent alignment with respect to an imaginary axis parallel to and equidistant from the first and second substrates.

9. The LCD of claim 7, wherein the biaxial compensation film comprises an optical dielectric layer having a negative anisotropy.

10. The LCD of claim 7, further comprising at least one hybrid C plate compensation film provided between the liquid crystal cell and the at least one biaxial compensation film.

11. A liquid crystal display (LCD), comprising:

a first substrate having an inner surface and an outer surface;

a first orientation layer provided on the inner surface of the first substrate;

a first polarizing plate formed on the first biaxial compensation film;

a second substrate having an inner surface and an outer surface;

a second orientation layer provided on the inner surface of the second substrate;

a second polarization plate formed on the second biaxial compensation film;

at least one biaxial compensation film provided on at least one of the outer surfaces of the first and second substrates;

a liquid crystal cell formed between the inner surfaces of the first and second substrates; and

a liquid crystal layer provided in the liquid crystal cell,

wherein the biaxial compensation film has a retardation value (ny−nx)*d of about −60±10 nm and a retardation value (nz−nx)*d of about $-R_{LC}/2\pm30$ nm,

where "d" is a cell gap of the liquid crystal cell, "R_{LC}" is a phase retardation value of the liquid crystal layer, and "nx", "ny" and "nz" are refractive indices of molecules of the biaxial compensation film in x, y and z directions, the x and y directions being parallel to the inner surfaces of the first and second substrates and the z direction being perpendicular to the inner surfaces of first and second substrate.

12. The LCD of claim 11, wherein the liquid crystal layer has a symmetrically bent alignment with respect to an imaginary axis parallel to and equidistant from the first and second substrates.

13. The LCD of claim 11, wherein the biaxial compensation film comprises an optical dielectric layer having a negative anisotropy.

14. The LCD of claim 11, further comprising at least one hybrid C plate compensation film provided between the liquid crystal cell and the at least one biaxial compensation film.

* * * * *

专利名称(译)	使用补偿膜的具有宽视角的液晶显示器		
公开(公告)号	US7123329	公开(公告)日	2006-10-17
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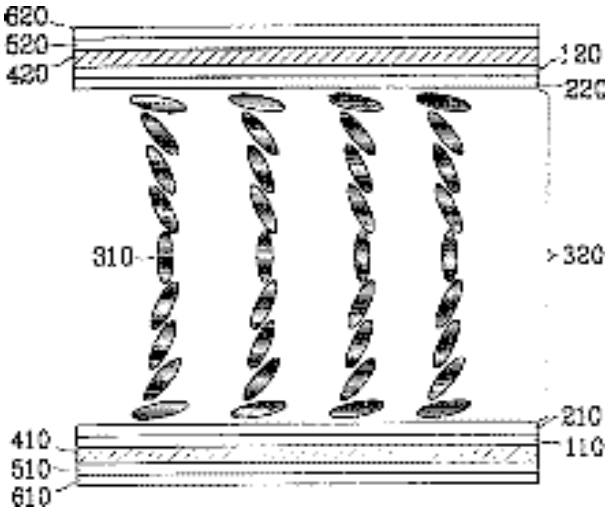
摘要(译)

本发明公开了一种液晶显示器，包括：液晶单元，包括一对透明基板;在其内表面上沉积有取向层;以及液晶材料的液晶层，注入在所述基板之间;设置在液晶单元的外表面上的双轴补偿膜，双轴补偿膜包括光学介电材料层;设置在双轴补偿膜的外表面上的偏振板，其中如果“d”被设定为液晶单元的单元间隙，则“RLC”被设定为液晶层的相位延迟值，垂直于由基板制成的平面设定为z轴，x轴和y轴形成在基板的平面表面上，并且在x，y和z方向上包括双轴补偿膜的分子的折射率表示为通过nx，ny和nz，双轴补偿膜的延迟值（ny-nx）* d和（nz-nx）* d分别在-30±5nm和-RLC / 4±15nm的范围内。