(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 028 536 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
17.07.2013 Bulletin 2013/29

(51) Int Cl.:
G02F 1/1335 *(2006.01)* ***G02F 1/13363*** *(2006.01)*

(21) Application number: **08018712.3**

(22) Date of filing: **22.10.2004**

(54) In-plane switching liquid crystal display comprising compensation film for angular field of view using +A-plate and +C-plate

In der Ebene schaltende (IPS) Flüssigkristallanzeige mit Ausgleichsfolie für das Blickwinkelfeld unter Verwendung einer +A-Platte und einer +C-Platte

Affichage à cristaux liquides à commutation dans le plan (IPS) comportant un film de compensation pour un champ angulaire d'affichage utilisant une plaque +A et une plaque +C

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR

(30) Priority: **22.10.2003 KR 20030073792**

(43) Date of publication of application:
25.02.2009 Bulletin 2009/09

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
04793559.8 / 1 676 170

(73) Proprietor: **LG Chem, Ltd.**
Seoul 150-721 (KR)

(72) Inventors:
- **Jeon, Byoung Kun**
  Daejeon 305-340 (KR)
- **Belyaev, Sergey**
  Daejeon 305-340 (KR)
- **Yu, Jeong Su**
  Daejeon 305-380 (KR)
- **Malimonenko, Nikolay**
  Daejeon 305-340 (KR)

(74) Representative: **Prinz & Partner**
Patentanwälte
Rundfunkplatz 2
80335 München (DE)

(56) References cited:
WO-A-2004/090627 US-A- 6 115 095

- **ANDERSON J E ET AL: "Methods and concerns of compensating in-plane switching liquid crystal displays" JAPANESE JOURNAL OF APPLIED PHYSICS, JAPAN SOCIETY OF APPLIED PHYSICS, TOKYO, JP, vol. 39, no. 11, November 2000 (2000-11), pages 6388-6392, XP002288101 ISSN: 0021-4922**

EP 2 028 536 B1

Description

Technical Field

[0001] The present invention relates to a liquid crystal display (LCD), and more particularly to an in-plane switching liquid crystal display (IPS-LCD) including a compensation film using a +A-plate(s) and a +C-plate(s) in order to improve a viewing angle characteristic of the in-plane switching liquid crystal display filled with liquid crystal of positive dielectric anisotropy ($\Delta\varepsilon > 0$).

Background Art

[0002] An IPS-LCD is disclosed in U.S. Patent No. 3,807,831. However, the IPS-LCD disclosed in U.S. Patent No. 3,807,831 does not use a compensation film. Accordingly, the above IPS-LCD represents a low contrast ratio at a predetermined inclination angle due to a relatively great amount of light leakage in the black state of the IPS-LCD.

[0003] U.S. Patent No. 5,189,538 discloses an LCD including a viewing angle compensation film using an A-plate and a positive blaxial retardation film.

[0004] In addition, U.S. Patent No. 6,115,095 discloses an IPS-LCD including a compensation film using a +C-plate and an A-plate. Characteristics of the IPS-LCD disclosed in U.S. Patent No. 6,115,095 are as follows:

1) A liquid crystal layer is horizontally aligned between two substrates in such a manner that an electric field is supplied in parallel to the liquid crystal layer by means of electrodes.
2) At least one A-plate and C-plate is sandwiched between two polarizer plate.
3) A main optical axis of an A-plate is perpendicular to a main optical axis of a liquid crystal layer.
4) A retardation value of a liquid crystal layer R_{LC}, a retardation value of a + C-plate R_{+C}, and a retardation value of an A-plate R_{+A} are determined such that they satisfy the following equation.

$$R_{LC}:R_{+C}:R_{+A} \fallingdotseq 1:0.5:0.25$$

5) A relationship between retardation values of the A-plate and C-plate and a thickness retardation value of a polarizer plate protective film (TAC, COP and PNB) is not disclosed.

[0005] A main object of using the A-plate and C-plate in U.S. Patent No. 6,115,095 is to compensate for a color shift of the IPS-LCD in a white state(a bright state). In this case, although the color shift of the IPS-LCD in the white state can be reduced, a great amount of light leakage may occur at a predetermined inclination angle of the IPS-LCD in a black state. For this reason, the IPS-LCD represents a relatively low contrast ratio at the predetermined inclination angle.

[0006] Recently, various methods of reducing the color shift in the white state has been proposed and used. For example, a two-domain liquid crystal alignment using a zig-zag type electrode structure has been suggested in order to minimize the color shift in the white state.

Brief Description of the Drawings

[0007]

FIG. 1 is a view illustrating a basic structure of an IPS-LCD.
FIG. 2 is a view illustrating an alignment of an absorption axis of a polarizer plate and an optical axis of liquid crystal in IPS-LCD panel of Fig. 1.
FIG. 3 is a view illustrating a refractive index of a retardation film.
FIGS. 4 to 9 are views illustrating structures of IPS-LCDs including a viewing angle compensation film wherein Figs. 6-9 represent IPS-LCD structures according to one embodiment of the present invention, in which FIG. 4 is a first IPS-LCD structure, FIG. 5 is a second IPS-LCD structure, FIG. 6 is a third IPS-LCD structure, FIG. 7 is a fourth IPS-LCD structure, FIG. 8 is a fifth IPS-LCD structure, and FIG. 9 is a sixth IPS-LCD structure.
FIGS. 10 to 14 are graphs representing simulation results for a contrast characteristic at inclination angles of 0° to 80° in all azimuthal angles when a white light is used in a structure of an IPS-LCD including a viewing angle compensation film, in which FIG. 10 is a simulation result of a first IPS-LCD structure, FIG. 11 is a simulation result of a second IPS-LCD structure, FIG. 12 is a simulation result of a third IPS-LCD structure, FIG. 13 is a simulation result of a fourth IPS-LCD structure, and FIG. 14 is a simulation result of a fifth IPS-LCD structure.
FIGS. 15 to 26 are views illustrating structures of IPS-LCDs including a viewing angle compensation film wherein Figs. 15-18 and 21-26 represent IPS-LCD structures according to one embodiment of the present invention, in which

FIG. 15 is a seventh IPS-LCD structure, FIG. 16 is an eighth IPS-LCD structure, FIG. 17 is a ninth IPS-LCD structure, FIG. 18 is a tenth IPS-LCD structure, FIG. 19 is an eleventh IPS-LCD structure, FIG. 20 is a twelfth IPS-LCD structure, FIG. 21 is a thirteenth IPS-LCD structure, FIG. 22 is a fourteenth IPS-LCD structure, FIG. 23 is a fifteenth IPS-LCD structure, FIG. 24 is a sixteenth IPS-LCD structure, FIG. 25 is a seventeenth IPS-LCD structure, and FIG. 26 is an eighteenth IPS-LCD structure.

FIGS. 27 to 32 are graphs representing simulation results for a contrast characteristic at inclination angles of 0° to 80° in all azimuthal angles when a white light is used in a structure of an IPS-LCD including a viewing angle compensation film, in which FIG. 27 is simulation results of seventh and eighth IPS-LCD structures, FIG. 28 is simulation results of ninth and tenth IPS-LCD structures, FIG. 29 is simulation results of eleventh and twelfth IPS-LCD structures, FIG. 30 is simulation results of thirteenth and fourteenth IPS-LCD structures, FIG. 31 is simulation results of fifteenth and sixteenth IPS-LCD structures, and FIG. 32 is simulation results of seventeenth and eighteenth IPS-LCD structures.

Disclosure of the Invention

[0008] It is an object of the present invention to provide an IPS-LCD representing a superior contrast characteristic and a low color shift at a front and at a predetermined inclination angle of the IPS-LCD by minimizing light leakage in a black state at the predetermined inclination angle.

[0009] The viewing angle characteristic of the IPS-LCD may be lowered due to a dependency of a perpendicularity between the absorption axes of two polarizer plates, to the viewing angle and a dependency of a birefringence of an IPS-LCD panel to the viewing angle.

[0010] The present inventors have found that a +A-plate and a +C-plate are necessary to compensate for the above problems lowering the viewing angle characteristic of the IPS-LCD. Accordingly, the present inventors have designed two type retardation films of the +A-plate and +C-plate, thereby obtaining a wide viewing angle characteristic.

[0011] In addition, the present inventors have found that an optical axis direction of the +A-plate must be properly determined in match with an alignment order of the +A-plate and +C-plate positioned between a polarizer plate and an IPS-LCD panel. The present invention has been suggested on the basis of the above concepts.

[0012] Accordingly, the present invention provides an in-plane switching liquid crystal display (IPS-LCD) capable of solving the above-mentioned problems by using +A-plate and +C-plate.

[0013] In detail, the present invention is defined in claim 1 and provides an in-plane switching liquid crystal display comprising: a first polarizer plate; a liquid crystal cell, which is horizontally aligned and filled with liquid crystal of positive dielectric anisotropy (4E>0), an optical axis of the liquid crystal filled in the liquid crystal cell being aligned in-plane in parallel to polarizer plate; and a second polarizer plate, wherein an absorption axis of the first polarizer plate is perpendicular to an absorption axis of the second polarizer plate, and the optical axis of the liquid crystal filled in the liquid crystal cell is parallel to the absorption axis of the first polarizer plate,

wherein at least one +A-plate ($n_x > n_y = n_z$) and at least one +C-plate ($n_x = n_y < n_z$) are interposed between the polarizer plate and the liquid crystal cell in order to compensate for a viewing angle in a dark state, and an optical axis of the +A-plate is adjusted according to an alignment order of +A-plate(s) and +C-plate(s).

[0014] According to the present invention, a pair of compensation films including the +A-plate and the +C-plate are aligned between the second polarizer plate (2) and the liquid crystal cell; and the optical axis of the +A-plate is aligned in parallel to the absorption axis (5) of the second polarizer plate wherein the +A-plate is adjacent to the liquid crystal cell (3).

[0015] When the IPS-LCD exclusively uses the polarizer plates, a contrast ratio at the inclination angle of 70° is equal to or less than 10:1. However, the IPS-LCD of the present invention using the +A-plate and the +C-plate may represent a minimum contrast ratio above 20:1, preferably 50:1, at the inclination angle of 70°.

[0016] Reference will now be made in detail to the preferred embodiments of the present invention.

[0017] FIG. 1 is a view illustrating a basic structure of an IPS-LCD.

[0018] The IPS-LCD includes a first polarizer plate 1, a second polarizer plate 2 and an IPS-LCD panel 3. An absorption axis 4 of the first polarizer plate 1 is aligned in perpendicular to the an absorption axis 5 of the second polarizer plate 2 and the absorption axis 4 of the first polarizer plate 1 is parallel to an optical axis 6 of the IPS-LCD panel 3. In FIG. 2, two absorption axes 4 and 5 of two polarizer plates and one optical axis 6 of one IPS-LCD panel are shown.

[0019] That is, the liquid crystal display using a compensation film according to the present invention includes the first polarizer plate 1, the IPS-LCD panel 3, which is horizontally aligned between two glass substrates 15 and 16 and includes a liquid crystal cell filled with liquid crystal of positive dielectric anisotropy ($\Delta \varepsilon>0$), and the second polarizer plate 2. The optical axis 6 of the liquid crystal filled in the liquid crystal cell is aligned in-plane in parallel to the first and second polarizer plates 1 and 2. The absorption axis 4 of the first polarizer plate 1 is aligned in perpendicular to the absorption axis 5 of the second polarizer plate 2 and the absorption axis 4 of the first polarizer plate 1 is parallel to the optical axis 6 of the liquid crystal filled in the liquid crystal cell of the IPS-LCD panel 3. In addition, one of first and second substrates 15 and 16 includes an active matrix drive electrode having a pair of electrodes, which is formed on a surface of the substrate adjacent to a liquid crystal layer.

[0020] A retardation value of the liquid crystal cell of the IPS-LCD according to the present invention is preferably 200nm to 450nm at a wavelength of 550nm.

[0021] A white state of the IPS-LCD can be obtained by (1) linearly polarizing light radiated from a backlight unit at an angle of 0° after passing through one polarizer plate, (2) rotating the 0°-linearly polarized light into the 90°-linearly polarized light after passing through a liquid crystal cell, and then (3) transmitting the 90°-linearly polarized light through the other polarizer plate. In order to allow the 0°-polarized light to be converted into the 90°-polarized light, the liquid crystal cell must have a retardation value corresponding to a half of a wavelength of an incident light. In addition, it is also possible to use a waveguide characteristic of a liquid crystal layer of a liquid crystal cell in a reverse-TN (twisted nematic) IPS-LCD, in which the retardation value of the liquid crystal cell is set to 400nm. The retardation value of the liquid crystal cell may vary depending on modes of the IPS-LCD.

[0022] The LCD according to the present invention may align the liquid crystal in multi-directions, or the liquid crystal may be divided into multi-regions by voltage applied thereto.

[0023] The LCDs can be classified into IPS (In-Plain Switching) LCDs, S-IPS (Super-In-Plan Switching) LCDs and FFS (Fringe Field Switching) LCDs according to modes of the active matrix drive electrode including a pair of electrodes. In the present invention, the IPS-LCD may include the S-IPS LCD, the FFS LCD, and a reverse TN IPS LCD.

[0024] According to the present invention, the IPS-LCD uses a +A-plate and a +C plate in order to compensate for a viewing angle thereof. When IPS-LCD uses the +A-plate combined with the +C plate in order to compensate for the viewing angle of the IPS-LCD, a wide viewing angle characteristic can be obtained.

[0025] FIG. 3 illustrates a refractive index of a retardation film used for compensating for a viewing angle of the IPS-LCD. Referring to FIG. 3, an in-plane refractive index in an x-axis direction is n_x(8), an in-plane refractive index in a y-axis direction is ny(9), and a thickness refractive index in a z-axis direction is n_z(10). In addition, the characteristic of the retardation film depends on the refractive index.

[0026] A uniaxial retardation film represents mutually different refractive indexes in two-axis directions among x-axis, y-axis and z-axis directions. The uniaxial retardation film is defined as follows:

(1) The +A-plate satisfies an equation of $n_x > n_y = n_z$, and an in-plane retardation value thereof can be defined as following Equation 1 by using a difference between two in-plane refractive indexes and a thickness of a film.

Equation 1

$$R_{in} = d \times (n_x - n_y),$$ wherein d is a thickness of a film.

The +A-plate has a thickness retardation value of almost

wherein d is a thickness of a film.

The +A-plate has a thickness retardation value of almost 0 and a positive in-plane retardation value.

(2) The +C-plate satisfies an equation of $n_x = n_y < n_z$, and a thickness retardation value thereof can be defined as following Equation 2 by using a thickness of a film and a difference between an in-plane refractive index and a thickness refractive index.

Equation 2

$$R_{th} = d \times (n_z - n_y),$$ wherein d is a thickness of a film.

wherein d is a thickness of a film.

The +C-plate 11 has an in-plane retardation value of almost 0 and a positive thickness retardation value.

[0027] In order to compensate for the viewing angle of the IPS-LCD, the +A-plate preferably has an in-plane retardation value of 30nm to 500nm at a wavelength of 550nm, and the +C-plate preferably has a thickness retardation value of 30nm to 500nm at a wavelength of 550nm.

[0028] Light leakage may occur in the black state of the IPS-LCD mainly because of a polarizer plate and partially because of an IPS-LCD panel. Therefore, a range of the retardation value required for compensating for the IPS-LCD can be obtained by slightly expanding the retardation value such that the light leakage of the polarizer plate can be compensated. That is, the range of the retardation values for the +A-plate and the +C-plate required for minimizing the light leakage generated from two polarizer plates with the absorption axes thereof aligned perpendicularly to each other, is 50nm to 300nm, respectively. In addition, when taking the IPS-LCD panel into consideration, the above range can be slightly expanded. For this reason, the range of the retardation values for the +A-plate and the +C-plate required for compensating for the viewing angle of the IPS-LCD is 30nm to 500nm, respectively.

[0029] The wavelength dispersion characteristic of the retardation film includes normal wavelength dispersion, flat wavelength dispersion, and reverse wavelength dispersion.

[0030] FIGS. 4 to 9 and 15 to 26 illustrate structures of a viewing angle compensation film including a +C-plate 11 and a +A-plate 12 used in an IPS-LCD according to the present invention.

[0031] An IPS-LCD panel 3 is interposed between polarizer plates, wherein liquid crystal molecules 7 are aligned in parallel to IPS-LCD panel substrates 15 and 16 and in a rubbing direction, which is formed on the substrates by surface-treating the substrates such that liquid crystal molecules are aligned in one direction. In order to obtain the viewing angle compensation function, retardation films must be interposed between the IPS-LCD panel 3 and polarizer plates 1 and 2. An optical axis (or slow axis) 13 of the retardation film is aligned in perpendicular to the absorption axis 5 of the adjacent polarizer plate. Since an optical axis of the +C-plate is perpendicular to the polarizer plate, it may not directly relate to the viewing angle characteristic. That is, only an angle formed between the optical axis of the +A-plate and the absorption axis of the polarizer plate may exert an influence upon the viewing angle characteristic.

[0032] The optical axis direction of the +A-plate is determined according to an alignment order of the retardation films.

[0033] When designing a viewing angle compensation film of the IPS-LCD, the present invention considers that an internal protective film of a polarizer plate has a function of the retardation film while taking a case in which the internal protective film has a thickness retardation value and a case in which the internal protective film has no thickness retardation value into consideration. Design values of the +A-plate and +C-plate with the internal protective film of the polarizer plate having the thickness retardation value are different from those of the +A-plate and +C-plate with the internal protective film having no thickness retardation value. Tables 1 to 10 show a variation in the design values of the +A-plate and +C-plate according to the internal protective films.

[0034] According to a first comparative example, there is provided an LCD including a first polarizer plate 1, an IPS panel liquid crystal cell 3, a +C-plate 11, an A-plate 12, and a second polarizer plate, which are sequentially aligned and in which an optical axis 13 of the A-plate is perpendicular to an absorption axis 5 of the second polarizer plate.

[0035] When the A-plate is adjacent to the polarizer plate and the +C-plate is positioned next to the A-plate, the viewing angle can be compensated only when the optical axis of the A-plate is perpendicular to the absorption axis of the adjacent polarizer plate. That is, the viewing angle characteristic may be lowered if the optical axis of the A-plate is aligned in parallel to the absorption axis of the adjacent polarizer plate.

[0036] At this time, the A-plate 12 preferably has an in-plane retardation value in a range of 30nm to 500nm at a wavelength of 550nm, and the +C-plate 11 preferably has a thickness retardation value in a range of 30nm to 500nm at a wavelength of 550nm.

[0037] FIG. 4 shows a first IPS-LCD structure including a compensation film according to the first comparative example and FIG. 5 shows a second IPS-LCD structure including a compensation film according to the first comparative example.

[0038] The first and second IPS-LCD structures shown in FIGS. 4 and 5 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The first and second IPS-LCD structures shown in FIGS. 4 and 5 represent the same viewing angle characteristics.

[0039] FIG. 10 and Table 1 show a simulation result when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 4.

Table 1

Internal protective film of 1st polarizer plate	IPS-LCD	Retardation value of +C-plate (nm)	Retardation value of A-plate (nm)	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
COP	290nm	94	150	COP	167
		99	-	A-COP R_{in}=140nm	167
		99	110	40μmTAC	170
		116	80	80μmTAC	150
		174	53	PNB R_{th}=-130mn	100
40μmTAC		54	132	COP	75
		70	110	90μmTAC	75
		100	90	80μmTAC	60
80μmTAC		35	137	COP	33
		35	100	40μmTAC	33
		50	70	80μmTAC	30

[0040] Table 1 shows the contrast ratio value (contrast ratio value of the white state to the black state) in the IPS-LCD structure obtained through the simulation at the inclination angle of 70°.

[0041] The contrast ratio value is an index representing a degree of definition for an image, and a higher contrast ratio value allows a higher definition image. The simulation is carried out at the inclination angle of 70° because the contrast characteristic of the IPS-LCD is greatly degraded at the inclination angle of 70°. When the IPS-LCD does not use the viewing angle compensation film, the minimum contrast ratio value of the IPS-LCD is identical to or less than 10:1. Accordingly, Table 1 shows an improved minimum contrast ratio value of the IPS-LCD at the inclination angle of 70°, which means that the contrast characteristic of the IPS-LCD may be improved at all viewing angles.

[0042] FIG. 11 shows a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 5.

[0043] According to a first embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, an IPS panel liquid crystal cell 3, an A-plate 12, a +C-plate 11, and a second polarizer plate, which are sequentially aligned and in which an optical axis 13 of the A-plate is parallel to an absorption axis 5 of the second polarizer plate.

[0044] Since the IPS-LCD panel rarely exerts an influence upon the viewing angle characteristic, the above alignment is substantially identical to an alignment in which the +A-plate and the +C-plate are aligned between the first and second polarizer plates. In addition, since the viewing angle compensation function can be obtained when the optical axis of the A-plate is aligned perpendicularly to the absorption axis of an adjacent polarizer plate, the optical axis of the A-plate must be aligned perpendicularly to the absorption axis of the first polarizer plate in order to act as a viewing angle compensation film.

[0045] At this time, the A-plate 12 preferably has an in-plane retardation value in a range of 50nm to 200nm at a wavelength of 550nm, and the +C-plate 11 preferably has a thickness retardation value in a range of 80nm to 300nm at a wavelength of 550nm.

[0046] In order to ideally compensate for light leakage of the polarizer plates, the A-plate preferably has an in-plane retardation value of about 130nm, and the +C-plate preferably has a thickness retardation value of 100-200nm. If the polarizer plate internal protective film acts as a retardation film having a negative thickness retardation value, the A-plate preferably has a retardation value of about 80nm, and the +C-plate preferably has a retardation value of 100-200nm. Since the IPS-LCD panel has a retardation value, it is preferable that the +A-plate has a retardation value of 50nm to 200nm according to the retardation value of the +C-plate and the +C-plate has a thickness retardation value of 80nm to 300nm according to the in-plane retardation value of the +A-plate(see Table 2).

[0047] FIG. 6 shows a third IPS-LCD structure including a compensation film according to the first embodiment of the present invention and FIG. 7 shows a fourth IPS-LCD structure including a compensation film according to the first embodiment of the present invention.

[0048] The third and fourth IPS-LCD structures shown in FIGS. 6 and 7 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The third and fourth IPS-LCD structures shown in FIGS. 6 and 7 represent the same viewing angle characteristics.

[0049] FIG. 12 and Table 2 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 6.

Table 2

Internal protective film of 1st polarizer plate	IPS-LCD	Retardation value of A-plate (nm)	Retardation value of +C-plate (nm)	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
COP	290nm	148	91	COP	195
		148	126	40μmTAC	187
		148	164	80μmTAC	176
		148	237	PNB R_{th}=-130nm	163
40μmTAC		180	89	COP	75
		180	161	COP	68
		176	234	PNB R_{th}=-130nm	62
80μmTAC		182	89	COP	29
		182	163	80μmTAC	27

[0050] FIG. 13 and Table 3 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 7.

Table 3

Internal protective film of 1st polarizer plate	IPS-LCD	Retardation value of A-plate (nm)	Retardation value of +C-plate (nm)	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
40μmTAC	259nm	170	175	80μmTAC	78
	290nm	180	161		78
	330nm	176	150		83

[0051] Although the first embodiment of the present invention illustrate that the A-plate and the +C-plate are interposed between the second polarizer plate and the IPS-LCD liquid cell, it is also possible to further align the A-plate and/or the +C-plate between the first polarizer plate and the IPS-LCD liquid cell as represented in second to seventh embodiments of the present invention.

[0052] According to the second embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first +C-plate 11, an IPS panel liquid crystal cell 3, an A-plate 12, a second +C-plate 14, and a second polarizer plate, which are sequentially aligned and in which an optical axis 13 of the A-plate is parallel to an absorption axis 5 of the second polarizer plate.

[0053] In this case, the A-plate 12 preferably has a retardation value in a range of 50nm to 200nm at a wavelength of 550nm. In order to ideally compensate for light leakage of the polarizer plates, the A-plate preferably has a retardation value of about 130nm. If the polarizer plate internal protective film acts as a retardation film having a negative thickness retardation value, the A-plate preferably has a retardation value of about 80nm. Since the IPS-LCD panel has a retardation value, it is preferable that the retardation value of the A-plate has 50nm to 200nm according to the thickness retardation value(see Table 4).

[0054] In addition, the first +C-plate 11 preferably has a retardation value in a range of 10nm to 400nm at a wavelength of 550nm. In order to ideally compensate for light leakage of the polarizer plates, the A-plate preferably has a retardation value of about 130nm and the +C-plate preferably has a thickness retardation value of 100 to 200nm. If the polarizer plate internal protective film acts as a retardation film having a negative thickness retardation value, the A-plate preferably has a retardation value of about 80nm and the +C-plate preferably has a retardation value of 100 to 200nm. Since the IPS-LCD panel has a retardation value, it is preferable that the +C-plate has a thickness retardation value of 80nm to 300nm according to the in-plane retardation value of the +A-plate. If the polarizer plate internal protective film has a great negative thickness retardation value, it is preferable to use a +C-plate having a thickness retardation value of 10nm to 400 (see Table 4).

[0055] The second +C-plate 14 preferably has a retardation value in a range of 90nm to 400nm at a wavelength of 550nm (see Table 4).

[0056] As can be understood from the simulation result shown in Table 4, the superior contrast characteristic is represented when the second +C-plate 14 has a retardation value in a range of 90nm to 400nm at a wavelength of 550nm.

[0057] FIG. 8 shows a fifth IPS-LCD structure including a compensation film according to the second embodiment of the present invention and FIG. 9 shows a sixth IPS-LCD structure including a compensation film according to the second embodiment of the present invention.

[0058] The fifth and sixth IPS-LCD structures shown in FIGS. 8 and 9 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The fifth and sixth IPS-LCD structures shown in FIGS. 8 and 9 represent the same viewing angle characteristics.

[0059] FIG. 14 and Table 4 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structure shown in FIG. 8.

Table 4

Internal protective film of 1st polarizer plate	Retardation value of +C-plate (nm)	IPS-LCD	Retardation value of A-plate (nm)	Retardation value of +C-plate (nm)	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
COP	10	290nm	130	98	COP	160
	10		130	170	80μmTAC	150
	50		104	120	COP	160
	100		80	145	COP	125
	100		80	218	80μmTAC	125
80μmTAC	100		125	173	80μmTAC	214
	150		92	202	80μmTAC	150
PNB R_{th}=-160nm	300		72	230	80μmTAC	100
	300		72	305	PNB R_{th}=-160nm	100

[0060] In the IPS-LCD structure according to the present invention, a relative position between two polarizer plates and liquid crystal is only important, regardless of the relative positions of an observer and a backlight unit.

[0061] According to the third embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first A-plate 11, an IPS panel liquid crystal cell 3, a second A-plate 13, a +C-plate 15, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate 11 is parallel to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate 13 is parallel to an absorption axis of the second polarizer plate.

[0062] In this case, the +C-plate 13 preferably has a retardation value in a range of 50nm to 400nm at a wavelength of 550nm.

[0063] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0064] FIG. 15 shows a seventh IPS-LCD structure including a compensation film according to the third embodiment of the present invention and FIG. 16 shows an eighth IPS-LCD structure including a compensation film according to the third embodiment of the present invention.

[0065] The seventh and eighth IPS-LCD structures shown in FIGS. 15 and 16 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The seventh and eighth IPS-LCD structures shown in FIGS. 15 and 16 represent the same viewing angle characteristics.

[0066] FIG. 27 and Table 5 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 15 and 16.

Table 5

Internal protective film of 1st polarizer plate	A-plate	IPS-LCD	A-plate	+C-plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	160	310nm	100	127	80μmTAC	27:1
40μmTAC	150		120	150		120:1
Isotropic COP	80		130	170		125:1
80μmTAC	150		120	90	40μmTAC	28:1
40μmTAC	210		120	120		120:1
Isotropic COP	0		140	130		139:1
80μmTAC	80		170	50	Isotropic COP	34:1
40μmTAC	80		160	60		80:1
Isotropic COP	130		140	110		92:1

[0067] According to the fourth embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first +C-plate 16, a first +A-plate 11, an IPS panel liquid crystal cell 3, a second +A-plate 13, a second +C-plate 15, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate is parallel to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate is parallel to an absorption axis 6 of the second polarizer plate.

[0068] In this case, the first +C-plate 16 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second +C-plate 15 preferably has a retardation value in a range of 1nm to 400nm at a wavelength of 550nm.

[0069] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0070] FIG. 17 shows a ninth IPS-LCD structure including a compensation film according to the fourth embodiment of the present invention and FIG. 18 shows a tenth IPS-LCD structure including a compensation film according to the fourth embodiment of the present invention. The ninth and tenth IPS-LCD structures shown in FIGS. 17 and 18 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The ninth and tenth IPS-LCD structures shown in FIGS. 17 and 18 represent the same viewing angle characteristics.

[0071] FIG. 28 and Table 6 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 17 and 18.

Table 6

Internal protective film of 1st polarizer plate	+C-plate	A-plate	IPS-LCD	A-plate	+C-plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	70	270	310nm	160	150	80μmTAC	45:1
40μmTAC	40	280		160	150		46:1
Isotropic COP	0	280		160	150		42:1
80μmTAC	40	280		120	130	40μmTAC	73:1
40μmTAC	30	0		140	120		94:1
Isotropic COP	30	0		120	140		146:1
80μmTAC	30	100		150	60	Isotropic COP	90:1
40μmTAC	20	100		140	90		126:1
Isotropic COP	30	0		120	110		142:1

[0072] According to the second comparative example, there is provided an LCD including a first polarizer plate 1, a first +A-plate 11, a first +C-plate 16, an IPS panel liquid crystal cell 3, a second +C-plate 15, a second +A-plate 13, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate is parallel to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate is perpendicular to an absorption axis 6 of the second polarizer plate.

[0073] In this case, the first +C-plate 16 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second +C-plate 15 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0074] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0075] FIG. 19 shows an eleventh IPS-LCD structure including a compensation film according to the second comparative example and FIG. 20 shows a twelfth IPS-LCD structure including a compensation film according to the second comparative example. The eleventh and twelfth IPS-LCD structures shown in FIGS. 19 and 20 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The eleventh and twelfth IPS-LCD structures shown in FIGS. 19 and 20 represent the same viewing angle characteristics.

[0076] FIG. 29 and Table 7 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 19 and 20.

Table 7

Internal protective film of 1st polarizer plate	A-plate	+C-plate	IPS-LCD	+C-plate	A-plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	110	110	310nm	210	40	80μmTAC	24:1
40μmTAC	110	110		210	100		75:1
Isotropic COP	0	110		210	110		59:1
80μmTAC	30	110		150	110	40μmTAC	133:1
40μmTAC	20	110		170	130		109:1
Isotropic COP	0	110		200	130		64:1
80μmTAC	0	110		190	160	Isotropic COP	62:1
40μmTAC	180	120		240	130		30:1
Isotropic COP	180	120		200	160		48:1

[0077] According to the fifth embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first +C-plate 16, a first +A-plate 11, an IPS panel liquid crystal cell 3, a second +C-plate 15, a second +A-plate 13, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate is parallel to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate is perpendicular to an absorption axis 6 of the second polarizer plate.

[0078] In this case, the first +C-plate 16 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second +C-plate 15 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0079] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0080] FIG. 21 shows a thirteenth IPS-LCD structure including a compensation film according to the fifth embodiment of the present invention and FIG. 22 shows a fourteenth IPS-LCD structure including a compensation film according to the fifth embodiment of the present invention. The thirteenth and fourteenth IPS-LCD structures shown in FIGS. 21 and 22 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The thirteenth and fourteenth IPS-LCD structures shown in FIGS. 21 and 22 represent the same viewing angle characteristics.

[0081] FIG. 30 and Table 8 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 21 and 22.

Table 8

Internal protective film of 1st polarizer plate	C-plate	A-plate	IPS-LCD	+C-plate	A-plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	100	200	310nm	70	100	80μmTAC	40:1
40μmTAC	60	230		60	100		25:1
	0	90		110	80		99:1
80μmTAC	50	70		80	90	40μmTAC	63:1
40μmTAC	20	70		90	100		94:1
	10	90		100	120		117:1
80μmTAC	50	40		80	120	Isotropic COP	95:1
40μmTAC	50	60		100	150		133:1
	50	40		110	180		69:1

[0082] According to the sixth embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first +A-plate 11, a first +C-plate 16, an IPS panel liquid crystal cell 3, a second +A-plate 13, a second +C-plate 15, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate is parallel to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate is parallel to an absorption axis 6 of the second polarizer plate.

[0083] In this case, the first +C-plate 16 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second +C-plate 15 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0084] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0085] FIG. 23 shows a fifteenth IPS-LCD structure including a compensation film according to the sixth embodiment of the present invention and FIG. 24 shows a sixteenth IPS-LCD structure including a compensation film according to the sixth embodiment of the present invention. The fifteenth and sixteenth IPS-LCD structures shown in FIGS. 23 and 24 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The fifteenth and sixteenth IPS-LCD structures shown in FIGS. 23 and 24 represent the same viewing angle characteristics.

[0086] FIG. 31 and Table 9 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 23 and 24.

Table 9

Internal protective film of 1st polarizer plate	A-plate	+C-plate	IPS-LCD	A-plate	+C- plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	60	60	310nm	100	120	80μmTAC	86:1
40μmTAC	60	60		100	160		156:1
Isotropic COP	0	60		100	190		92:1

(continued)

Internal protective film of 1st polarizer plate	A-plate	+C-plate	IPS-LCD	A-plate	+C- plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	110	70		50	120	40μmTAC	46:1
40μmTAC	80	70		90	140		135:1
Isotropic COP	0	70		100	160		84:1
80μmTAC	60	80		90	80	Isotropic COP	171:1
40μmTAC	70	80		90	100		121:1
Isotropic COP	0	70		100	130		94:1

[0087] According to the seventh embodiment of the present invention, there is provided an LCD including a first polarizer plate 1, a first +A-plate 11, a first +C-plate 16, an IPS panel liquid crystal cell 3, a second +A-plate 13, a second +C-plate 15, and a second polarizer plate, which are sequentially aligned and in which an optical axis 12 of the first A-plate is perpendicular to an absorption axis 4 of the first polarizer plate and an optical axis 14 of the second A-plate is parallel to an absorption axis 6 of the second polarizer plate.

[0088] In this case, the first +C-plate 16 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm and the second +C-plate 15 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0089] In addition, the first A-plate 11 preferably has a retardation value in a range of 1nm to 400nm at a wavelength of 550nm and the second A-plate 13 preferably has a retardation value in a range of 1nm to 500nm at a wavelength of 550nm.

[0090] FIG. 25 shows a seventeenth IPS-LCD structure including a compensation film according to the seventh embodiment of the present invention and FIG. 26 shows a eighteenth IPS-LCD structure including a compensation film according to the seventh embodiment of the present invention. The seventeenth and eighteenth IPS-LCD structures shown in FIGS. 25 and 26 are substantially identical to each other, except for light sources thereof, which are aligned in opposition to each other. The seventeenth and eighteenth IPS-LCD structures shown in FIGS. 25 and 26 represent the same viewing angle characteristics.

[0091] FIG. 32 and Table 10 show a simulation result for the contrast characteristic when practical design values of a retardation film are applied to the IPS-LCD structures shown in FIGS. 25 and 26.

Table 10

Internal protective film of 1st polarizer plate	A-plate	+C-plate	IPS-LCD	A-plate	+C-plate	Internal protective film of 2nd polarizer plate	Minimum contrast ratio value at inclination angle of 70°
80μmTAC	20	100	310nm	160	150	80μmTAC	23:1
40μmTAC	10	90		110	170		79:1
Isotropic COP	10	100		100	220		61:1
80μmTAC	250	100		140	350	40μmTAC	87:1
40μmTAC	250	100		150	350		107:1
Isotropic COP	250	90		150	320		113:1
80μmTAC	260	100		140	340	Isotropic COP	121:1
40μmTAC	260	100		140	320		120:1
Isotropic COP	260	90		150	300		112:1

[0092] A diagonal direction represents a direction forming an angle of 45° with regard to the absorption axis of the polarizer plate, causing the worst viewing angle characteristic of the IPS-LCD. When two type retardation films are used as viewing angle compensation films of the IPS-LCD, the viewing angle characteristic in the diagonal direction may be improved (see contrast characteristics illustrated in FIGS. 10 to 14 and 27 to 32).

[0093] Protective films used for protecting the polarizer plates may exert an influence upon the viewing angle compensation characteristic of the IPS-LCD. In general, the polarizer plate is made from stretched PVA (polyvinyl alcohol) doped with iodine, and the protective film used for the polarizer plate can be made from a TAC (triacetate cellulose) film having a thickness retardation value, PNB (polynobonene) or a non-oriented COP (cyclo olefin **without stretching)** film having no thickness retardation value. If the protective film having the thickness retardation value, such as the TAC film, is used for the polarizer plate, the viewing angle compensation characteristic may be deteriorated. However, if an isotropic film, such as the non-oriented COP film(COP without stretching), is used as the protective film for the polarizer plate, a superior viewing angle characteristic can be obtained.

[0094] Preferably, the internal protective film for the first and second polarizer plates is one selected from the group consisting of non-stretched COP (cyclo olefin), 40μm TAC (triacetate cellulose), 80μm TAC (triacetate cellulose), and PNB (polynobonene). Particularly, the internal protective film for the first polarizer plate 1 is preferably made from COP having a thickness retardation value of 0 or 40μm TAC.

[0095] If the internal protective film made from COP is used for the first polarizer plate, that is, when the internal protective film has the thickness retardation value of 0, the best contrast characteristic can be obtained. Contrast characteristics of the IPS-LCD at the inclination angle of 70° represented when the COP film or the TAC film is used as the internal protective film for the first polarizer plate are illustrated in Tables 1 to 10. As illustrated in Tables 1 to 10, the IPS-LCD represents the best contrast characteristic when the COP film or the 40μm TAC film is used as the internal protective film for the polarizer plate.

[0096] The retardation film used for the A-plate 12 includes a uniaxially stretched polycarbonate film, a uniaxially stretched COP, a nematic liquid crystal film or a discotic liquid crystal film. In addition, a film used for the C-plate 11 includes a homeotropically aligned liquid crystal film or a biaxially stretched polycarbonate film. The +C plate can be fabricated by using a polymer film or a UV curable liquid crystal film.

[0097] Meanwhile, the polarizer plate includes an external protective film, PVA-I (stretched PVA doped with iodine), and an internal protective film. Although the TAC film is mainly used as the internal protective film for the polarizer plate, a +A-plate film or a +C-plate film can be used instead of the internal protective film.

Advanced Effect

[0098] As described above, the in-plane switching liquid crystal display according to the present invention can improve the contrast characteristic at a front and at a predetermined inclination angle thereof by using the +A-plate and the +C-plate while minimizing a color shift according to viewing angles in the black state.

Embodiments

[0099] Hereinafter, preferred embodiments of the present invention will be described. However, it is noted that the preferred embodiments described below are used for illustrative purpose and the present invention is not limited thereto.

Reference example 1

[0100] The IPS-LCD shown in FIG. 4 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The +C-plate 11 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 174nm at a wavelength of 550nm. The A-plate 12 is fabricated by using a stretched polycarbonate film and has an in-plane retardation value R_{in} = 53nm. The internal protective film for the first polarizer plate 1 is made from an isotropic COP film, and the internal protective film for the second polarizer plate 2 is made from a PNB (polynobonene) film having a thickness retardation value R_{th} = -130nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 10.

[0101] Referring to FIG. 10, a center of a circle corresponds to an inclination angle of 0, and the inclination angle increases as a radius of the circle becomes enlarged. Numerals 20, 40, 60 and 80 marked along the radius of the circle in FIG. 10 represent the inclination angles.

[0102] In addition, numerals 0 to 330 marked along a circumference of the circle represent the azimuthal angles. FIG. 10 shows the contrast characteristic in all viewing directions (inclination angles of 0° to 80° and azimuthal angles of 0° to 360°) when an upper polarizer plate is aligned in a direction of an azimuthal angle of 0°, and a lower polarizer plate is aligned in a direction of an azimuthal angle of 90°. An IPS-LCD, which exclusively uses a polarizer plate, may represent a contrast ratio equal to or less than 10:1 at an inclination angle of 80°. However, the IPS-LCD of the present invention represents a contrast ratio above 100:1 at an inclination angle of 80° as shown in FIG. 10.

Reference example 2

[0103] The IPS-LCD shown in FIG. 5 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The +C-plate 11 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 70nm at a wavelength of 550nm. The A-plate 12 is fabricated by using a stretched polycarbonate film and has an in-plane retardation value R_{in} = 110. The internal protective film for the first and second polarizer plates 1 and 2 is made from a 40μn TAC film having a thickness retardation value R_{th} = - 32nm.

[0104] When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 11. Referring to FIG. 11, the IPS-LCD represents the superior contrast characteristic above 50:1 at an inclination angle of 80°.

Embodiment 1

[0105] The IPS-LCD shown in FIG. 6 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The +C-plate 11 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 91nm at a wavelength of 550nm. The A-plate 12 is fabricated by using a stretched polycarbonate film and has an in-plane retardation value R_{in} = 148. The internal protective film for the first and second polarizer plates 1 and 2 is made from an isotropic COP film. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 12. Referring to FIG. 12, the IPS-LCD represents the superior contrast characteristic above 200:1 at an inclination angle of 80°.

Embodiment 2

[0106] The IPS-LCD shown in FIG. 7 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first +C-plate 11 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 175nm at a wavelength of 550nm. The A-plate 12 is fabricated by using a stretched polycarbonate film and has an in-plane retardation value R_{in} = 170. The internal protective film for the first polarizer plate 1 is made from 40μm TAC having a thickness retardation value R_{th} = -32nm and the internal protective film for the second polarizer plate 2 is made from 80μn TAC having a thickness retardation value R_{th} = -64nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 13. Referring to FIG. 13, the IPS-LCD represents the superior contrast characteristic above 50:1 at an inclination angle of 80°.

Embodiment 3

[0107] The IPS-LCD shown in FIGS. 8 and 9 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 2.9μm, a pretilt angle of 3°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first +C-plate 11 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has an in-plane retardation value R_{in} = 100nm. The second +C-plate 14 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 173nm at a wavelength of 550nm. The A-plate 12 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 125nm. The internal protective film for the first and second polarizer plates is made from 80μm TAC having a thickness retardation value R_{th} = -64nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 14. Referring to FIG. 14, the IPS-LCD represents the superior contrast characteristic above 200:1 at an inclination angle of 80°.

Embodiment 4

[0108] The IPS-LCD shown in FIGS. 15 and 16 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm, a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 60nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 160nm. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 80nm. The internal protective film for the first polarizer plate 1 is made from a 40μm TAC film having a thickness retardation value R_{th} = -30nm and the internal protective film for the second polarizer plate 2 is made from a non-stretched isotropic COP film, which rarely represents thickness retardation. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 27.

Embodiment 5

[0109] The IPS-LCD shown in FIGS. 17 and 18 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm, a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$= +7, and a birefringence of Δn = 0.1. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 100nm. The first +C-plate 16 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 20nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 140nm. The second +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 90nm at a wavelength of 550nm. The internal protective film for the first polarizer plate 1 is made from a 40μm TAC film having a thickness retardation value R_{th} = -30nm and the internal protective film for the second polarizer plate 2 is made from a non-stretched isotropic COP film, which rarely represents thickness retardation. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 28.

Reference Example 8

[0110] The IPS-LCD shown in FIGS. 19 and 20 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 20nm. The first +C-plate 16 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 110nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 130nm. The second +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 170nm at a wavelength of 550nm. The internal protective film for the first and second polarizer plates 1 and 2 is made from a 40μm TAC film having a thickness retardation value R_{th} = -30nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 29.

Embodiment 6

[0111] The IPS-LCD shown in FIGS. 21 and 22 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm, a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 70nm. The first +C-plate 16 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 50nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 90nm. The second +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 80nm at a wavelength of 550nm. The internal protective film for the first polarizer plate 1 is made from a 80μm TAC film having a thickness retardation value R_{th} = -50nm, and the internal protective film for the second polarizer plate 2 is made from a 40μm TAC film having a thickness retardation value R_{th} = -30nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 30.

Embodiment 7

[0112] The IPS-LCD shown in FIGS. 23 and 24 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm, a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 60nm. The first +C-plate 16 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 60nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 100nm. The second +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 120nm at a wavelength of 550nm. The internal protective film for the first and second polarizer plates 1 and 2 is made from a 80μm TAC film having a thickness retardation value R_{th} = -50nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 31.

Embodiment 8

[0113] The IPS-LCD shown in FIGS. 25 and 26 includes an IPS liquid crystal cell filled with liquid crystal having a cell gap of 3.1μm, a pretilt angle of 1°, dielectric anisotropy of $\Delta\varepsilon$ = +7, and a birefringence of Δn = 0.1. The first A-plate 11 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 250nm. The first +C-plate 16 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 100nm at a wavelength of 550nm. The second A-plate 13 is fabricated by using a stretched COP film and has an in-plane retardation value R_{in} = 150nm. The second +C-plate 15 is fabricated by using an UV curable and homeotropically aligned liquid crystal film and has a thickness retardation value R_{th} = 350nm at a wavelength of 550nm. The internal protective film for the first and second polarizer plates 1 and 2 is made from a 40μm TAC film having a thickness retardation value R_{th} = -30nm. When a white light is used, the contrast characteristic of the IPS-LCD at an inclination angle of 0° to 80° in all azimuthal angles is illustrated in FIG. 32.

[0114] While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment and the drawings, but, on the contrary, it is intended to cover various modifications and variations within the scope of the appended claims.

Claims

1. An in-plane switching liquid crystal display comprising:

   a first polarizer plate (1);
   a liquid crystal cell (3), which is horizontally aligned and filled with liquid crystal of positive dielectric anisotropy ($\Delta\varepsilon$>0), an optical axis of the liquid crystal filled in the liquid crystal cell being aligned in-plane in parallel to the first polarizer plate; and
   a second polarizer plate (2),
   wherein an absorption axis (4) of the first polarizer plate (1) is perpendicular to an absorption axis (5) of the second polarizer plate (2),
   at least one +A-plate ($n_x > n_y = n_z$) (12; 13) and at least one +C-plate ($n_x = n_y < n_z$) (11; 14; 15) are interposed between the polarizer plates (1, 2) and the liquid crystal cell (3) in order to compensate for a viewing angle in a dark state, and in which n_x and n_y represent an in-plane refractive index, n_z represents a thickness refractive index, the +A-plate (12; 13) has an in-plane retardation value of $R_{in} = d \times (n_x - ny)$, and the +C-plate (11; 14; 15) has a thickness retardation value of $R_{in} = d \times (n_z - n_y)$, wherein d is a thickness of a retardation film wherein the first polarizer plate (1), the liquid crystal cell (3), the +A-plate (12; 13), the +C-plate (11; 14; 15), and the second polarizer plate (2) are sequentially aligned,
   characterized in that the optical axis (6) of the liquid crystal (3) filled in the liquid crystal cell is parallel to the absorption axis (4) of the first polarizer plate (1), and the optical axis (13; 14) of the +A-plate (12; 13) is parallel to an absorption axis (5) of the second polarizer plate (2).

2. The in-plane switching liquid crystal display as claimed in claim 1, wherein the +A-plate has an in-plane retardation value in a range of 50nm to 200nm at a wavelength of 550nm.

3. The in-plane switching liquid crystal display as claimed in claim 1, wherein the +C-plate has a retardation value in a range of 80nm to 300nm at a wavelength of 550nm.

4. The in-plane switching liquid crystal display as claimed in claim 1, **characterized in that** the first polarizer plate (1), a first +C-plate (11), the liquid crystal cell (3), the +A-plate (12), a second +C-plate (14), and the second polarizer plate (2) are sequentially aligned, in which the optical axis (13) of the +A-plate (12) is parallel to an absorption axis (5) of the second polarizer plate (2).

5. The in-plane switching liquid crystal display as claimed in claim 4, wherein the +A-plate has an in-plane retardation value in a range of 50nm to 200nm at a wavelength of 550nm.

6. The in-plane switching liquid crystal display as claimed in claim 4, wherein the first +C-plate has a retardation value in a range of 10nm to 400nm at a wavelength of 550nm.

7. The in-plane switching liquid crystal display as claimed in claim 4, wherein the second +C-plate has a retardation

value in a range of 90nm to 400nm at a wavelength of 550nm.

8. The in-plane switching liquid crystal display as claimed in claim 1, **characterized in that** the first polarizer plate (1), a first +A-plate (11), the liquid crystal cell (3), a second +A-plate (13), the +C-plate (15), and the second polarizer plate (2) are sequentially aligned, in which an optical axis (12) of the first +A-plate (11) is parallel to an absorption axis (4) of the first polarizer plate (1), and an optical axis (14) of the second +A-plate (13) is parallel to an absorption axis (5) of the second polarizer plate (2).

9. The in-plane switching liquid crystal display as claimed in claim 1,**characterized in that** the first polarizer plate (1), a first +C-plate (16), a first +A-plate (11), the liquid crystal cell (3), a second +A-plate (13), a second +C-plate (15), and the second polarizer plate (2) are sequentially aligned, in which an optical axis (12) of the first +A-plate (11) is parallel to an absorption axis (4) of the first polarizer plate (1), and an optical axis (14) of the second +A-plate (13) is parallel to an absorption axis (5) of the second polarizer plate (2).

10. The in-plane switching liquid crystal display as claimed in claim 1, **characterized in that** the first polarizer plate (1), a first +A-plate (11), a first +C-plate (16), the liquid crystal cell (3), a second +A-plate (13), a second +C-plate (15), and the second polarizer plate (2) are sequentially aligned, in which an optical axis (12) of the first +A-plate (11) is parallel to an absorption axis (4) of the first polarizer plate (1), and an optical axis (14) of the second +A-plate (13) is parallel to an absorption axis (5) of the second polarizer plate (2).

11. The in-plane switching liquid crystal display as claimed in claim 1, **characterized in that** the first polarizer plate (1), a first +A-plate (11), a first +C-plate (16), the liquid crystal cell (3), a second +A-plate (13), a second +C-plate (15), and the second polarizer plate (2) are sequentially aligned, in which an optical axis (12) of the first +A-plate (11) is perpendicular to an absorption axis (4) of the first polarizer plate (1), and an optical axis (14) of the second +A-plate (13) is parallel to an absorption axis (5) of the second polarizer plate (2).

12. The in-plane switching liquid crystal display as claimed in claim 8, wherein the +C-plate has a retardation value in a range of 50nm to 400nm at a wavelength of 550nm.

13. The in-plane switching liquid crystal display as claimed in any one of claims 8 to 11, wherein the first and second +A-plates have a retardation value in a range of 1 nm to 500nm at a wavelength of 550nm, respectively.

14. The in-plane switching liquid crystal display as claimed in any one of claims 9 to 11, wherein the first and second +C-plates have a retardation value in a range of 1 nm to 500nm at a wavelength of 550nm, respectively.

15. The in-plane switching liquid crystal display as claimed in any one of claims 1, 4, and 8 to 11, wherein at least one of internal protective films for the first and second polarizer plates has a retardation value of 0 or a negative thickness retardation value.

16. The in-plane switching liquid crystal display as claimed in any one of claims 1, 4, and 8 to 11, wherein the +A-plate is used as an internal protective film for at least one polarizer plate.

17. The in-plane switching liquid crystal display as claimed in any one of claims 1, 4, and 8 to 11, wherein the +C-plate is used as an internal protective film for at least one polarizer plate.

Patentansprüche

1. In der Ebene schaltende Flüssigkristallanzeige mit:

einer ersten Polarisationsplatte (1),
einer Flüssigkristallzelle (3), die horizontal ausgerichtet und mit Flüssigkristall positiver dielektrischer Anisotropie ($\Delta\varepsilon>0$) gefüllt ist, wobei eine optische Achse des in die Flüssigkristallzelle gefüllten Flüssigkristalls in der Ebene parallel zur ersten Polarisationsplatte ausgerichtet ist, und
einer zweiten Polarisationsplatte (2),
wobei eine Absorptionsachse (4) der ersten Polarisationsplatte (1) senkrecht zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist,
wenigstens eine +A-Platte ($n_x > n_y = n_z$) (12; 13) und wenigstens eine +C-Platte ($n_x = n_y < n_z$) (11; 14; 15)

zwischen die Polarisationsplatten (1, 2) und die Flüssigkristallzelle (3) eingefügt sind, um einen Betrachtungswinkel in einem Dunkelzustand auszugleichen, und wobei n_x und n_y einen Brechungsindex in der Ebene darstellen, n_z einen Dikkenbrechungsindex darstellt, die +A-Platte (12; 13) einen Verzögerungswert in der Ebene von $R_{in} = d \times (n_x - n_y)$ hat und die +C-Platte (11; 14; 15) einen Dickenverzögerungswert von $R_{in} = d \times (n_z - n_y)$ hat, wobei d eine Dicke eines Verzögerungsfilms ist,
wobei die erste Polarisationsplatte (1), die Flüssigkristallzelle (3), die +A-Platte (12; 13), die +C-Platte (11; 14; 15) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind,
dadurch gekennzeichnet, dass
die optische Achse (6) des in die Flüssigkristallzelle gefüllten Flüssigkristalls (3) parallel zur Absorptionsachse (4) der ersten Polarisationsplatte (1) ist, und die optische Achse (13; 14) der +A-Platte (12; 13) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

2. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, bei der die +A-Platte einen Verzögerungswert in der Ebene in einem Bereich von 50 nm bis 200 nm bei einer Wellenlänge von 550 nm hat.

3. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, bei der die +C-Platte einen Verzögerungswert in einem Bereich von 80 nm bis 300 nm bei einer Wellenlänge von 550 nm hat.

4. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, **dadurch gekennzeichnet, dass** die erste Polarisationsplatte (1), eine erste +C-Platte (11), die Flüssigkristallzelle (3), die +A-Platte (12), eine zweite +C-Platte (14) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind, wobei die optische Achse (13) der +A-Platte (12) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

5. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 4, bei der die +A-Platte einen Verzögerungswert in der Ebene in einem Bereich von 50 nm bis 200 nm bei einer Wellenlänge von 550 nm hat.

6. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 4, bei der die erste +C-Platte einen Verzögerungswert in einem Bereich von 10 nm bis 400 nm bei einer Wellenlänge von 550 nm hat.

7. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 4, bei der die zweite +C-Platte einen Verzögerungswert in einem Bereich von 90 nm bis 400 nm bei einer Wellenlänge von 550 nm hat.

8. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, **dadurch gekennzeichnet, dass** die erste Polarisationsplatte (1), eine erste +A-Platte (11), die Flüssigkristallzelle (3), eine zweite +A-Platte (13), die +C-Platte (15) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind, wobei eine optische Achse (12) der ersten +A-Platte (11) parallel zu einer Absorptionsachse (4) der ersten Polarisationsplatte (1) ist und eine optische Achse (14) der zweiten +A-Platte (13) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

9. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, **dadurch gekennzeichnet, dass** die erste Polarisationsplatte (1), eine erste +C-Platte (16), eine erste +A-Platte (11), die Flüssigkristallzelle (3), eine zweite +A-Platte (13), eine zweite +C-Platte (15) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind, wobei eine optische Achse (12) der ersten +A-Platte (11) parallel zu einer Absorptionsachse (4) der ersten Polarisationsplatte (1) ist und eine optische Achse (14) der zweiten +A-Platte (13) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

10. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, **dadurch gekennzeichnet, dass** die erste Polarisationsplatte (1), eine erste +A-Platte (11), eine erste +C-Platte (16), die Flüssigkristallzelle (3), eine zweite +A-Platte (13), eine zweite +C-Platte (15) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind, wobei eine optische Achse (12) der ersten +A-Platte (11) parallel zu einer Absorptionsachse (4) der ersten Polarisationsplatte (1) ist und eine optische Achse (14) der zweiten +A-Platte (13) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

11. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 1, **dadurch gekennzeichnet, dass** die erste Polarisationsplatte (1), eine erste +A-Platte (11), eine erste +C-Platte (16), die Flüssigkristallzelle (3), eine zweite +A-Platte (13), eine zweite +C-Platte (15) und die zweite Polarisationsplatte (2) sequentiell ausgerichtet sind, wobei eine optische Achse (12) der ersten +A-Platte (11) senkrecht zu einer Absorptionsachse (4) der ersten Polarisationsplatte (1) ist und eine optische Achse (14) der zweiten +A-Platte (13) parallel zu einer Absorptionsachse (5) der zweiten Polarisationsplatte (2) ist.

12. In der Ebene schaltende Flüssigkristallanzeige nach Anspruch 8, bei der die +C-Platte einen Verzögerungswert in einem Bereich von 50 nm bis 400 nm bei einer Wellenlänge von 550 nm hat.

13. In der Ebene schaltende Flüssigkristallanzeige nach einem der Ansprüche 8 bis 11, bei der die erste und die zweite +A-Platte jeweils einen Verzögerungswert in einem Bereich von 1 nm bis 500 nm bei einer Wellenlänge von 550 nm haben.

14. In der Ebene schaltende Flüssigkristallanzeige nach einem der Ansprüche 9 bis 11, bei der die erste und die zweite +C-Platte jeweils einen Verzögerungswert in einem Bereich von 1 nm bis 500 nm bei einer Wellenlänge von 550 nm haben.

15. In der Ebene schaltende Flüssigkristallanzeige nach einem der Ansprüche 1, 4 und 8 bis 11, bei der ein innerer Schutzfilm für die erste Polarisationsplatte und/oder für die zweite Polarisationsplatte einen Verzögerungswert von 0 oder einen negativen Dickenverzögerungswert hat.

16. In der Ebene schaltende Flüssigkristallanzeige nach einem der Ansprüche 1, 4 und 8 bis 11, bei der die +A-Platte als innerer Schutzfilm für wenigstens eine Polarisationsplatte verwendet wird.

17. In der Ebene schaltende Flüssigkristallanzeige nach einem der Ansprüche 1, 4 und 8 bis 11, bei der die +C-Platte als innerer Schutzfilm für wenigstens eine Polarisationsplatte verwendet wird.

Revendications

1. Écran à cristaux liquides à commutation dans le plan, comportant :

une première plaque de polarisation (1) ;
une cellule à cristaux liquides (3) alignée horizontalement et remplie de cristaux liquides présentant une anisotropie diélectrique positive ($\Delta\varepsilon > 0$), un axe optique des cristaux liquides remplis dans la cellule à cristaux liquides étant aligné dans le plan parallèlement à la première plaque de polarisation ; et
une deuxième plaque de polarisation (2),
un axe d'absorption (4) de la première plaque de polarisation (1) étant perpendiculaire à un axe d'absorption (5) de la deuxième plaque de polarisation (2),
au moins une plaque +A ($n_x > n_y = n_z$) (12 ; 13) et au moins une plaque +C ($n_x = n_y < n_z$) (11 ; 14 ; 15) étant interposées entre les plaques de polarisation (1, 2) et la cellule à cristaux liquides (3) en vue de compenser un angle de vue dans un état sombre, et n_x et n_y représentant un indice de réfraction dans le plan, n_z représentant un indice de réfraction dans le sens de l'épaisseur, la plaque +A (12 ; 13) présentant une valeur de retard dans le plan de $R_{in} = d \times (n_x - n_y)$, et la plaque +C (11 ; 14 ; 15) présentant une valeur de retard en épaisseur de $R_{in} = d \times (n_z - n_y)$, d étant l'épaisseur d'un film de retard,
la première plaque de polarisation (1), la cellule à cristaux liquides (3), la plaque +A (12; 13), la plaque +C (11 ; 14; 15) et la deuxième plaque de polarisation (2) étant alignées de manière séquentielle,
caractérisé en ce que
l'axe optique (6) des cristaux liquides (3) remplis dans la cellule à cristaux liquides est parallèle à l'axe d'absorption (4) de la première plaque de polarisation (1), et
l'axe optique (13 ; 14) de la plaque +A (12 ; 13) est parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

2. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, dans lequel la plaque +A présente une valeur de retard dans le plan dans une plage de 50 nm à 200 nm à une longueur d'onde de 550 nm.

3. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, dans lequel la plaque +C présente une valeur de retard dans une plage de 80 nm à 300 nm à une longueur d'onde de 550 nm.

4. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, **caractérisé en ce que** la première plaque de polarisation (1), une première plaque +C (11), la cellule à cristaux liquides (3), la plaque +A (12), une deuxième plaque +C (14) et la deuxième plaque de polarisation (2) sont alignées de manière séquentielle, l'axe optique (13) de la plaque +A (12) étant parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

5. Ecran à cristaux liquides à commutation dans le plan selon la revendication 4, dans lequel la plaque +A présente une valeur de retard dans le plan dans une plage de 50 nm à 200 nm à une longueur d'onde de 550 nm.

6. Ecran à cristaux liquides à commutation dans le plan selon la revendication 4, dans lequel la première plaque +C présente une valeur de retard dans une plage de 10 nm à 400 nm à une longueur d'onde de 550 nm.

7. Ecran à cristaux liquides à commutation dans le plan selon la revendication 4, dans lequel la deuxième plaque +C présente une valeur de retard dans une plage de 90 nm à 400 nm à une longueur d'onde de 550 nm.

8. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, **caractérisé en ce que** la première plaque de polarisation (1), une première plaque +A (11), la cellule à cristaux liquides (3), une deuxième plaque +A (13), la plaque +C (15), et la deuxième plaque de polarisation (2) sont alignées de manière séquentielle, un axe optique (12) de la première plaque +A (11) étant parallèle à un axe d'absorption (4) de la première plaque de polarisation (1), et un axe optique (14) de la deuxième plaque +A (13) étant parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

9. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, **caractérisé en ce que** la première plaque de polarisation (1), une première plaque +C (16), une première plaque +A (11), la cellule à cristaux liquides (3), une deuxième plaque +A (13), une deuxième plaque +C (15) et la deuxième plaque de polarisation (2) sont alignées de manière séquentielle, un axe optique (12) de la première plaque +A (11) étant parallèle à un axe d'absorption (4) de la première plaque de polarisation (1), et un axe optique (14) de la deuxième plaque +A (13) étant parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

10. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, **caractérisé en ce que** la première plaque de polarisation (1), une première plaque +A (11), une première plaque +C (16), la cellule à cristaux liquides (3), une deuxième plaque +A (13), une deuxième plaque +C (15) et la deuxième plaque de polarisation (2) sont alignées de manière séquentielle, un axe optique (12) de la première plaque +A (11) étant parallèle à un axe d'absorption (4) de la première plaque de polarisation (1), et un axe optique (14) de la deuxième plaque +A (13) étant parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

11. Ecran à cristaux liquides à commutation dans le plan selon la revendication 1, **caractérisé en ce que** la première plaque de polarisation (1), une première plaque +A (11), une première plaque +C (16), la cellule à cristaux liquides (3), une deuxième plaque +A (13), une deuxième plaque +C (15) et la deuxième plaque de polarisation (2) sont alignées de manière séquentielle, un axe optique (12) de la première plaque +A (11) étant perpendiculaire à un axe d'absorption (4) de la première plaque de polarisation (1), et un axe optique (14) de la deuxième plaque +A (13) étant parallèle à un axe d'absorption (5) de la deuxième plaque de polarisation (2).

12. Ecran à cristaux liquides à commutation dans le plan selon la revendication 8, dans lequel la plaque +C présente une valeur de retard dans une plage de 50 nm à 400 nm à une longueur d'onde de 550 nm.

13. Ecran à cristaux liquides à commutation dans le plan selon l'une des revendications 8 à 11, dans lequel la première et la deuxième plaques +A présentent chacune une valeur de retard dans une plage de 1 nm à 500 nm à une longueur d'onde de 550 nm.

14. Ecran à cristaux liquides à commutation dans le plan selon l'une des revendications 9 à 11, dans lequel la première et la deuxième plaques +C présentent chacune une valeur de retard dans une plage de 1 nm à 500 nm à une longueur d'onde de 550 nm.

15. Ecran à cristaux liquides à commutation dans le plan selon l'une des revendications 1, 4 et 8 à 11, dans lequel au moins un des films de protection internes pour la première et la deuxième plaques de polarisation présente une valeur de retard de 0 ou une valeur négative de retard en épaisseur.

16. Ecran à cristaux liquides à commutation dans le plan selon l'une des revendications 1, 4 et 8 à 11, dans lequel la plaque +A est utilisée comme film de protection interne pour au moins une plaque de polarisation.

17. Ecran à cristaux liquides à commutation dans le plan selon l'une des revendications 1, 4 et 8 à 11, dans lequel la plaque +C est utilisée comme film de protection interne pour au moins une plaque de polarisation.

Fig. 1

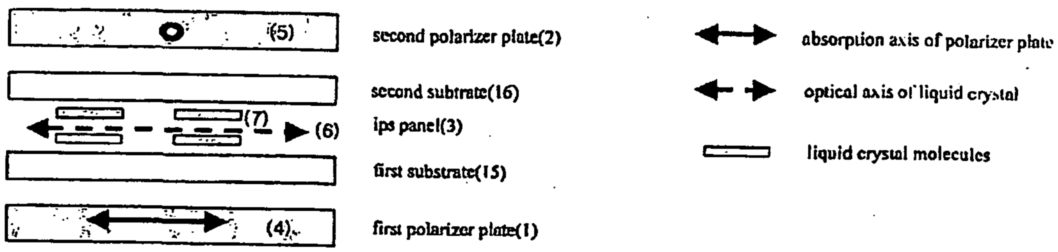


Fig. 2

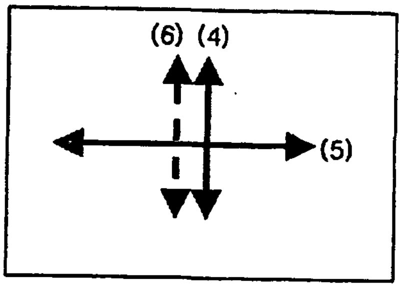


Fig. 3

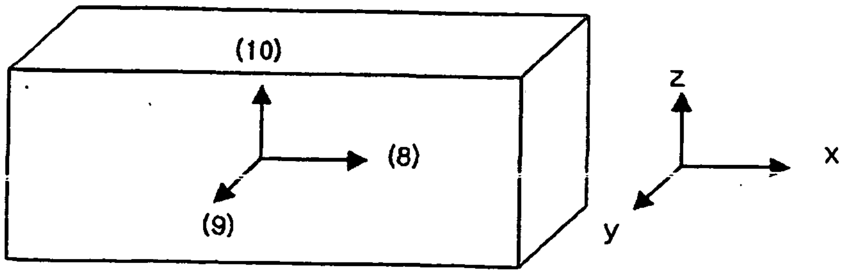


Fig. 4

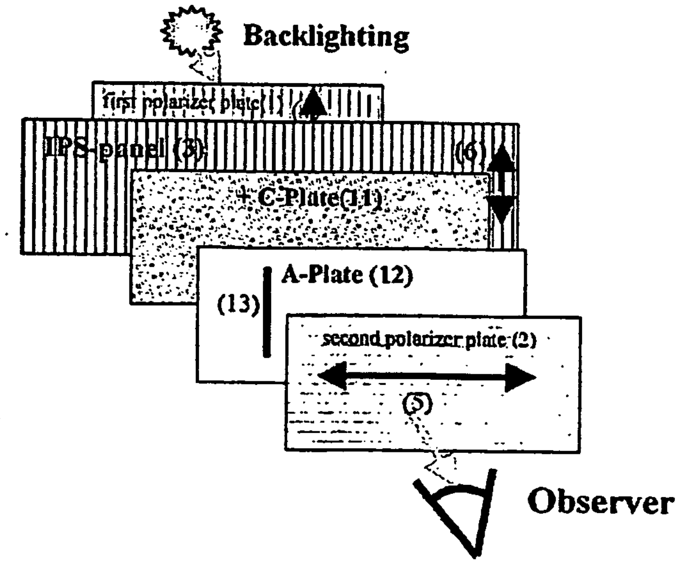

Backlighting
first polarizer plate(1)
(4)
IPS-panel (3)
(6)
+ C-Plate(11)
A-Plate (12)
(13)
second polarizer plate (2)
(5)
Observer

Fig. 5

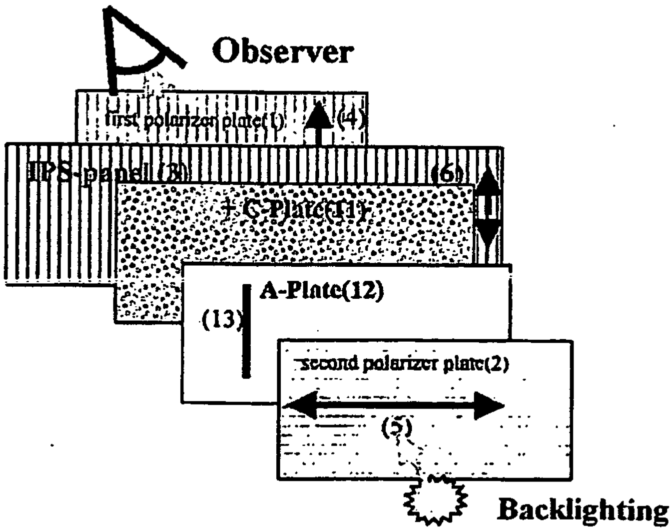

Observer
first polarizer plate(1)
(4)
IPS-panel (3)
(6)
+ C-Plate(11)
A-Plate(12)
(13)
second polarizer plate(2)
(5)
Backlighting

Fig. 6

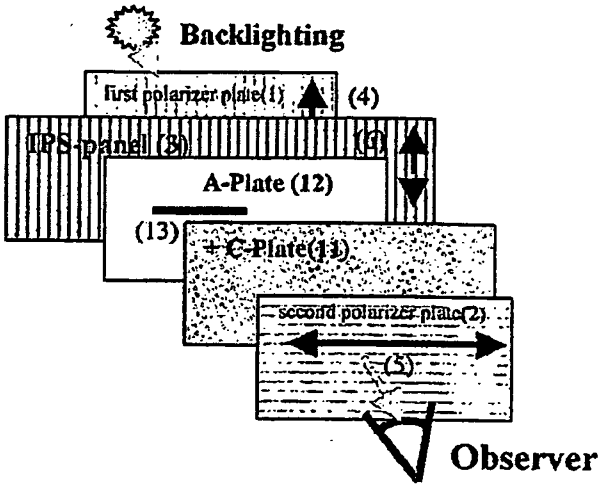

Backlighting
first polarizer plate(1)
(4)
IPS-panel (3)
(6)
A-Plate (12)
(13)
+C-Plate(11)
second polarizer plate(2)
(5)
Observer

Fig. 7

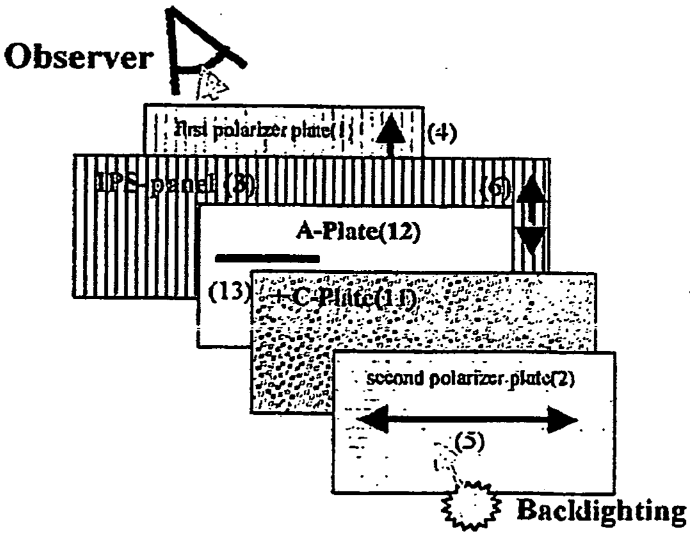

Observer
first polarizer plate(1)
(4)
IPS-panel (3)
(6)
A-Plate(12)
(13)
+C-Plate(11)
second polarizer plate(2)
(5)
Backlighting

Fig. 8

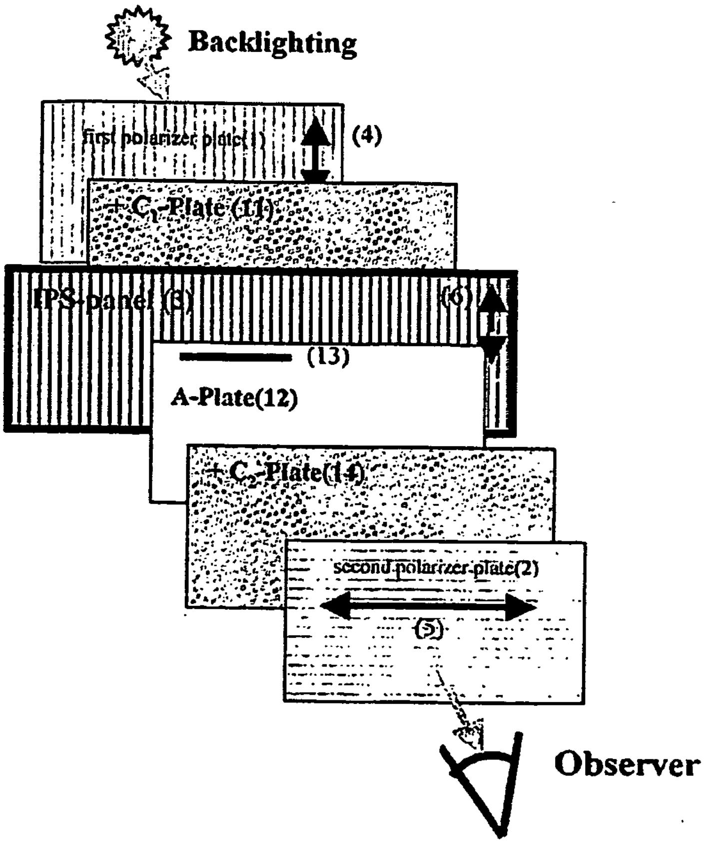

Backlighting
first polarizer plate(1)
(4)
+C1-Plate (11)
IPS-panel (3)
(6)
(13)
A-Plate(12)
+C2-Plate(14)
second polarizer plate(2)
(5)
Observer

Fig. 9

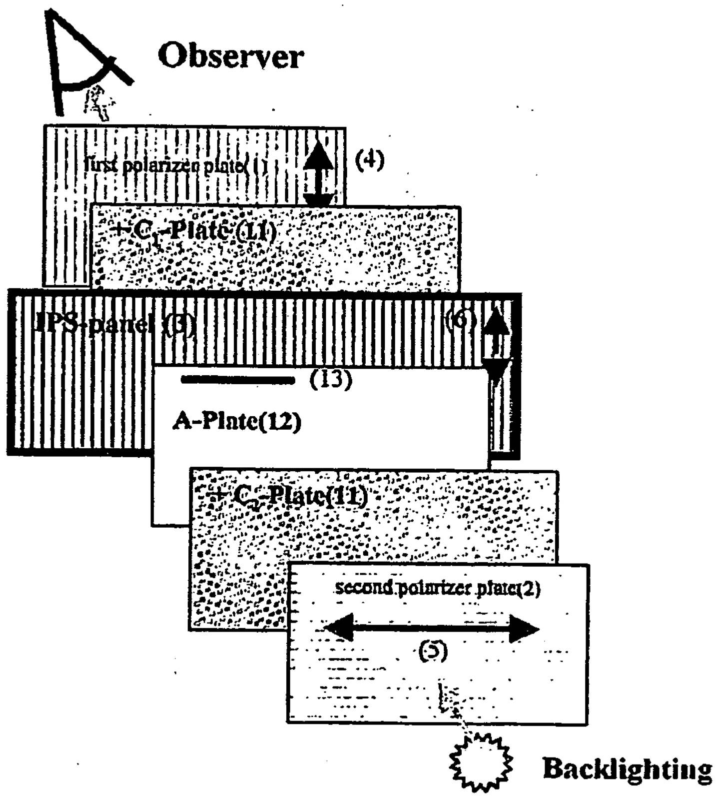

Observer
first polarizer plate(1)
(4)
$+C_1$-Plate(11)
IPS-panel (3)
(6)
(13)
A-Plate(12)
$+C_2$-Plate(11)
second polarizer plate(2)
(5)
Backlighting

Fig. 10

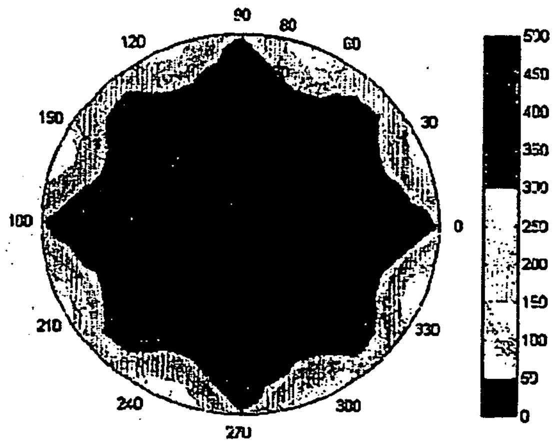

90
80
60
120
30
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

Fig. 11

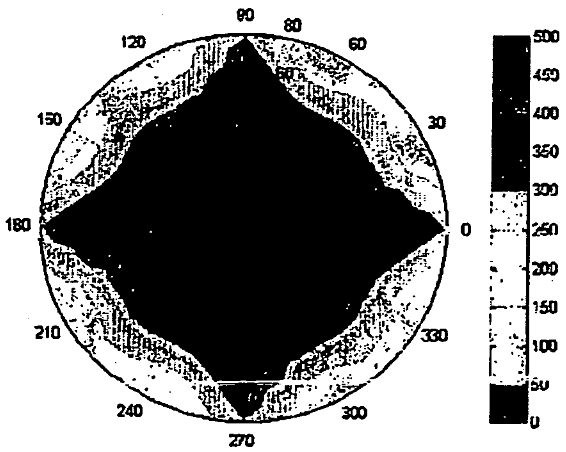

90
80
60
120
150
30
180
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

Fig. 12

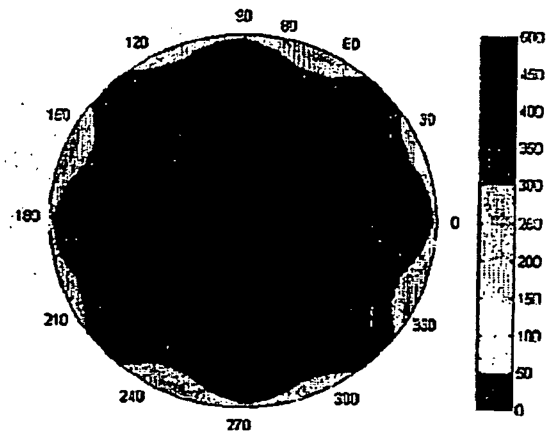

90
60
120
30
150
180
0
210
330
240
300
270
600
450
400
350
300
250
200
150
100
50
0

Fig. 13

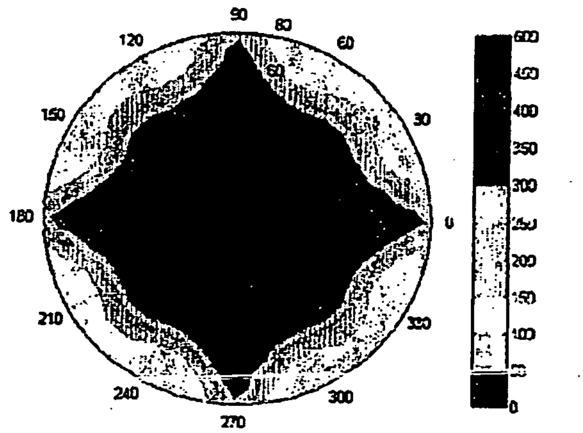

90
60
120
30
150
180
0
210
330
240
300
270
600
450
400
350
300
250
200
150
100
0

Fig. 14

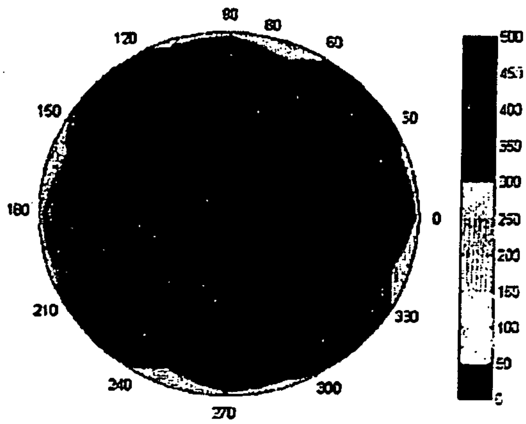

90
60
30
0
330
300
270
240
210
180
150
120
500
450
400
350
300
250
200
150
100
50
0

Fig. 15

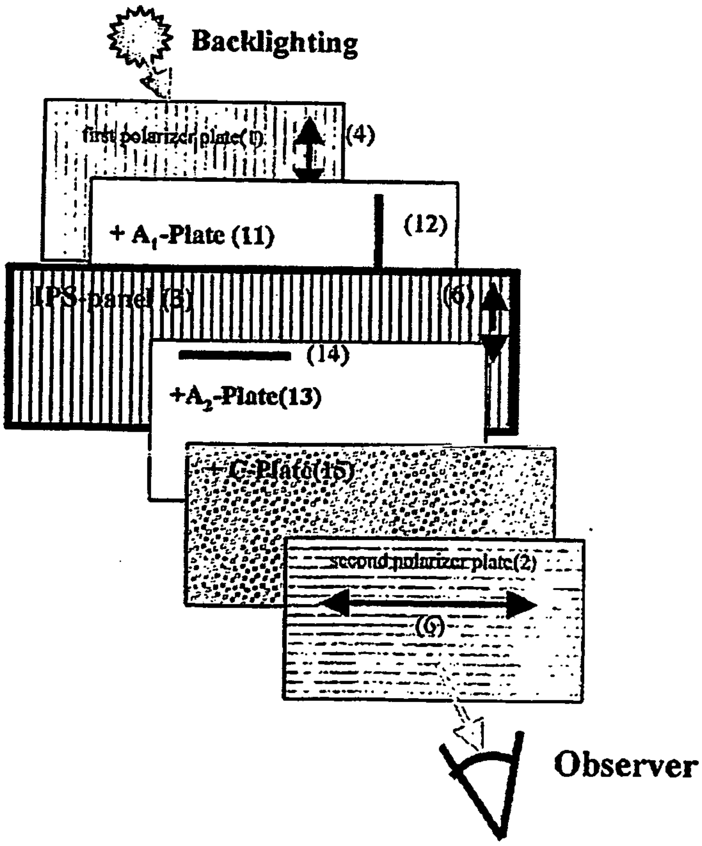

Backlighting
first polarizer plate(1)
(4)
+ A1-Plate (11)
(12)
IPS-panel (3)
(6)
(14)
+A2-Plate(13)
+C-Plate(15)
second polarizer plate(2)
(5)
Observer

Fig. 16

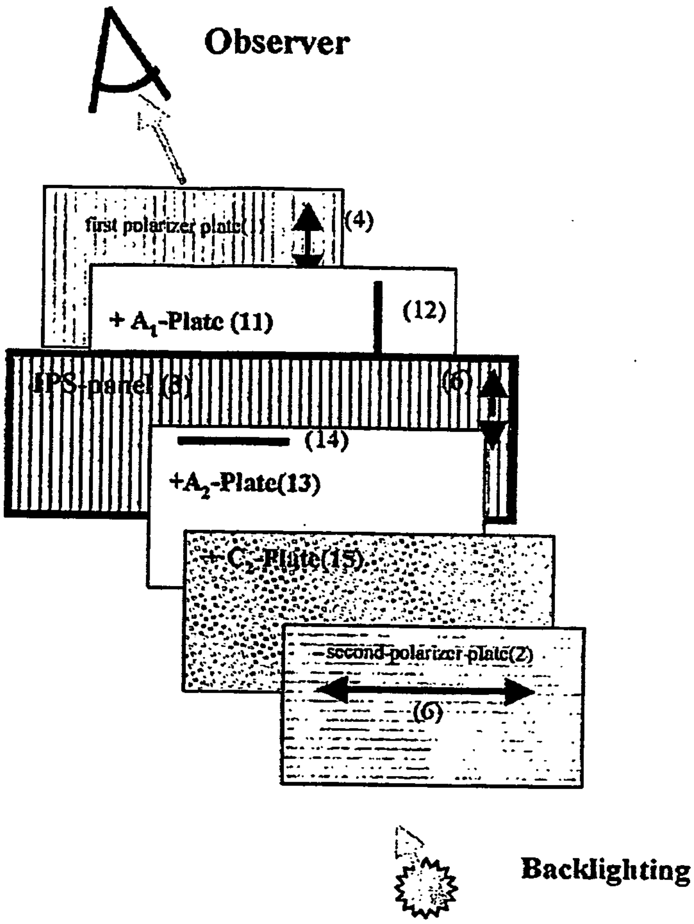

Observer
first polarizer plate(1)
(4)
+ A_1-Plate (11)
(12)
IPS-panel (3)
(6)
(14)
+A_2-Plate(13)
+ C_2-Plate(15)
second polarizer plate(2)
(6)
Backlighting

Fig. 17

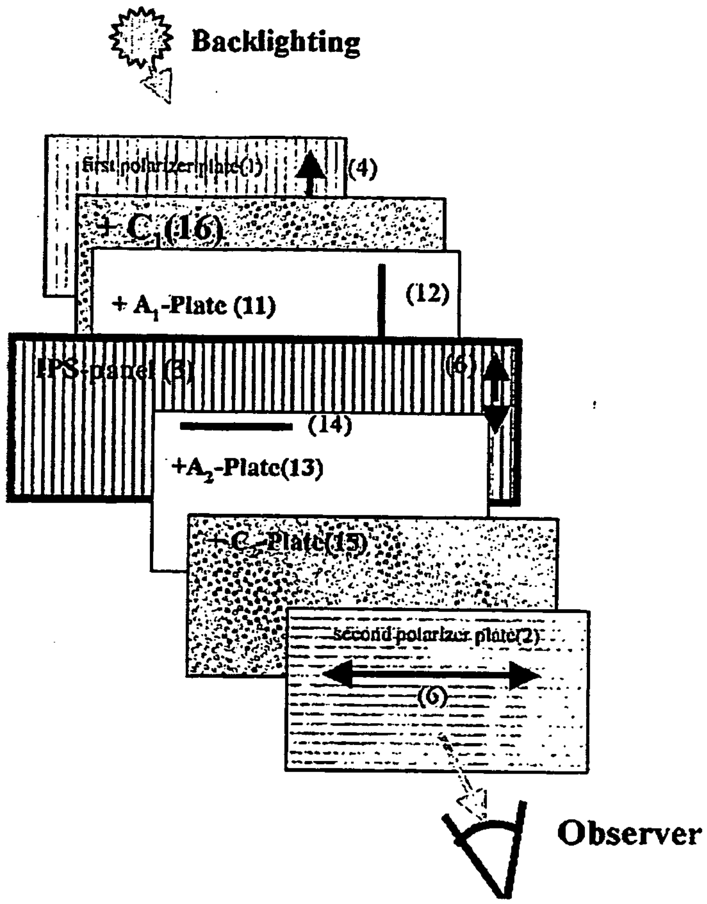

Backlighting
first polarizer plate(1)
(4)
+ C (16)
+ A1-Plate (11)
(12)
IPS-panel (3)
(6)
(14)
+A2-Plate(13)
+C-Plate(15)
second polarizer plate(2)
(6)
Observer

Fig. 18

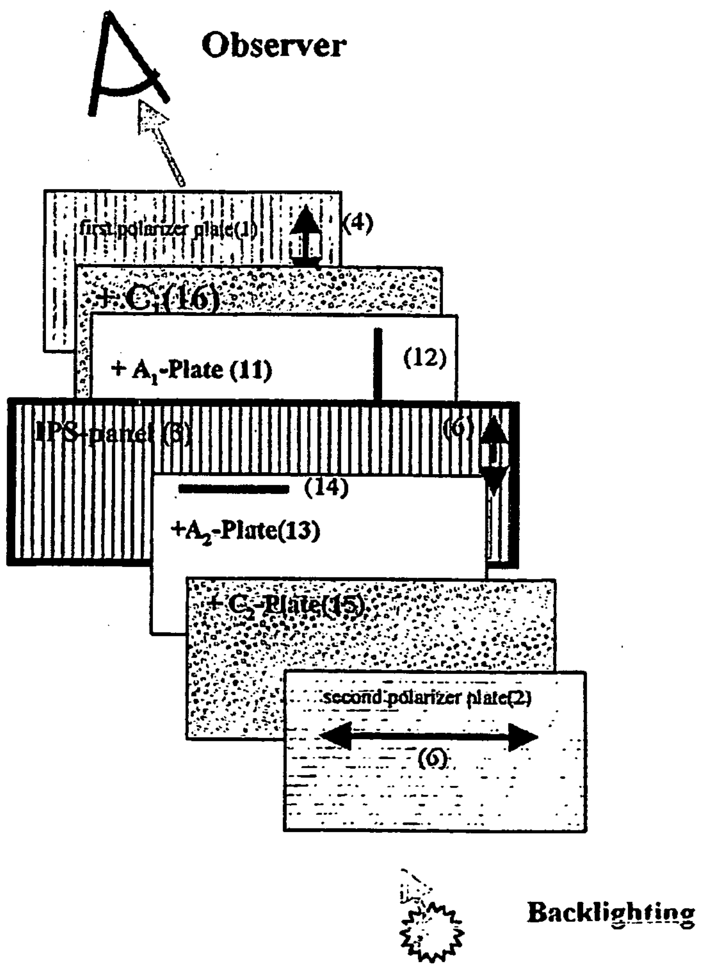

Observer
first polarizer plate(1)
(4)
+ C₁(16)
+ A₁-Plate (11)
(12)
IPS-panel (3)
(6)
(14)
+A₂-Plate(13)
+ C₂-Plate(15)
second polarizer plate(2)
(6)
Backlighting

Fig. 19

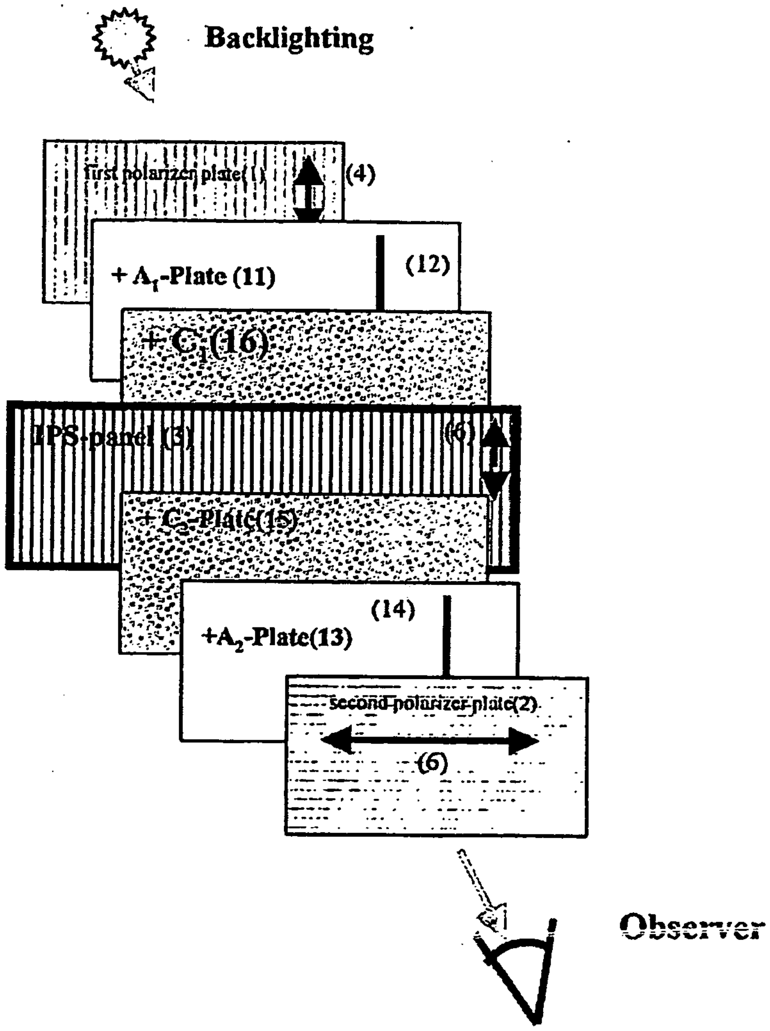
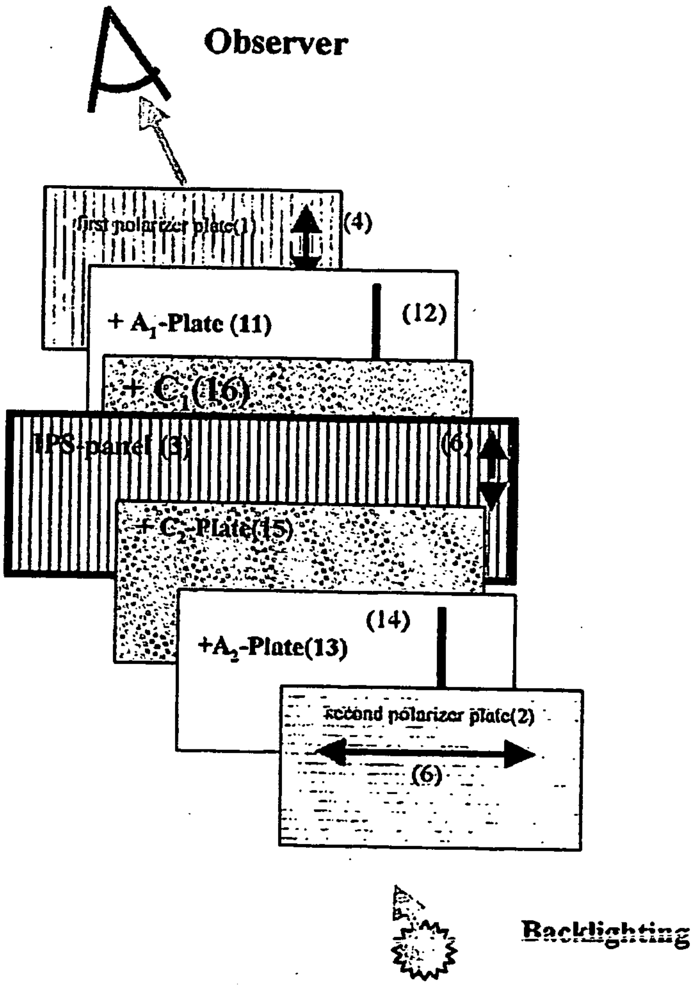

Backlighting
first polarizer plate(1)
(4)
+ A_1-Plate (11)
(12)
+ C_1 (16)
IPS-panel (3)
(6)
+ C_2-Plate(15)
(14)
+A_2-Plate(13)
second polarizer plate(2)
(6)
Observer

Fig. 20



Observer
first polarizer plate(1)
(4)
+ A1-Plate (11)
(12)
+ C1(16)
IPS-panel (3)
(6)
+ C2-Plate(15)
(14)
+A2-Plate(13)
second polarizer plate(2)
(6)
Backlighting

Fig. 21

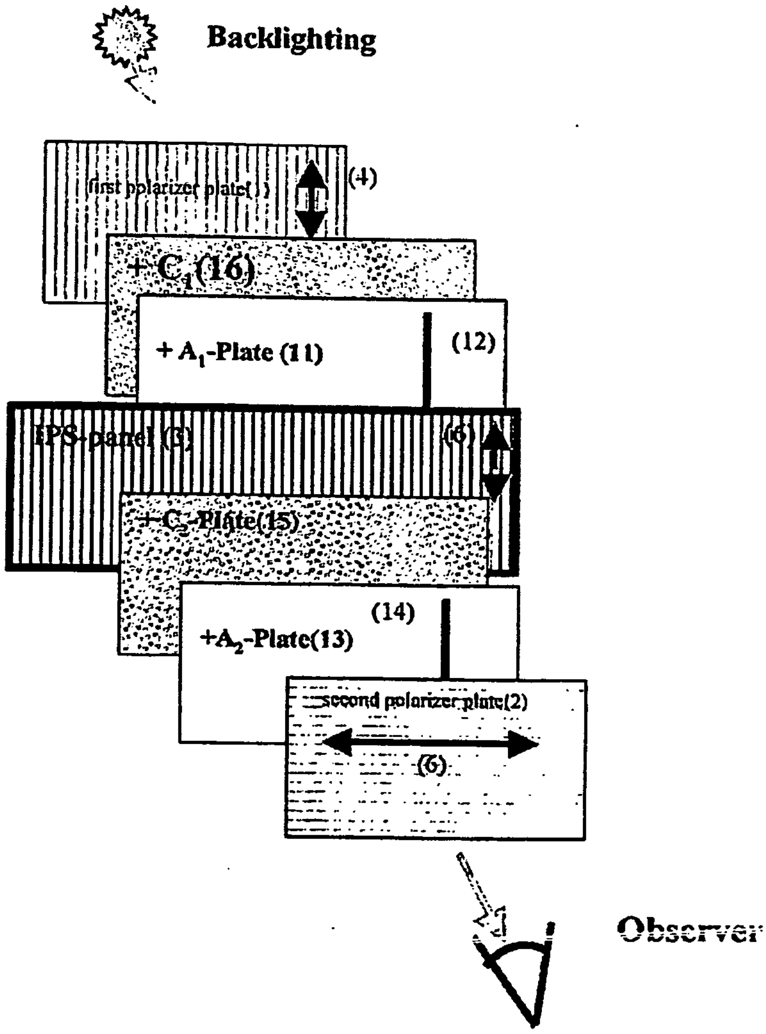

Backlighting
first polarizer plate(1)
(4)
+C1(16)
+A1-Plate (11)
(12)
IPS-panel (3)
(6)
+C2-Plate(15)
(14)
+A2-Plate(13)
second polarizer plate(2)
(6)
Observer

Fig. 22

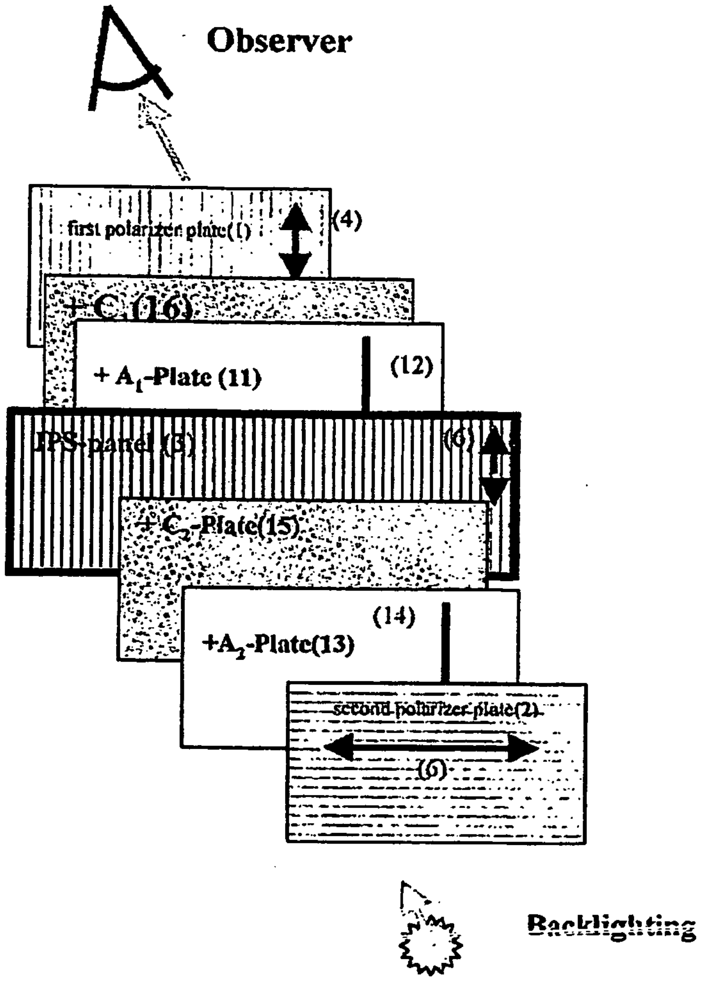

Observer
first polarizer plate(1)
(4)
+C (16)
+ A_1-Plate (11)
(12)
IPS-panel (3)
(6)
+ C_2-Plate(15)
(14)
+A_2-Plate(13)
second polarizer plate(2)
(5)
Backlighting

Fig. 23

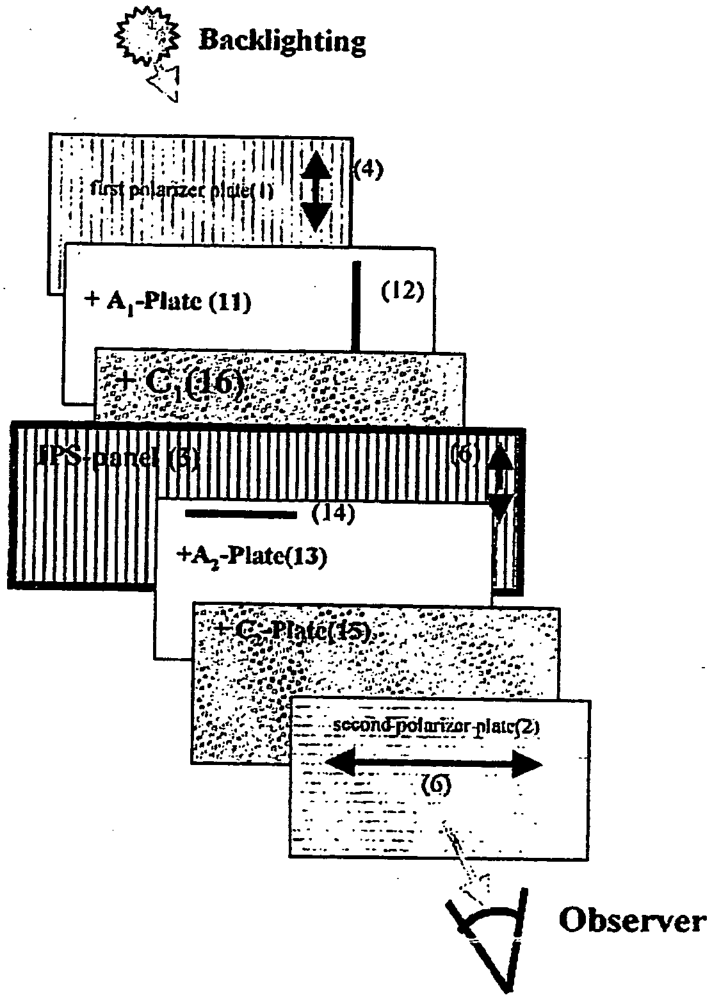

Backlighting
first polarizer plate(1)
(4)
+ A_1-Plate (11)
(12)
+ C_1(16)
IPS-panel (3)
(6)
(14)
+A_2-Plate(13)
+ C_2-Plate(15)
second polarizer plate(2)
(6)
Observer

Fig. 24

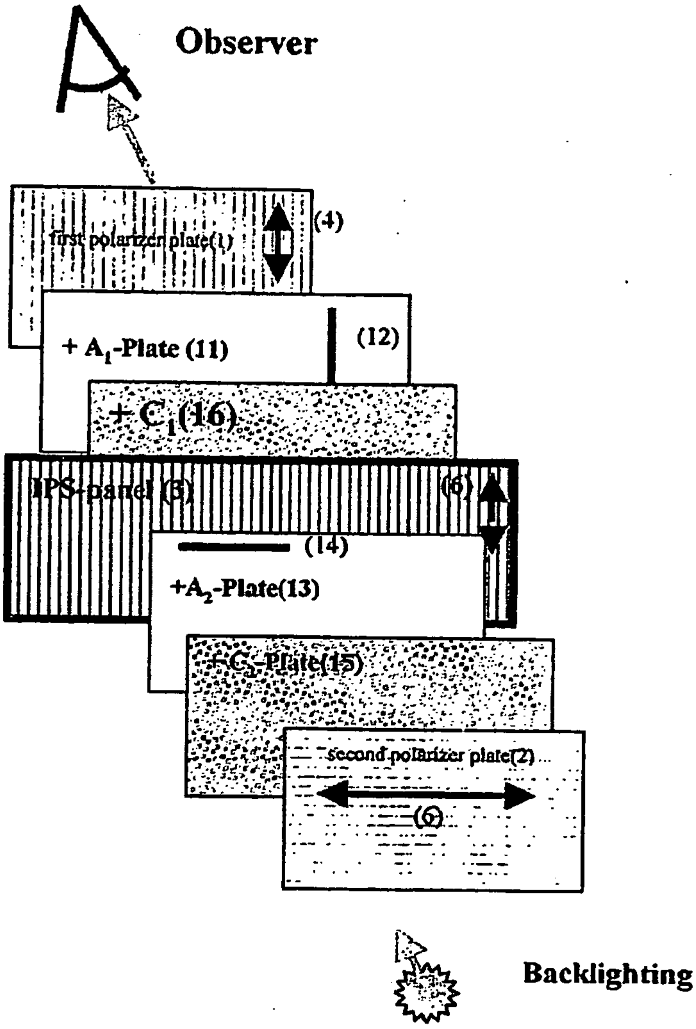

Observer
(4)
first polarizer plate(1)
+ A_1-Plate (11)
(12)
+ C_1(16)
IPS-panel (3)
(6)
(14)
+A_2-Plate(13)
+C_2-Plate(15)
second polarizer plate(2)
(6)
Backlighting

Fig. 25

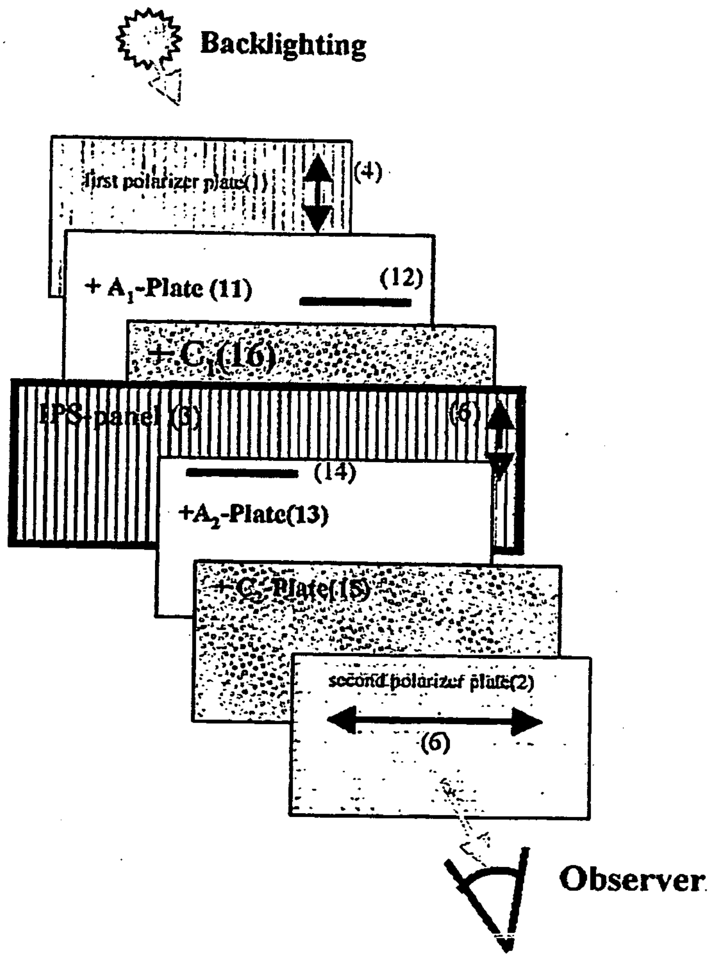

Backlighting
first polarizer plate(1)
(4)
+ A_1-Plate (11)
(12)
+ C_1(16)
IPS-panel (3)
(6)
(14)
+A_2-Plate(13)
+C_2-Plate(15)
second polarizer plate(2)
(6)
Observer

Fig. 26

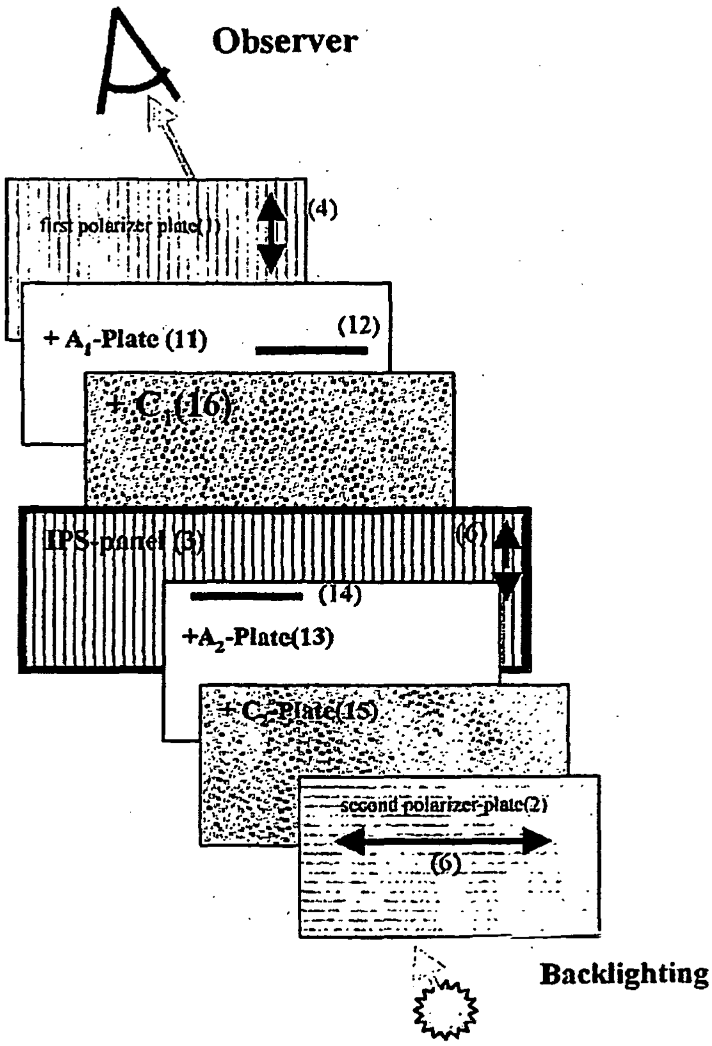

Observer
first polarizer plate(1)
(4)
+ A1-Plate (11)
(12)
+ C1(16)
IPS-panel (3)
(6)
(14)
+A2-Plate(13)
+ C2-Plate(15)
second polarizer-plate(2)
(6)
Backlighting

Fig. 27

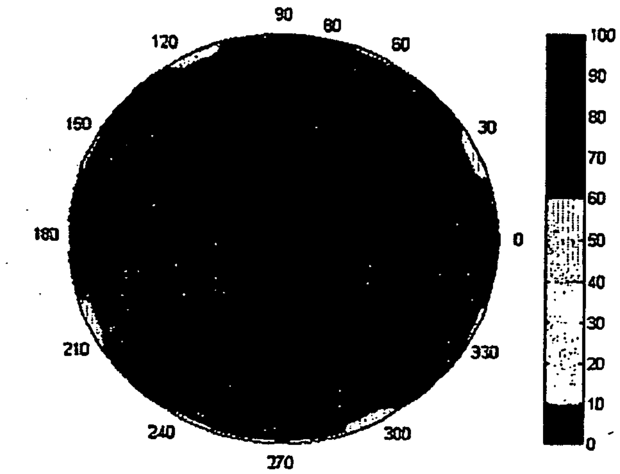

90
80
60
30
0
330
300
270
240
210
180
150
120
100
90
80
70
60
50
40
30
20
10
0

Fig. 28

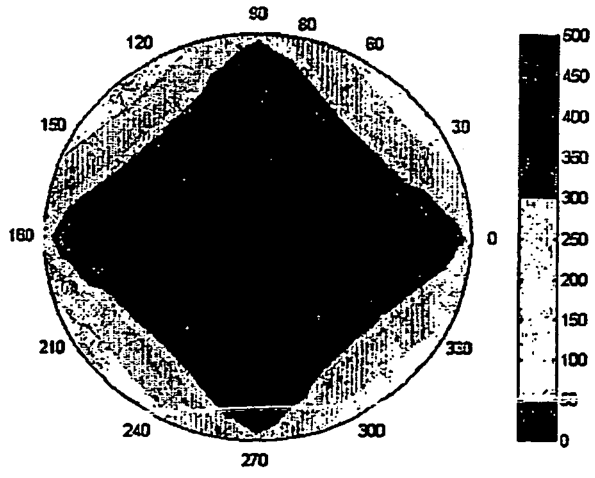

90
80
60
30
0
330
300
270
240
210
180
150
120
500
450
400
350
300
250
200
150
100
0

Fig. 29

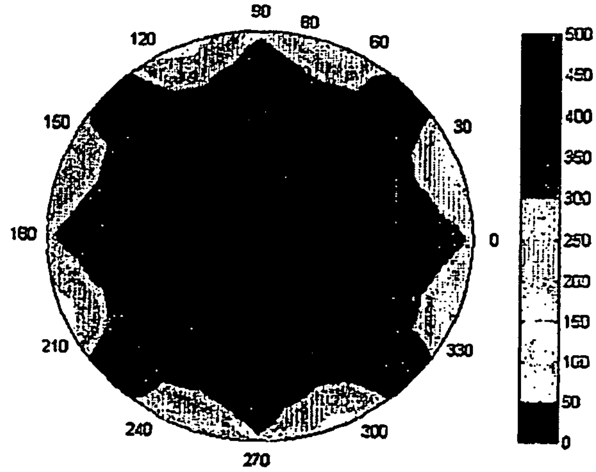

90
60
120
60
150
30
180
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

Fig. 30

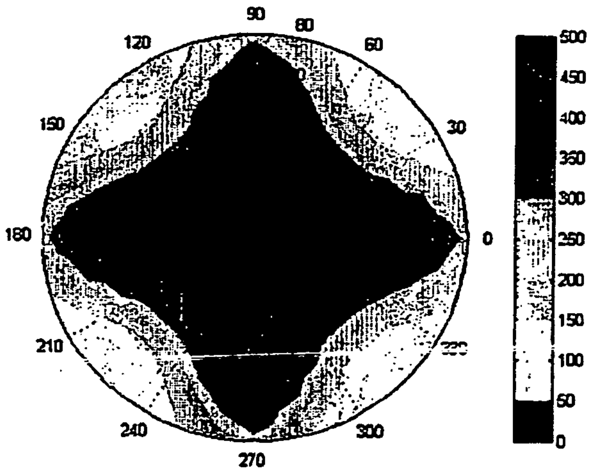

90
60
120
60
150
30
180
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

Fig. 31

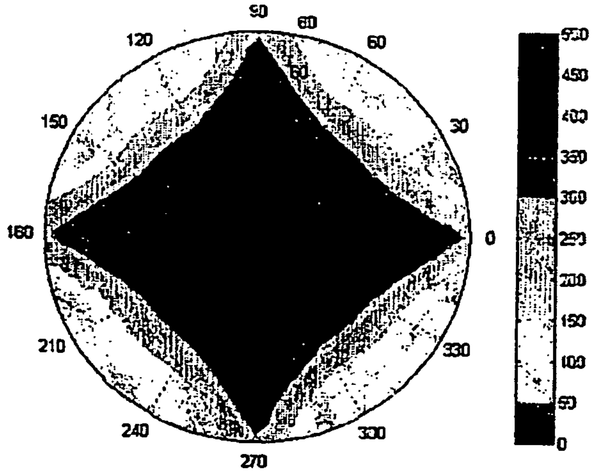
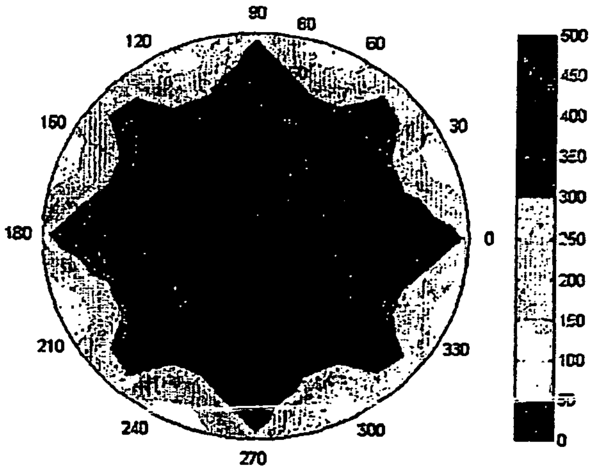

90
60
120
60
150
30
180
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

Fig. 32


90
60
120
60
150
30
180
0
210
330
240
300
270
500
450
400
350
300
250
200
150
100
50
0

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 3807831 A **[0002]**
- US 5189538 A **[0003]**
- US 6115095 A **[0004] [0005]**

patsnap

专利名称(译)	面内切换液晶显示器，包括用于使用+ A-板和+ C-板的角视场的补偿膜		
公开(公告)号	EP2028536B1	公开(公告)日	2013-07-17
申请号	EP2008018712	申请日	2004-10-22
[标]申请(专利权)人(译)	乐金化学股份有限公司		
申请(专利权)人(译)	LG化学有限公司.		
当前申请(专利权)人(译)	LG化学有限公司.		
[标]发明人	JEON BYOUNG KUN BELYAEV SERGEY YU JEONG SU MALIMONENKO NIKOLAY		
发明人	JEON, BYOUNG KUN BELYAEV, SERGEY YU, JEONG SU MALIMONENKO, NIKOLAY		
IPC分类号	G02F1/1335 G02F1/13363 G02F1/1343		
CPC分类号	G02F1/133634 G02F1/13363 G02F1/134363 G02F2413/06 G02F2413/08 G02F2413/11 G02F2413/13		
优先权	1020030073792 2003-10-22 KR		
其他公开文献	EP2028536A1		
外部链接	Espacenet		

摘要(译)

公开了一种面内切换液晶显示器。面内切换液晶显示器通过使用+ A-板和+ C-板改善其前方和预定倾斜角的对比度特性，同时根据黑色状态下的视角最小化色移。

Equation 1

$R_{in} = d \times (n_x - n_y)$, wherein d is a thickness of a film.

The +A-plate has a thickness retardation value of almost