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(54) **Liquid crystal display device**

Flüssigkristallanzeige

Dispositif d'affichage à cristaux liquides

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- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 05, 14 September 2000 (2000-09-14) -& JP 2000 035570 A (SHARP CORP), 2 February 2000 (2000-02-02) -& US 2001/055082 A1 (KUBO ET AL) 27 December 2001 (2001-12-27)**
- **PATENT ABSTRACTS OF JAPAN vol. 1999, no. 09, 30 July 1999 (1999-07-30) -& JP 11 101992 A (SHARP CORP), 13 April 1999 (1999-04-13)**

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Description

[0001] The invention relates to a liquid crystal display device having an area through which a light is allowed to pass for forming images on a screen, and an area in which a light is reflected for forming images on a screen.

[0002] A liquid crystal display device has advantages that it is thin, and it consumes small power. Due to the advantages, a liquid crystal display device is widely used, for instance, for a monitoring screen in various displays.

[0003] Unlike a cathode ray tube (CRT) and an electroluminescence (EL) display device, a liquid crystal display device does not have a function of emitting a light. Hence, a liquid crystal display device is necessary to have a light source separately from a monitoring screen. In dependence on a type of a light source, a liquid crystal display device is grouped into a light transmission type liquid crystal display device and a light reflection type liquid crystal display device.

[0004] A light transmission type liquid crystal display device includes a light source at a rear, and display images by switching transmission and interruption of a light (which is called "backlight") emitted from the light source.

[0005] In a light transmission type liquid crystal display device, power consumed for emitting a backlight is 50% or greater in total power consumption. That is, a light source for emitting a backlight causes much power consumption in a light transmission type liquid crystal display device.

[0006] In order to solve such a disadvantage of a light transmission type liquid crystal display device as mentioned above, there has been suggested a light reflection type liquid crystal display device.

[0007] A light reflection type liquid crystal display device includes a light-reflection plate at which surrounding lights are reflected. Images are displayed on a screen by switching transmission and interruption of lights having been reflected from the light-reflection plate. Unlike a light transmission type liquid crystal display device, a light reflection type liquid crystal display device is not necessary to include a light source, and hence, can reduce power consumption in comparison with a light transmission type liquid crystal display device.

[0008] For instance, a handy communication device such as a cellular phone is frequently used outside, and hence, can use surrounding lights as reflected lights. For that reason, a light reflection type liquid crystal display device is suitable to a monitoring screen of a handy communication device.

[0009] However, a light reflection type liquid crystal display device which uses surrounding lights as reflected lights is accompanied with a problem that if surrounding lights are not bright, a user cannot clearly look at a screen.

[0010] On the other hand, contrary to a light reflection type liquid crystal display device, a light transmission type liquid crystal display device is accompanied with a problem that if surrounding lights are extremely bright, images displayed on a screen look dark in comparison with the surrounding lights.

[0011] In order to solve those problems, there has been suggested a light reflection and transmission type liquid crystal display device which accomplish both displaying images by partially transmitting a light and displaying images by partially reflecting a light, in a single liquid crystal display panel.

[0012] As an example, a light reflection and transmission type liquid crystal display device suggested in Japanese Patent No. 2955277 (B2) (Japanese Unexamined Patent Publication No. 11-101992 (A)) is illustrated in FIG. 1.

[0013] The illustrated liquid crystal display device is comprised of an active matrix substrate 100, an opposing substrate 110 facing the active matrix substrate 100, and a liquid crystal layer 120 sandwiched between the active matrix substrate 100 and the opposing substrate 110.

[0014] The active matrix substrate 100 is comprised of a first transparent substrate 101, a retardation plate 102 formed on the first transparent substrate 101 at the opposite side of the liquid crystal layer 120, and a polarizer 103 formed on the retardation plate 102.

[0015] A backlight source 104 is arranged below the polarizer 103.

[0016] The opposing substrate 110 is comprised of a second transparent substrate 111, a retardation plate 112 formed on the second transparent substrate 111, and a polarizer 113 formed on the retardation plate 112.

[0017] The first transparent substrate 101 has a first area A in which a light emitted from the backlight source 104 transmits through the active matrix substrate 100, the liquid crystal layer 120 and the opposing substrate 110, and a second area B in which an incoming light is reflected.

[0018] An electrically conductive transparent film 105 is formed on the first transparent substrate 101 in the first area A.

[0019] An electrically insulating film 106 having raised and recessed portions, and a light-reflection plate 107 covering the electrically insulating film 106 therewith are formed on the first transparent substrate 101 in the second area B.

[0020] A light 130 having been emitted from the backlight source 104 passes through the electrically conductive transparent film 105 for forming certain images on a liquid crystal display panel. A light 140 externally entering the liquid crystal display device is reflected at the light-reflection plate 107 for forming certain images on a liquid crystal display panel.

[0021] The retardation plates 102 and 112 provide retardation of a quarter length ($\lambda/4$) to such a transmission light and a reflected light. A transmission light and a reflected light are converted into a linearly polarized light from a circularly polarized light or vice versa, when they pass through the polarizers 103 and 113.

[0022] As illustrated in FIG. 1, the electrically insulating film 106 is not formed below the electrically conductive transparent film 105. Hence, it would be possible to equalize an optical length of a light in the liquid crystal layer 120 which light passes through the liquid crystal layer 120 in reciprocation in the second area B, and an optical length of a light in the liquid crystal layer 120 which light passes through the liquid crystal layer 120 in the first area A, to each other by designing a cell gap in the first area A, that is, a thickness Df of the liquid crystal layer 120 to be greater than a cell gap Dr in the second area B. As a result, it would be possible to control optical characteristics of lights passing through the liquid crystal layer 120 in the first area A and in the second area B such that the optical characteristics vary in the same manner.

[0023] However, the conventional liquid crystal display device illustrated in FIG. 1 is accompanied with a problem that if characteristics of displaying images through reflected lights are optimized, a luminance would be lowered, because the cell gap Df in the first area A is greater than the cell gap Dr in the second area B. This is because a twisting angle of liquid crystal is equal to about 72 degrees, if the above-mentioned characteristics are optimized, and an intensity of a transmission light is lowered at a twisting angle of about 72 degrees under the condition of Df < Dr.

[0024] In JP-A-2000035570 a liquid crystal display device is disclosed having improved coloring in a reflection mode by climinating the variation of polarization. To achieve this improvement respective in λ/4 wave plates and in λ/2 wave plates are arranged accordingly. In US-B1-6,195,140 a liquid crystal display device is disclosed combining advantages of the transmission mode display and the reflection mode display. In EP-A-1. 072 926 a reflection type liquid crystal display is disclosed, which disclosed all the features of the preamble of claim 1 in combination. It comprises a. liquid crystal element comprised of twisted nematic liquid crystal sandwiched between a first substrate provided with a reflector and first electrodes, and a second substrate provided with second electrodes, and a twisted retardation film, a first retardation film, a second retardation film and a polarizing film. The respective films are disposed such in sequence on the outer side of the second substrate, that a black display with low reflectance is obtained.

[0025] In view of the above-mentioned problems in the conventional liquid crystal display devices, it is an object of the present invention to provide a light-transmission and light-reflection type liquid crystal display device which is capable of avoiding reduction in brightness when used as a light-transmission type liquid crystal display device, and enhancing both contrast and luminance, when used as a light-reflection type liquid crystal display device.

[0026] These and other objects of the present invention are achieved by a liquid crystal display device according to independent claim 1. The dependent claims treat further advantageous developments of the present invention.

[0027] The advantages obtained by the aforementioned present invention will be described hereinbelow.

[0028] In accordance with the above-mentioned liquid crystal display device, it would be possible to use twist nematic liquid crystal which has a wide gap margin and is capable of accomplishing high white-colored display, when images are displayed through reflected lights, and to display images vividly in high contrast, when images are displayed through transmitted lights.

[0029] The reason is as follows.

[0030] When a liquid crystal device used for a light-reflection panel is designed, any angle other than 90 degrees is selected, taking into consideration display characteristics in displaying images through reflected lights. However, even if a voltage is applied to liquid crystal molecules, liquid crystal molecules existing in the vicinity of upper and lower substrates do not rise up at a twisting angle other than 90 degrees, resulting in that high contrast cannot be obtained due to existence of residual birefringence.

[0031] The liquid crystal display device in accordance with the present invention increases birefringence of the first retardation plate to thereby make the 1st retardation plates in parallel with a residual birefringence ellipsoid, and remove the residual retardation. In addition, combination of the 1st and 2nd retardation plates would compensate for retardation in a wide range, and present a high contrast ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a cross-sectional view of a conventional liquid crystal display device.

FIG. 2 is a cross-sectional view of a liquid crystal display device in accordance with the first embodiment of the present invention.

FIG. 3 is a top plan view of the liquid crystal display device illustrated in FIG. 2.

FIG. 4A illustrates a first example of a relation among arrangement angles of the retardation plates in the liquid crystal display device illustrated in FIG. 2.

FIG. 4B is a graph showing a relation between a transmission or reflection rate and a voltage to be applied to liquid crystal in the liquid crystal display device illustrated in FIG. 4A.

FIG. 5A illustrates a second example of a relation among arrangement angles of the retardation plates in the liquid crystal display device illustrated in **FIG. 2.**

FIG. 5B is a graph showing a relation between a transmission or reflection rate and a voltage to be applied to liquid crystal in the liquid crystal display device illustrated in FIG. 5A.

FIG. 6A illustrates a third example of a relation among arrangement angles of the retardation plates in the liquid crystal display device illustrated in FIG. 2.

FIG. 6B is a graph showing a relation between a transmission or reflection rate and a voltage to be applied to liquid crystal in the liquid crystal display device illustrated in FIG. 6A.

FIG. 7A illustrates a fourth example of a relation among arrangement angles of the retardation plates in the liquid crystal display device illustrated in FIG. 2.

FIG. 7B is a graph showing a relation between a transmission or reflection rate and a voltage to be applied to liquid crystal in the liquid crystal display device illustrated in FIG. 7A.

FIGs. 8A and 8B are graphs showing the results of simulating a relation between a cell gap and a transmission rate.

FIG. 9 is a block diagram of a first example of an electronic device to which the liquid crystal display device in accordance with the first embodiment is applied.

FIG. 10 is a block diagram of a second example of an electronic device to which the liquid crystal display device in accordance with the first embodiment is applied.

[0033] Preferred embodiments in accordance with the present invention will be explained hereinbelow with reference to drawings.

[0034] FIG. 2 is a cross-sectional view of a liquid crystal display device 10 in accordance with the first embodiment.

[0035] The liquid crystal display device 10 in accordance with the first embodiment is comprised of an active matrix substrate 20, an opposing substrate 40 facing the active matrix substrate 20, a liquid crystal layer 50 sandwiched between the active matrix substrate 20 and the opposing substrate 40, and a backlight source 30 arranged below the active matrix substrate 20.

[0036] The active matrix substrate 20 is comprised of a first transparent substrate 21, a gate insulating film 22 formed on the first transparent substrate 21, a first electrically insulating film 23 formed on the gate insulating film 22, a second electrically insulating film 24 formed on the gate insulating film 22 to cover the first electrically insulating film 23 therewith, a light-reflection electrode 25 formed on the second electrically insulating film 24, a transparent electrode 26 formed on the second electrically insulating film 24 such that the transparent electrode 26 partially overlaps the light-reflection electrode 25, a thin film transistor 31 formed on the first transparent substrate 21, a first 1st retardation plate 27 formed on the first transparent substrate 21 at the opposite side of the liquid crystal layer 50, a second 1st retardation plate 28 formed on the first 1st retardation plate 27, and a first polarizer 29 formed on the second ist retardation plate 28.

[0037] The backlight source 30 is arranged immediately below the first polarizer 29.

[0038] The opposing substrate 40 is comprised of a second transparent substrate 41, a first 2nd retardation plate 42 formed on the second transparent substrate 41, a second 2nd retardation plate 43 formed on the first 2nd retardation plate 42, and a second polarizer 44 formed on the second 2nd retardation plate 43.

[0039] The opposing substrate 40 further includes a transparent electrode (not illustrated) and an alignment film (not illustrated) formed on the second transparent substrate 41 in contact with the liquid crystal layer 50.

[0040] The active matrix substrate 20 further includes an alignment film (not illustrated) formed on both the light-reflection electrode 25 and the transparent electrode 26 in contact with the liquid crystal layer 50.

[0041] The active matrix substrate 20 has a first area A through which a light is allowed to pass, and a second area B in which an incoming light is reflected. The light-reflection electrode 25 is formed in the second area B, and the transparent electrode 26 is formed in the first area A. ,

[0042] In the second area B, the first electrically insulating film 23 is formed in spots in the form of a projection, and the second electrically insulating film 24 covering the first electrically insulating film therewith is formed to have raised and recessed portions. In the first area A, the first electrically insulating film 23 is planarized. Hence, in the second area B, the light-reflection electrode 25 formed on the second electrically-insulating film 24 also has raised and recessed portions, and, in the first area A, the transparent electrode 26 formed on the second electrically insulating film 24 is also planarized.

[0043] The structure of the liquid crystal display device in accordance with the first embodiment is not to be limited to the structure illustrated in FIG. 2. For instance, the first electrically insulating film 23 may be formed in spots in the form of a projection, and the, second electrically insulating film 24 covering the first electrically insulating film 23 therewith may be formed to have raised and recessed portions also in the first area A, similarly to the second area B.

[0044] The first electrically insulating film 23 may be planarized, and the second electrically insulating film 24 may be planarized also in the second area B, in which case, reflected lights are scattered by the opposing substrate 40.

[0045] A light emitted from the backlight source 30 passes through the first area A to thereby display certain images on a liquid crystal panel. An incident light 160 entering the liquid crystal display device 10 from outside is reflected at the light-reflection electrode 25 to there by display certain images on a liquid crystal panel.

[0046] The thin film transistor 31 is comprised of a gate electrode 32 formed on the first transparent substrate 21, an amorphous silicon (a-Si) layer 33a formed on the gate insulating film 22 above the gate electrode 32, an n+ amorphous silicon (a-Si) layer 33b formed partially on the a-Si layer 33a, a drain electrode 34 formed on the gate insulating film 22 covering the n+ a-Si layer 33b and the a-Si layer 33a therewith, and a source electrode 35 formed on the gate insulating film 22 covering the n+ a-Si layer 33b and the a-Si layer 33a therewith.

[0047] The light-reflection electrode 25 makes electrical contact with the source electrode 35 at a contact 36.

[0048] The first 1st retardation plate 27 has retardation of 140 nm, and the second 1st retardation plate 28 has retardation of 250 nm.

[0049] The first 1st retardation plate 27 may have retardation in the range of 135 nm to 160 nm, and the second 1st retardation plate 28 may have retardation in the range of 250 nm to 300 nm.

[0050] FIG. 3 is a top plan view of the liquid crystal display device 10 in accordance with the first embodiment. FIG. 2 corresponds to a cross-sectional view taken along the line II-II in FIG. 3.

[0051] As illustrated in FIG. 3, the active matrix substrate 20 includes gate lines 1 and drain lines 2 extending perpendicularly to each other. The thin film transistor 31 as a switching device is arranged in each of pixels defined by the gate lines 1 and the drain lines 2.

[0052] The light-reflection electrode 25 reflects a light entering each of the pixels. A voltage is applied to the liquid crystal layer 50 sandwiched between the active matrix substrate 20 and the opposing substrate 40, through the light-reflection electrode 25.

[0053] The transparent electrode 26 formed adjacent to the light-reflection electrode 25 allows a light emitted from the backlight source 30 to pass therethrough.

[0054] The gate electrode 32 is electrically connected to the gate lines 1, the drain electrode 34 is electrically connected to the drain lines 2, and the source electrode 35 is electrically connected to the light-reflection electrode 25.

[0055] Assuming that the first 1st retardation plate 27 has an optical axis arranged at a first angle relative to a reference direction, the first 2nd retardation plate 42 has an optical axis arranged at a second angle relative to the reference direction, the first and second angles are deviated from each other by about 90 degrees. Similarly, assuming hat the second 1st retardation plate 28 has an optical axis arranged at a third angle relative to a reference direction, the second 2nd retardation plate 43 has an optical axis arranged at a fourth angle relative to the reference direction, the third and fourth angles are deviated from each other by about 90 degrees.

[0056] Hereinbelow, an angle at which an optical axis of a retardation plate is arranged relative to a reference direction is referred to as an arrangement angle.

[0057] Specifically, assuming that first to N-th 1st retardation plates are formed on the first transparent substrate 21 such that a K-th 1st retardation plate is located closer to the first transparent substrate 21 than a (K+1)·th 1st retardation plate wherein K is an integer equal to or greater than one, but equal to or smaller than (N-1), and that first to N-th 2nd retardation plates are formed on the second transparent substrate 41 such that a K-th 1st retardation plate is located closer to the second transparent substrate 41 than a (K+1)-th 1st retardation plate, a K-th 1st retardation plate corresponds to a K-th 2nd retardation plate, and angles of the corresponding 1st and 2nd retardation plates at which optical axes thereof are arranged relative to a reference direction are deviated from each other by about 90 degrees.

[0058] In the examples explained hereinbelow, a reference direction is defined as a direction perpendicular to a direction in which liquid crystal molecules existing at the middle in a thickness-wise direction of the liquid crystal layer 50 are aligned , and a direction in which liquid crystal molecules in the liquid crystal layer 50 are twisted starting from the opposing substrate 40 towards the active matrix substrate 20 is defined as a Positive twisting direction.

[0059] In the first example, in the second area B, the first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44 are designed to have retardation and arrangement angle in accordance with Japanese Patent Application No. 2001-022485 suggesting a light-reflection type liquid crystal display device which is capable of avoiding displayed images from being colored when a black is displayed, and presenting high contrast to displayed images.

[0060] Then, there are prepared retardation plates having the same retardation as those of the first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44, as the first 1st retardation plate 27, the second 1st retardation plate 28 and the first polarizer 29, respectively, all of which are influenced by the first area A. The arrangement angles between those corresponding retardation plates and polarizers are designed to be deviated from each other by about 90 degrees.

[0061] FIG. 4A illustrates the first example showing a relation between the arrangement angles of the first 1st retardation plate 27 and the first 2nd retardation plate 42 and further between the arrangement angles of the second 1st retardation plate 28 and the second 2nd retardation plate 43.

[0062] FIG. 4B is a graph showing a relation between a voltage to be applied to liquid crystal and a light transmission rate (or a light reflection rate) in the first example.

[0063] As illustrated in FIG. 4A, in the first example, the first polarizer 29 has an absorption axis inclining by 0 degrees relative to the reference direction, and the second polarizer 44 has an absorption axis inclining by 90 degrees relative to the reference direction.

[0064] The active matrix substrate 20 has a rubbing angle of 126 degrees, and the opposing substrate 40 has a rubbing angle of 54 degrees. ,

[0065] In the first example, the first 1st retardation plate 27 and the first 2nd retardation plate 42 are comprised of a retardation plate having retardation of about a quarter wavelength ($\lambda/4$), whereas the second 1st retardation plate 28 and the second 2nd retardation plate 43 are comprised of a retardation plate having retardation of about a half wavelength ($\lambda/2$).

[0066] The first 1st retardation plate 27 has an arrangement angle of 105 degrees. The first 2nd retardation plate 42 corresponding to the first 1st retardation plate 27 has an arrangement angle of 15 degrees. Thus, the arrangement angles between the first 1st retardation plate 27 and the first 2nd retardation plate 42 are deviated from each other by 90 degrees.

[0067] The second 1st retardation plate 28 has an arrangement angle of 165 degrees. The second 2nd retardation plate 43 corresponding to the second 1st retardation plate 28 has an arrangement angle of 76 degrees. Thus, the arrangement angles between the second 1st retardation plate 28 and the second 2nd retardation plate 43 are deviated from each other by about 90 degrees (accurately, 89 degrees).

[0068] There was fabricated a liquid crystal display device including the first 1st retardation plate 27, the second 1st retardation plate 28, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 all having the above-mentioned relation with respect to the arrangement angle, and a contrast ratio was measured when images were displayed through transmission lights having passed through the first area A.

[0069] The measured contrast ratio was 105.

[0070] The measured contrast ratio is an improved one in comparison with a contrast ratio in a conventional liquid crystal display device which contrast ratio is equal to or smaller than 100.

[0071] FIG. 5A illustrates the second example showing a relation between the arrangement angles of the first 1st retardation plate 27 and the first 2nd retardation plate 42 and further between the arrangement angles of the second 1st retardation plate 28 and the second 2nd retardation plate 43.

[0072] FIG. 5B is a graph showing a relation between a voltage to be applied to liquid crystal and a light transmission rate (or alight reflection rate) in the second example.

[0073] The first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44 in the second example are designed to have the same retardation and arrangement angles as those of the above-mentioned first example.

[0074] The first 1st retardation plate 27 is designed to have retardation deviated from that of the first example by 3 nm at a center thereof in order to compensate for residual retardation by means of the first 1st retardation plate 27. However, it can be considered that the first 1st retardation plate 27 has substantially the same retardation as that of the first example. In contrast, the first 1st retardation plate 27 and the second 1st retardation plate 28 are designed to have arrangement angles different from those of the first example, and the deviation between the arrangement angles of the first and second 2nd retardation plates 42 and 43 is determined to be out of 90 degrees.

[0075] As illustrated in FIG. 5A, in the second example, the first polarizer 29 has an absorption axis inclining by -1 degrees relative to the reference direction, and the second polarizer 44 has an absorption axis inclining by 90 degrees relative to the reference direction.

[0076] The active matrix substrate 20 has a rubbing angle of 126 degrees, and the opposing substrate 40 has a rubbing angle of 54 degrees.

[0077] Similarly to the first example, in the second example, the first 1st retardation plate 27 and the first 2nd retardation plate 42 are comprised of a retardation plate having retardation of about a quarter wavelength (λ/4), whereas the second 1st retardation plate 28 and the second 2nd retardation plate 43 are comprised of a retardation plate having retardation of about a half wavelength (λ /2).

[0078] The first 1st retardation plate 27. has an arrangement angle of -2.8 degrees. The first 2nd retardation plate 42 corresponding to the first 1st retardation plate 27 has an arrangement angle of 15 degrees. Whereas the arrangement angles between the first 1st retardation plate 27 and the first 2nd retardation plate 42 corresponding to the first 1st retardation plate 27 are deviated from each other by 90 degrees in the above-mentioned first example, deviation in the arrangement angles between the first 1st retardation plate 27 and the first 2nd retardation plate 42 in the second example is not equal to 90 degrees, unlike the first example, because residual retardation is compensated for by the first 1st retardation plate 27.

[0079] The second 1st retardation plate 28 has an arrangement angle of 110 degrees, and the second 2nd retardation plate 43 corresponding to the second 1st retardation plate 28 has an arrangement angle of 76 degrees. Hence, a difference in an arrangement angle between the second 1st retardation plate 28 and the second 2nd retardation plate 43 is not equal to 90 degrees.

[0080] There was fabricated a liquid crystal display device including the first 1st retardation plate 27, the second 1st retardation plate 28, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 all having the above-mentioned relation with respect to the arrangement angle, and a contrast ratio was measured when images were displayed through transmission lights having passed through the first area A.

[0081] The measured contrast ratio was 500.

[0082] The measured contrast ratio is an improved one in comparison with a contrast ratio in a conventional liquid crystal display device which contrast ratio is equal to or smaller than 100.

[0083] FIG. 6A illustrates the third example showing a relation between the arrangement angles of the first 1st retardation plate 27 and the first 2nd retardation plate 42 and further between the arrangement angles of the second 1st retardation plate 28 and the second 2nd retardation plate 43.

[0084] FIG. 6B is a graph showing a relation between a voltage to be applied to liquid crystal and a light transmission rate (or a light reflection rate) in the third example.

[0085] In a first step in the third example, the first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44 are designed to have retardation and arrangement angles such that variance in retardation in the liquid crystal layer 50, caused by variance in a viewing angle, and variance in retardation in retardation films, caused by variance in a viewing angle cancel each other in the second area B. In the third example explained hereinbelow, the liquid crystal display device includes only the second area B, but does not include the first area A.

[0086] As illustrated in FIG. 6A, the opposing substrate 40 has a rubbing angle of 54 degrees, and a product Δ nd of the liquid crystal layer 50 and a cell gap of the liquid crystal layer 50 is set equal to about 0.27 micrometers. A twisting angle of the liquid crystal layer 50 has an allowable range of about ±4 degrees, and the product Δnd has an allowable range of about ± 0,04 micrometers. Accordingly, a twisting angle of the liquid crystal layer 50 may be determined in the range of 66 to 74 degrees, and the product Δ nd of the liquid crystal layer 50 may be determined in the range of 0.21 to 0.31 micrometers.

[0087] The first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44 are arranged in this order on the second transparent substrate 41 at the opposite side of the liquid crystal layer 50. The first 2nd retardation plate 42 is designed to have retardation in the range of 145 nm to 180 nm relative to a monochromatic light having a wavelength of 550 nm, and the second 2nd retardation plate 43 is designed to have retardation in the range of 250 nm to 300 nm relative to the same.

[0088] As illustrated in FIG. 6A, alignment of liquid crystal in the liquid crystal layer 50 is determined in dependence on a direction in which alignment films of both the opposing substrate 40 and the active matrix substrate 20 are aligned. Specifically, liquid crystal in the liquid crystal layer 50 is aligned in such a way that the liquid crystal is continuously twisted from an interface of the opposing substrate 40 towards an interface of the active matrix substrate 20.

[0089] The first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44 are designed to have such polarized absorption axes that they have arrangement angles of α, β and γ, respectively, assuming that a direction perpendicular to a first direction in which liquid crystal molecules in the liquid crystal layer 50 at a middle in a thickness-wise direction of the liquid crystal layer 50 are aligned, which first direction is a direction bisecting a direction in which liquid crystal molecules are aligned in the vicinity of the opposing substrate 40 and a direction in which liquid crystal molecules are aligned in the vicinity of the active matrix substrate 20, is selected as a reference direction, and a direction in which liquid crystal is twisted from the opposing substrate 40 towards the active matrix substrate 20 is a positive direction.

[0090] In the third example, the arrangement angle α is designed to be in the range of -15 to 15 degrees, the arrangement angle β is designed to be in the range of 45 to 75 degrees, and the arrangement angle γ is designed to be in the range of 60 to 90 degrees, for avoiding images from being colored due to variance in a viewing angle. ,

[0091] The liquid crystal display device in accordance with the third example acts as a normally white device exhibiting bright condition, in the second area B, when no voltage is applied to liquid crystal. A light entering the liquid crystal display device is converted into a circularly polarized light or a almost circularly polarized light while it passes through the second polarizer 44, the second 2nd retardation plate 43 and the first 2nd retardation plate 42, and then, enters the liquid crystal layer 50. By applying an electric field to the liquid crystal layer 50 through a common transparent electrode (not illustrated) of the opposing electrode 40, it is possible to vary alignment of liquid crystal in the liquid crystal layer 50 for causing an incident light to be reflected at the light-reflection electrode 25 in different manners, resulting in that an intensity of a light reaching a user is varied, and hence, desired images are displayed on a liquid crystal panel.

[0092] In the first embodiment, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 may be composed of polycarbonate family high polymer, polysulfone family high polymer, norbornene family high polymer or polyvinyl alcohol family high polymer.

[0093] As mentioned above, the second area B in the liquid crystal display device in accordance with the first embodiment makes it possible to display full-colored images without unevenness which images are bright, have a high contrast ratio, and do not become yellowish, even if a viewing angle is varied in bright display condition.

[0094] In the second step in the third example, the first 1st retardation plate 27 is designed to have retardation in the range of 125 to 155 nm in order to cause the first 1st retardation plate 27 to compensate for residual retardation in the first area A. The second 1st retardation plate 28 is designed to have the same retardation as that of the second 2nd retardation plate 43. The first 1st retardation plate 27, the second 1st retardation plate 28 and the first polarizer 29 are designed to have arrangement angles which are deviated by 90 degrees from arrangement angles of the corresponding first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second polarizer 44, respectively.

[0095] As illustrated in FIG. 6A, in the third example, the first polarizer 29 has an absorption axis inclining by 163 degrees relative to the reference direction, and the second polarizer 44 has an absorption axis inclining by 73. degrees relative to the reference direction.

[0096] The active matrix substrate 20 has a rubbing angle of 126 degrees, and the opposing substrate 40 has a rubbing angle of 54 degrees.

[0097] Similarly to the above-mentioned first and second examples, in the first example, the first 1st retardation plate 27 and the first 2nd retardation plate 42 are comprised of a retardation plate having retardation of about a quarter wavelength ($\lambda/4$), whereas the second 1st retardation plate 28 and the second 2nd retardation plate 43 are comprised of a retardation plate having retardation of about a half wavelength ($\lambda/2$).

[0098] The first 1st retardation plate 27 has an arrangement angle : of 90 degrees. The first 2nd retardation plate, 42 corresponding to the first 1st retardation plate 27 has an arrangement angle of 0 degrees. Thus, the arrangement angles between the first 1st retardation plate 27 and the first 2nd retardation plate 42 are deviated from each other by 90 degrees.

[0099] The second 1st retardation plate 28 has an arrangement angle of 149 degrees. The second 2nd retardation plate 43 corresponding to the second 1st retardation plate 28 has an arrangement angle of 59 degrees. Thus, the arrangement angles between the second 1st retardation plate 28 and the second 2nd retardation plate 43 are deviated from each other by about 90 degrees.

[0100] There was fabricated a liquid crystal display device including the first 1st retardation plate 27, the second 1st retardation plate 28, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 all having the above-mentioned relation with respect to the arrangement angle, and a contrast ratio was measured when images were displayed through transmission lights having passed through the first area A.

[0101] The measured contrast ratio was 800.

[0102] The measured contrast ratio is significantly improved in comparison with a contrast ratio in a conventional liquid crystal display device which contrast ratio is equal to or smaller than 100.

[0103] Whereas the residual retardation is compensated for by the first 1st retardation plate 27 of the active matrix substrate 20 in the second example, the residual retardation is compensated for by the first 2nd retardation plate 42 of the opposing substrate 40 in the third example. Thus, the residual retardation may be compensated for by either the first 1st retardation plate 27 or the first 2nd retardation plate 42. As an alternative, the residual retardation may be compensated for both of the first 1st retardation plate 27 and the first 2nd retardation plate 42.

[0104] FIG. 7A illustrates the fourth example showing a relation between the arrangement angles of the first 1st retardation plate 27 and the first 2nd retardation plate 42 and further between the arrangement angles of the second 1st retardation plate 28 and the second 2nd retardation plate 43.

[0105] FIG. 7B is a graph showing a relation between a voltage to be applied to liquid crystal and a light transmission rate (or a light reflection rate) in the fourth example.

[0106] The second 1st retardation plate 28 and the first polarizer 29 are designed to have the same retardation and arrangement angles as those of the third example.

[0107] The first 2nd retardation plate 42 is designed to have retardation deviated from that of the third example by 6 nm at a center thereof in order to compensate for residual retardation by means of the first 2nd retardation plate 42. However, it can be considered that the first 2nd retardation plate 42 has substantially the same retardation as that of the third example. In contrast, the first 1st retardation plate 27 are designed to have arrangement angles different from that of the third example, and the deviation in the arrangement angle between the first 1st retardation plate 27 and the first 2nd retardation plate 42 corresponding to the first 1st retardation plate 27 is determined to be out of 90 degrees.

[0108] As illustrated in FIG. 7A, in the fourth example, the first polarizer 29 has an absorption axis inclining by 163 degrees relative to the reference direction, and the second polarizer 44 has an absorption axis inclining by 73 degrees relative to the reference direction.

[0109] The active matrix substrate 20 has a rubbing angle of 126 degrees, and the opposing substrate 40 has a rubbing angle of 54 degrees.

[0110] Similarly to the first to third examples, in the fourth example, the first 1st retardation plate 27 and the first 2nd retardation plate 42 are comprised of a retardation plate having retardation of about a quarter wavelength (λ/4), whereas the second 1st retardation plate 28 and the second 2nd retardation plate 43 are comprised of a retardation plate having retardation of about a half wavelength (λ/2).

[0111] The first 1st retardation plate 27 has an arrangement angle of 105 degrees. The first 2nd retardation plate , 42 corresponding to the first 1st retardation plate 27 has an arrangement angle of 0 degrees. Thus, the arrangement angles between the first 1st retardation plate 27 and the first 2nd retardation plate 42 are deviated from each other by 90 degrees.

[0112] The second 1st retardation plate 28 has an arrangement angle of 149 degrees, and the second 2nd retardation plate 43 corresponding to the second 1st retardation plate 28 has an arrangement angle of 59 degrees. Thus, the arrangement angles between the second 1st retardation plate 28 and the second 2nd retardation plate 43 are deviated from each other by 90 degrees.

[0113] There was fabricated a liquid crystal display device including the first 1st retardation plate 27, the second 1st retardation plate 28, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 all having the above-mentioned relation with respect to the arrangement angle, and a contrast ratio was measured when images were displayed through transmission lights having passed through the first area A.

[0114] The measured contrast ratio was 330.

[0115] The measured contrast ratio is an improved one in comparison with a contrast ratio in a conventional liquid crystal display device which contrast ratio is equal to or smaller than 100.

[0116] Whereas the residual retardation is compensated for by the first 1st retardation plate 27 of the active matrix substrate 20 in the second example, the residual retardation is compensated for by the first 2nd retardation plate 42 of the opposing substrate 40 in the fourth example, similarly to the third example.

[0117] As having been explained in the first to fourth examples, it would be possible to significantly improve a contrast ratio obtained when images are displayed through transmission lights passing through the first area A, in comparison with a conventional liquid crystal display device, by designing the first 1st retardation plate 27, the second 1st retardation plate 28, the first 2nd retardation plate 42 and the second 2nd retardation plate 43 to have a relation as defined in any one of the above-mentioned first to fourth examples with respect to the arrangement angles, namely, such a relation that arrangement angles between the corresponding retardation plates are deviated from each other by 90 degrees.

[0118] Though both the active matrix substrate 20 and the opposing substrate 40 are designed to have two retardation plates in the first to fourth examples, the number of retardation plates is not to be limited to two (2). The active matrix substrate 20 and the opposing substrate 40 may be designed to have one or three or more retardation plates.

[0119] In the liquid crystal display device 10 in accordance with the first embodiment, a cell gap in the second area B, that is, a thickness Dr of the liquid crystal layer 50 is designed longer than a cell gap in the first area A, that is, a thickness Df of the liquid crystal layer 50.

[0120] Since the light-reflection electrode 25 has raised and recessed portions in the second area B, a cell gap Dr in the second area B is defined as an average in optical lengths in the second area B.

[0121] By designing the cell gap Dr longer than the cell gap Df, it would be possible to improve white color temperature in displayed images in the liquid crystal display device 10. In a light transmission and reflection type liquid crystal display device, the cell gap Dr is selected such that a luminance in the second area B is maximized. Hence, by designing the cell gap Df in the first area A to be equal to the cell gap Dr, a luminance in the first area A can be also maximized.

[0122] FIG. 8A shows the results of simulating a relation between a cell gap and a light transmission rate. As is readily understood in view of FIG. 8A, a luminance is in maximum when a cell gap is equal to 3.2 micrometers. However, since there is a jump in V-T (applied voltage vs. light transmission rate) characteristic, it is preferable that a cell gap is designed equal to 3 micrometers. Hence, a cell gap in the first area A in the first embodiment is designed equal to 3 micrometers.

[0123] FIG. 8B shows the results of simulating a relation between a cell gap and light transmission rates for red, green and blue. It is understood in view of FIG. 8B that a luminance for blue is enhanced, if the cell gap Df in the first area A is designed smaller than 3 micrometers. That is, by designing the cell gap Df smaller than a cell gap at which a luminance is maximized, it would be possible to raise a color temperature for white.

[0124] Since the light-reflection electrode 25 has raised and recessed portions in the second area B, the cell gap Dr in the second area B is determined as an average of optical lengths in the second area B. When spherical micro-pearls are introduced into the liquid crystal layer 50 for ensuring a cell gap, such micro-pearls have a diameter smaller than a height of the raised and recessed portions of the light-reflection electrode 25, and hence, it would be impossible to control a cell gap in the second area B by means of such micro-pearls. In contrast, since the transparent electrode 26 has a flat surface, it is possible to control a cell gap in the first area A by means of such micro-pearls.

[0125] The cell gap Dr may be designed to be equal to or almost equal to the cell gap Df. As mentioned earlier, the cell gap Dr is determined usually such that a luminance in the second area B is in maximum. Hence, by designing the cell gap Df in the first area A to be equal to the cell gap Dr, it would be possible to maximize a luminance in the first area A, in which case, the cell gap Df would be readily controlled, because the transparent electrode 26 is planarized at a surface in the first area A.

[0126] The liquid crystal display device 10 in accordance with the first embodiment may be applied to an electronic device. Hereinbelow, some examples are explained.

[0127] FIG. 9 is a block diagram of a portable communication device 250 to which the liquid crystal display device 10 is applied. In the portable communication device 250, the liquid crystal display device 10 in accordance with the first embodiment is used as a part of a later mentioned liquid crystal panel 265.

[0128] The portable communication terminal 250 is comprised of a display unit 268 including a liquid crystal panel 265, a backlight emitter 266, and an image signal processor 267, a controller 269 controlling operation of the parts constituting the portable communication terminal 250, a memory 271 storing a program to be executed by the controller 269 and various data, a communication unit 272 which makes data communication, an input device 273 comprised of a keyboard or a pointer, and a power source 274 supplying power to the above-mentioned parts constituting the portable communication terminal 250.

[0129] The liquid crystal panel 265 including the liquid crystal display device 10 in accordance with the first embodiment enhances an aperture ratio in the display unit 268, and further enhances a luminance in the display unit 268.

[0130] The liquid crystal panel 265 including the liquid crystal display device 10 may be applied to a monitor, of a portable personal computer, a note type personal computer, or a desktop type personal computer.

[0131] FIG. 10 is a block diagram of a cellular phone 275 to which the liquid crystal display device 10 is applied.

[0132] The cellular phone 275 is comprised of a display unit 276 including a liquid crystal panel 265, a backlight emitter 266, and an image signal processor 267, a controller 277 controlling operation of the parts constituting the cellular phone 275, a memory 278 storing a program to be executed by the controller 277 and various data, a radio signal receiver 279, a radio signal transmitter 281, an input device 282 comprised of a keyboard or a pointer, and a power source 283 supplying power to the above-mentioned parts constituting the cellular phone 275.

[0133] The liquid crystal panel 265 including the liquid crystal display device 10 in accordance with the first embodiment enhances an aperture ratio in the display unit 276, and further enhances a luminance in the display unit 276,

[0134] In the above-mentioned first embodiment, the parts by which the present invention is characterized are intensively explained, and parts known to those skilled in the art are not explained in detail. However, it should be noted that the latter could be readily understood to those skilled in the art without detailed explanation.

[0135] Though the first transparent substrate 21, the first 1st retardation plate 27, the second 1st retardation plate 28, the first polarizer 29 and the backlight source 30 are illustrated to make contact with adjacent parts in the above-mentioned first embodiment, it is not always necessary for them to make contact with adjacent parts. One or more of them may be arranged independently of others or one another.

[0136] The same can be applied to the second transparent substrate 41, the first 2nd retardation plate 42, the second 2nd retardation plate 43 and the second p,olarizer 44.

[0137] The liquid crystal display device 10 in accordance with the first embodiment is designed to include two retardation plates each above and below the liquid crystal layer 50. However, the number of the retardation plates is not to be limited to two (2). The liquid crystal display device 10 may be designed to include N retardation plates each above and below the ,liquid crystal layer 50, wherein N is an integer equal to or greater than one (1).

Claims

1. A liquid crystal display device comprising:

(a) a first substrate (20);
(b) a second substrate (40) spaced away from and facing the fist substrate (20); and
(c) a liquid crystal layer (50) sandwiched between the first and second substrates (20, 40) and twistingly oriented,

the first substrate (20) being comprised of:

(a1) a first transparent substrate (21) having a first area (A) through which light is allowed to pass and a second area (B) in which light is reflected;
(a2) first to N-th 1st retardation plates (27, 28) arranged on the first transparent substrate (21) at the opposite side of the liquid crystal layer (50) wherein a K-th 1st retardation plate (27) is closer to the first transparent substrate (21) than a (K+1)-th 1st retardation plate (28), and wherein N is an integer greater than 1, and K is an integer in the range from 1 to N-1; and
(a3) a first polarizer (29) arranged on the N-th 1st retardation plate (28), the second substrate (40) being comprised of:
(b1) a second transparent substrate (41);
(b2) first to N-the 2nd retardation plates (42, 43) arranged on the second transparent substrate (41) at the opposite side of the liquid crystal layer (50) wherein a K-th 2nd retardation plate (42) is closer to the second transparent substrate (41) than a (K+1)-th 2nd retardation plate (43), and wherein N is an integer greater than 1, and K is an integer in the range from 1 to N-1; and
(b3) a second polarizer (44) arranged on the N-th 2nd retardation plate (43), wherein a k-th retardation plate among the first to N-th 1st retardation plates (27, 28) has an optical axis arranged at a first angle relative to a reference direction and a k-th retardation plate among the first to N-th 2nd retardation plates (42, 43) has an optical axis arranged at a second angle relative to the reference direction, and wherein the first and second angles are different from each other by about 90 degrees, **characterised in that** a thickness of the liquid crystal layer (50) in the first area (A) is smaller than a thickness of the liquid crystal layer (50) in the second area (B).

2. The liquid crystal display device as set forth in claim 1, wherein a retardation plate (27) arranged closest to the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) has retardation in the range of 140 nm to 160 nm, and a retardation plate (43) arranged remotest from the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) has retardation in the range of 250 nm to 300 nm.

3. The liquid crystal display device as set forth in claim 1 or 2, wherein a retardation plate (27) arranged closest to the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) is arranged at an angle in the range of 90 to 120 degrees relative to a reference direction, a retardation plate (28) arranged remotest from the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) is arranged at an angle in the range of 150 of 180 degrees relative to the reference direction, and the first polarizer (29) is arranged at an angle in the range of -15 to 15 degrees relative to the reference direction,
and wherein a retardation plate (42) arranged closest to the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) is arranged at an angle of 15 degrees relative to the reference direction, a retardation plate (43) arranged remotest from the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) is arranged at an angle in the range of 60 to 90

degrees relative to the reference direction, and the second polarizer (44) is arranged at an angle in the range of 75 to 105 degrees relative to the reference direction.

4. The liquid crystal display device as set forth in claim 1 or 2, wherein a retardation plate (27) arranged closest to the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) is arranged at an angle in the range of 75 to 105 degrees relative to a reference direction, a retardation plate (28) arranged remotest from the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) is arranged at an angle in the range of 135 to 165 degrees relative to the reference direction, and the first polarizer (29) is arranged at an angle in the range of 150 to 180 degrees relative to the reference direction,
and wherein a retardation plate (42) arranged closest to the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) is arranged at an angle in the range of -1 to 15 degrees relative to the reference direction, a retardation plate (43) arranged remotest from the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) is arranged at an angle in the range of 45 to 75 degrees relative to the reference direction, and the second polarizer (44) is arranged at an angle in the range of 60 to 90 degrees relative to the reference direction.

5. The liquid crystal display device as set forth in claim 1, wherein a retardation plate (27) arranged closest to the first transparent substrate (21) among the first to N-th 1st retardation plates (27, 28) has retardation in the range of 125 nm to 155 nm, a retardation plate (42) arranged remotest from the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) has retardation in the range of 250 nm to 300 nm, and a retardation plate (42) arranged closest to the second transparent substrate (41) among the first to N-th 2nd retardation plates (42, 43) has retardation in the range of 140 nm to 170 nm.

6. An electronic device including a liquid crystal display device defined in any one of claims 1 to 5.

Patentansprüche

1. Flüssigkristallanzeigevorrichtung mit:

(a) einem ersten Substrat (20),
(b) einem zweiten Substrat (40), das davon beabstandet ist und das dein ersten Substrat (20) gegenüber angeordnet ist, und
(c) einer Flüssigkristallschicht (50), die zwischen dem ersten und dem zweiten Substrat (20, 40) angeordnet ist und verdreht orientiert ist,

wobei das erste Substrat (20) aufweist:

(a1) ein erstes transparentes Substrat (21) mit einem ersten Bereich (A), durch den Licht durchgehen kann, und einem zweiten Bereich (B), in dem Licht reflektiert wird,
(a2) erste bis N-te erste Phasenverschiebungsplatten (27, 28), die auf dem ersten transparenten Substrat (21) auf der gegenüber liegenden Seite der Flüssigkristallschicht (50) angeordnet sind, wobei eine K-te erste Phasenverschiebungsplatte (27) näher an dem ersten transparenten Substrat (21) als eine (K+1)-te erste Phasenverschiebungsplatte (28) angeordnet ist und wobei N eine ganze Zahl größer als 1 und K eine ganze Zahl in dem Bereich von 1 bis N-1 ist, und
(a3) einen ersten Polarisator (29), der auf der N-ten ersten Phasenverschiebungsplatte (28) angeordnet ist, wobei das zweite Substrate (40) aufweist:
(b1) ein zweites transparentes Substrat (41),
(b2) erste bis N-te zweite Phasenverschiebungsplatten (42, 43), die auf dem zweiten transparenten Substrat (41) auf der gegenüber liegenden Seite der Flüssigkristallschicht (50) angeordnet sind, wobei eine K-te zweite Phasenverschiebungsplatte (42) näher an dem zweiten transparenten Substrat (41) als eine (K+1)-te zweite Phasenverschiebungsplatte (43) angeordnet ist und wobei N eine ganze Zahl größer als 1 und K eine ganze Zahl in dem Bereich von 1 bis N-1 ist, und
(b3) einen zweiten Polarisator (44), der auf der N-ten zweiten Phasenverschiebungsplatte (43) angeordnet ist, wobei eine K-te Phasenverschiebungsplatte unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) eine optische Achse aufweist, die mit einem ersten Winkel in Bezug auf eine Bezugsrichtung angeordnet ist, und wobei eine K-te Phasenverschiebungsplatte unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) eine optische Achse aufweist, die mit einem zweiten Winkel in Bezug auf die Bezugsrichtung angeordnet ist, und wobei sich der erste und der zweite Winkel voneinander um ungefähr 90 Grad unterscheiden, **dadurch gekennzeichnet, dass** eine Dikke der Flüssigkristallschicht (50) in dem ersten Bereich (A) kleiner als eine Dicke der Flüssigkristallschicht (50) in dem zweiten

Bereich (B) ist.

2. Flüssigkristallanzeigevorrichtung nach Anspruch 1, wobei eine Phasenverschiebungsplatte (27), die am nächsten zu dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, eine Phasenverschiebung in dem Bereich von 140 nm bis 160 nm aufweist, und eine Phasenverschiebungsplatte (41), die am weitesten entfernt von dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, eine Phasenverschiebung in dem Bereich von 250 nm bis 300 nm aufweist.

3. Flüssigkristallanzeigevorrichtung nach Anspruch 1 oder 2, wobei eine Phasenverschiebungsplatte (27), die am nächsten zu dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, mit einem Winkel in dem Bereich von 90 bis 120 Grad in Bezug auf eine Bezugsrichtung angeordnet ist, eine Phasenverschiebungsplatte (28), die am weitesten entfernt von dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, mit einem Winkel in dem Bereich von 150 bis 180 Grad in Bezug auf die Bezugsrichtung angeordnet ist, und der erste Polarizator (29) bei einem Winkel in dem Bereich von -15 bis 15 Grad in Bezug auf die Bezugsrichtung angeordnet ist,
und wobei eine Phasenverschiebungsplatte (42), die am nächsten zu dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, mit einem Winkel von 15 Grad in Bezug auf die Bezugsrichtung angeordnet ist, eine Phasenverschiebungsplatte (43), die am weitesten entfernt von dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, mit einem Winkel in dem Bereich von 60 bis 90 Grad in Bezug auf die Bezugsrichtung angeordnet ist, und der zweite Polarizator (44) bei einem Winkel in dem Bereich von 75 bis 1 OS Grad in Bezug auf die Bezugsrichtung angeordnet ist.

4. Flüssigkristallanzeigevorrichtung nach Anspruch 1 oder 2, wobei eine Phasenverschiebungsplatte (27), die am nächsten zu dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, mit einem Winkel in dem Bereich von 75 bis 105 Grad in Bezug auf eine Bezugsrichtung angeordnet ist, eine Phasenverschiebungsplatte (28), die am weitesten entfernt von dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, mit einem Winkel in dem Bereich von 135 bis 165 Grad in Bezug auf die Bezugsrichtung angeordnet ist, und der erste Polarizator (29) bei einem Winkel in dem Bereich von 150 bis 180 Grad in Bezug auf die Bezugsrichtung angeordnet ist,
und wobei eine Phasenverschiebungsplatte (42), die am nächsten zu dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, mit einem Winkel in dem Bereich von -15 bis 15 Grad in Bezug auf die Bezugsrichtung angeordnet ist, eine Phasenverschiebungsplatte (43), die am weitesten entfernt von dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, mit einem Winkel in dem Bereich von 45 bis 75 Grad in Bezug auf die Bezugsrichtung angeordnet ist, und der zweite Polarizator (44) bei einem Winkel in dem Bereich von 60 bis 90 Grad in Bezug auf die Bezugsrichtung angeordnet ist.

5. Flüssigkristallanzeigevorrichtung nach Anspruch 1, wobei eine Phasenverschiebungsplatte (27), die am nächsten zu dem ersten transparenten Substrat (21) unter den ersten bis N-ten ersten Phasenverschiebungsplatten (27, 28) angeordnet ist, eine Phasenverschiebung in dem Bereich von 125 nm bis 155 nm aufweist, eine Phasenverschiebungsplatte (43), die am weitesten entfernt von dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, eine Phasenverschiebung in dem Bereich von 250 nm bis 300 nm aufweist, und eine Phasenverschiebungsplatte (42), die am nächsten zu dem zweiten transparenten Substrat (41) unter den ersten bis N-ten zweiten Phasenverschiebungsplatten (42, 43) angeordnet ist, eine Phasenverschiebung in dem Bereich von 140 nm bis 170 nm aufweist.

6. Elektronische Vorrichtung mit einer Flüssigkristallanzeigevorrichtung nach einem der Ansprüche 1 bis 5.

Revendications

1. Dispositif d'affichage à cristaux liquides comprenant :

(a) un premier substrat (20);
(b) un second substrat (40) espacé du premier substrat (20) et lui faisant face ; et
(c) une couche de cristaux liquides (50) prise en sandwich entre les premier et second substrats (20, 40) et orientée par torsion,
le premier substrat (20) étant constitué :

(a1) d'un premier substrat transparent (21) ayant une première zone (A) à travers laquelle la lumière est autorisée à passer et une seconde zone (B) dans laquelle la lumière est réfléchie ;

(a2) d'une première à une $N^{ième}$ premières lames à retard (27, 28) agencées sur le premier substrat transparent (21) au niveau du côté opposé de la couche de cristaux liquides (50) dans lequel une $K^{ième}$ première lame à retard (27) est plus proche du premier substrat transparent (21) qu'une $(K + 1)^{ième}$ première lame à retard (28), et dans lequel N est un entier relatif supérieur à 1 et K est un entier relatif compris dans la plage allant de 1 à N - 1 ; et

(a3) d'un premier polariseur (29) agencé sur la $N^{ième}$ première lame à retard (28), le second substrat (40) étant constitué :

(b1) d'un second substrat transparent (41) ;

(b2) d'une première à une $N^{ième}$ secondes lames à retard (42, 43) agencées sur le second substrat transparent (41) au niveau du côté opposé de la couche de cristaux liquides (50) dans lequel une $K^{ième}$ seconde lame à retard (42) est plus proche du second substrat transparent (41) qu'une $(K + 1)^{ième}$ seconde lame à retard (43), et dans lequel N est un entier relatif supérieur à 1 et K est un entier relatif compris dans la plage allant de 1 à N - 1 ; et

(b3) d'un second polariseur (44) agencé sur la $N^{ième}$ seconde lame à retard (43), dans lequel une $K^{ième}$ lame à retard parmi la première à la $N^{ième}$ premières lames à retard (27, 28) dispose d'un axe optique agencé suivant un premier angle par rapport à une direction de référence et une $K^{ième}$ lame à retard parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) dispose d'un axe optique agencé suivant un second angle par rapport à la direction de référence, et dans lequel les premier et second angles sont différents l'un de l'autre d'environ 90 degrés, **caractérisé en ce qu'**une épaisseur de la couche de cristaux liquides (50) dans la première zone (A) est inférieure à une épaisseur de la couche de cristaux liquides (50) dans la seconde zone (B).

2. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel une lame à retard (27) agencée le plus prêt du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) a un retard compris dans la plage allant de 140 nm à 160 nm, et une lame à retard (43) agencée le plus loin du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) a un retard compris dans la plage allant de 250 nm à 300 nm.

3. Dispositif d'affichage à cristaux liquides selon la revendication 1 ou 2, dans lequel une lame à retard (27) agencée le plus prêt du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) est agencée suivant un angle compris dans la plage allant de 90 à 120 degrés par rapport à une direction de référence, une lame à retard (28) agencée le plus loin du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) est agencée suivant un angle compris dans la plage allant de 150 à 180 degrés par rapport à la direction de référence, et le premier polariseur (29) est agencé suivant un angle compris dans la plage allant de -15 à 15 degrés par rapport à la direction de référence,
et dans lequel une lame à retard (42) agencée le plus prêt du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) est agencée suivant un angle de 15 degrés par rapport à la direction de référence, une lame à retard (43) agencée le plus loin du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) est agencée suivant un angle compris dans la plage allant de 60 à 90 degrés par rapport à la direction de référence, et le second polariseur (44) est agencé suivant un angle compris dans la plage allant de 75 à 105 degrés par rapport à la direction de référence.

4. Dispositif d'affichage à cristaux liquides selon la revendication 1 ou 2, dans lequel une lame à retard (27) agencée le plus prêt du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) est agencée suivant un angle compris dans la plage allant de 75 à 105 degrés par rapport à une direction de référence, une lame à retard (28) agencée le plus loin du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) est agencée suivant un angle compris dans la plage allant de 135 à 165 degrés par rapport à la direction de référence, et le premier polariseur (29) est agencé suivant un angle compris dans la plage allant de 150 à 180 degrés par rapport à la direction de référence,
et dans lequel une lame à retard (42) agencée le plus prêt du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) est agencée suivant un angle compris dans la plage allant de -15 à 15 degrés par rapport à la direction de référence, une lame à retard (43) agencée le plus loin du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) est agencée suivant un angle compris dans la plage allant de 45 à 75 degrés par rapport à la direction de référence, et le second polariseur (44) est agencé suivant un angle compris dans la plage allant

de 60 à 90 degrés par rapport à la direction de référence.

5. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel une lame à retard (27) agencée le plus prêt du premier substrat transparent (21) parmi la première à la $N^{ième}$ premières lames à retard (27, 28) a un retard compris dans la plage allant de 125 nm à 155 nm, une lame à retard (42) agencée le plus loin du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) a un retard compris dans la plage allant de 250 nm à 300 nm, et une lame à retard (42) agencée le plus prêt du second substrat transparent (41) parmi la première à la $N^{ième}$ secondes lames à retard (42, 43) a un retard compris dans la plage allant de 140 nm à 170 nm.

6. Dispositif électronique comprenant un dispositif d'affichage à cristaux liquides selon l'une quelconque des revendications 1 à 5.

FIG.1
PRIOR ART

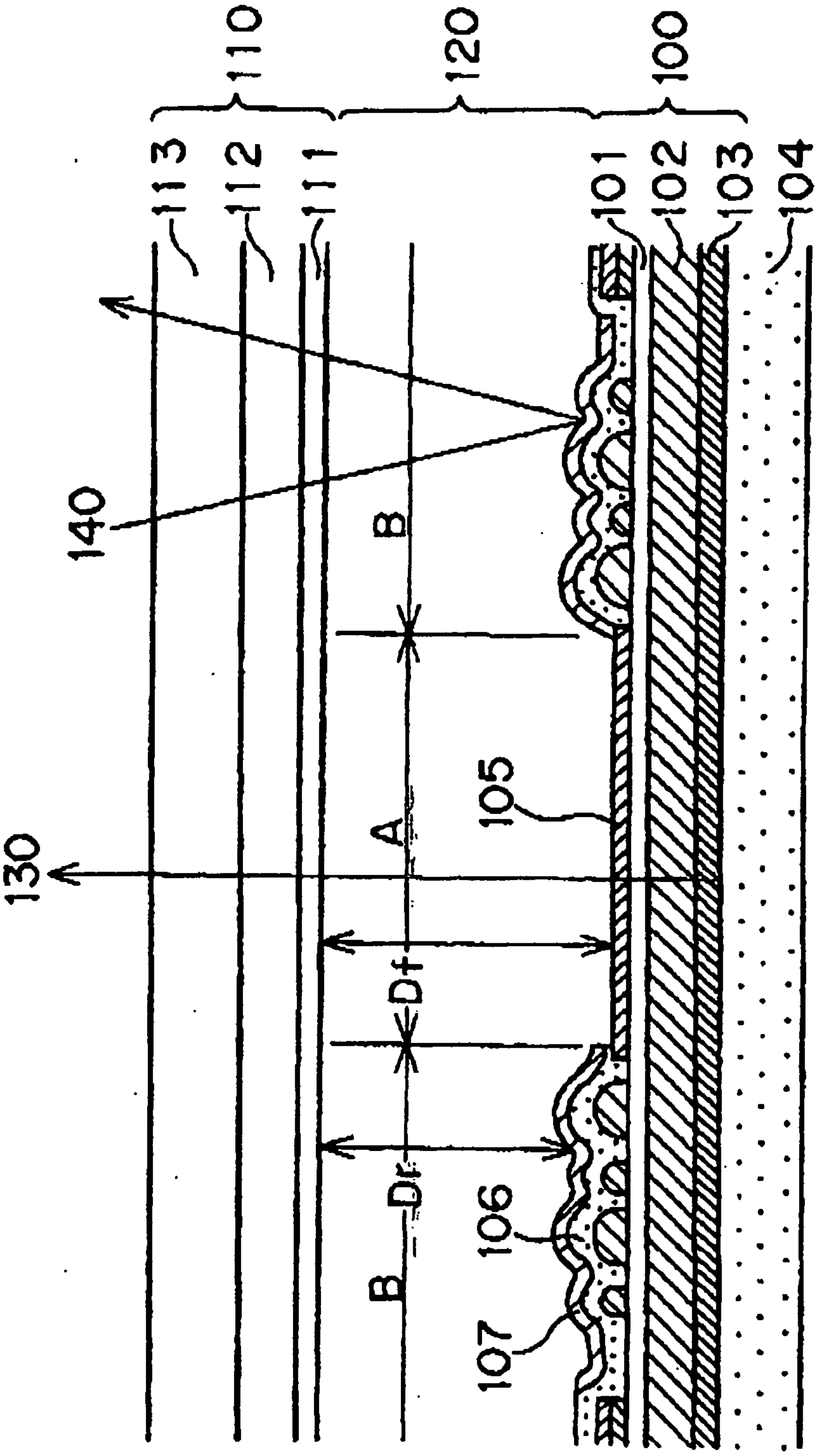


FIG.2

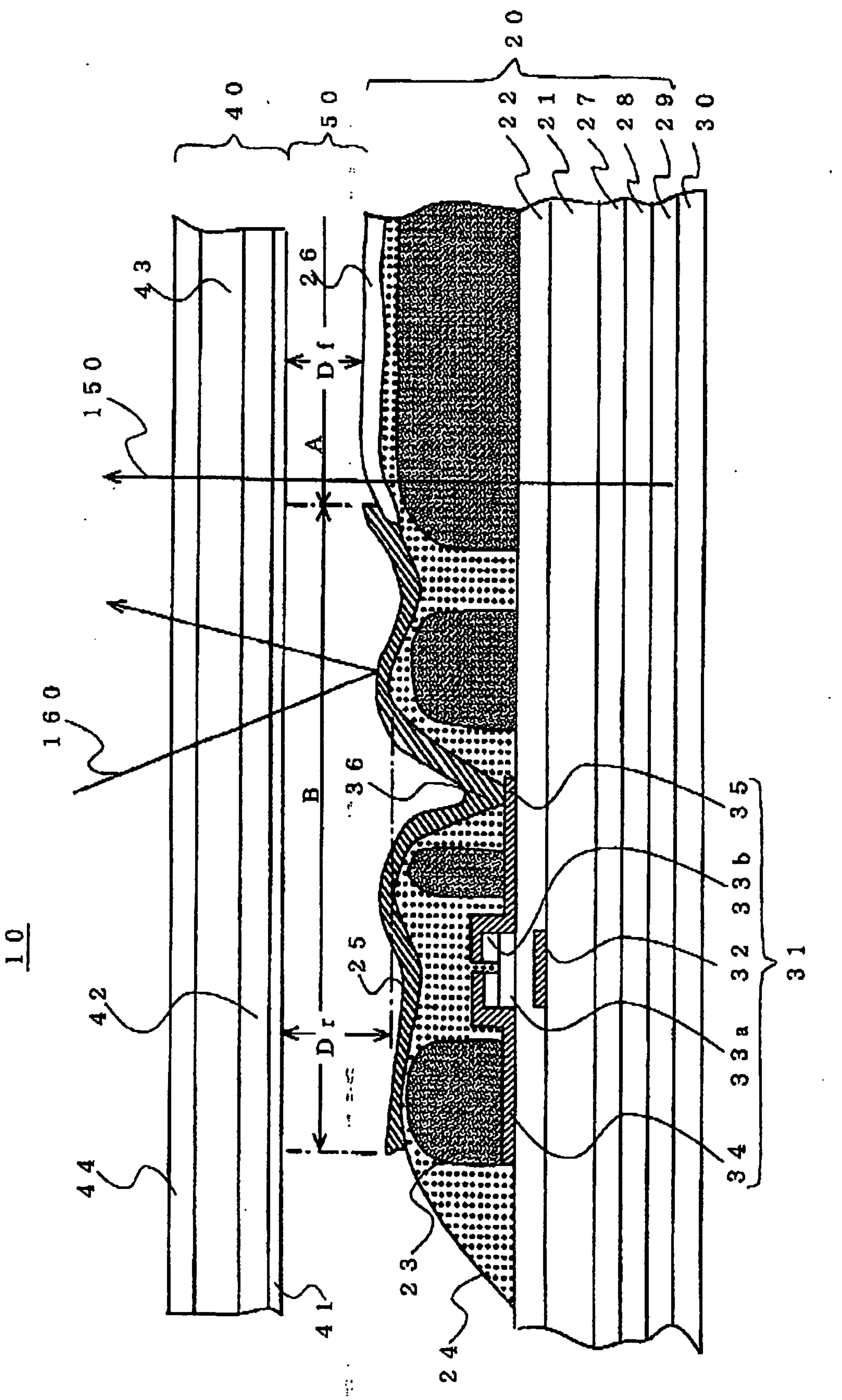

10
20
40
50
21
22
23
24
25
26
27
28
29
30
31
32
33a
33b
34
35
36
41
42
43
44
150
160
A
B
Df
Dr

FIG.3

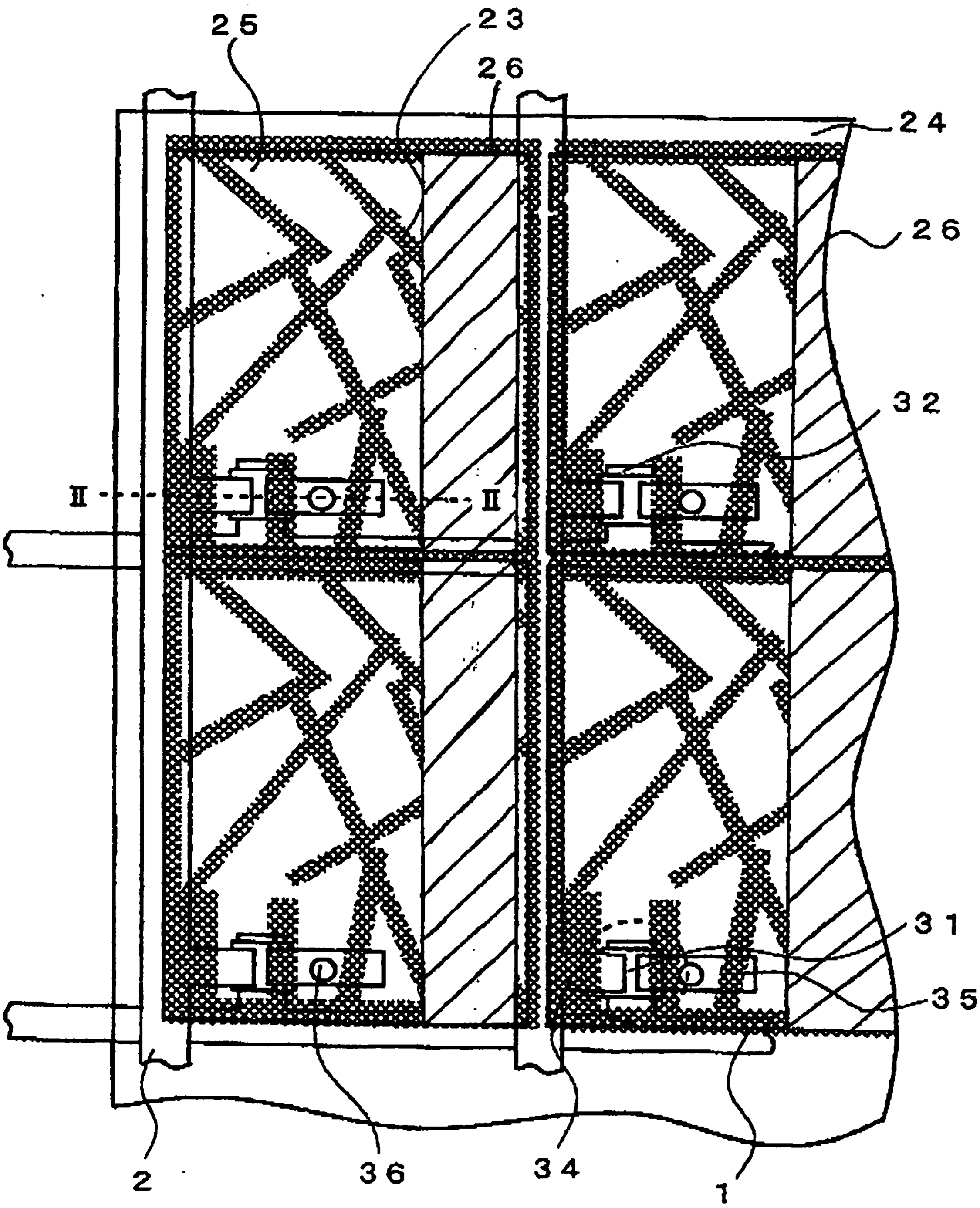


FIG.4A

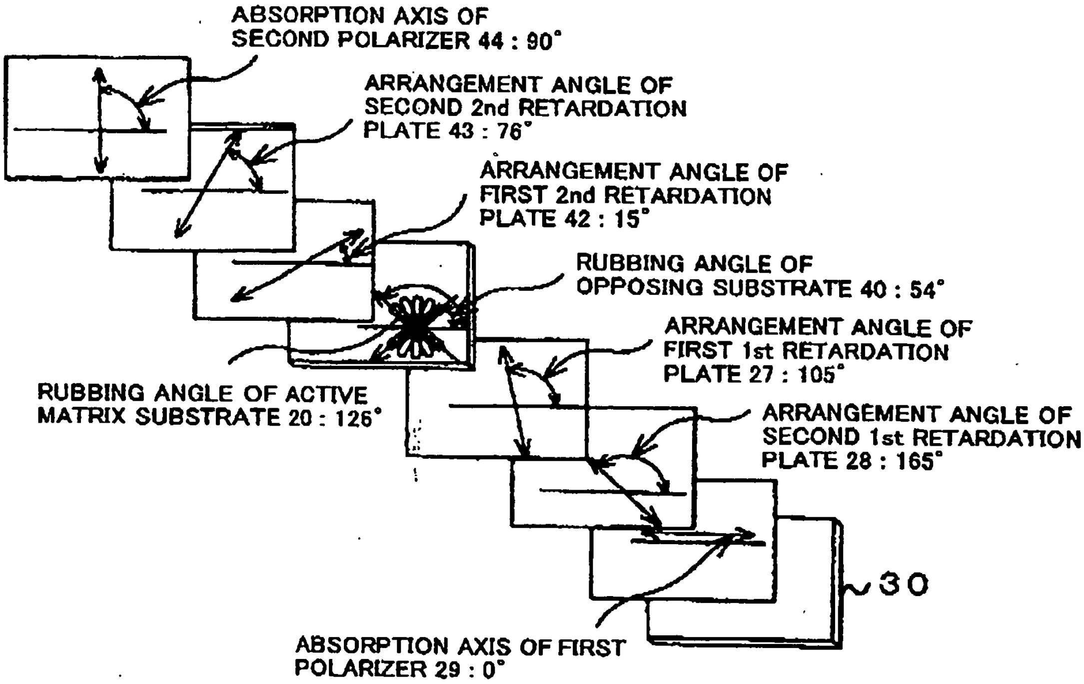

ABSORPTION AXIS OF SECOND POLARIZER 44 : 90°
ARRANGEMENT ANGLE OF SECOND 2nd RETARDATION PLATE 43 : 76°
ARRANGEMENT ANGLE OF FIRST 2nd RETARDATION PLATE 42 : 15°
RUBBING ANGLE OF OPPOSING SUBSTRATE 40 : 54°
ARRANGEMENT ANGLE OF FIRST 1st RETARDATION PLATE 27 : 105°
RUBBING ANGLE OF ACTIVE MATRIX SUBSTRATE 20 : 126°
ARRANGEMENT ANGLE OF SECOND 1st RETARDATION PLATE 28 : 165°
30
ABSORPTION AXIS OF FIRST POLARIZER 29 : 0°

FIG.4B

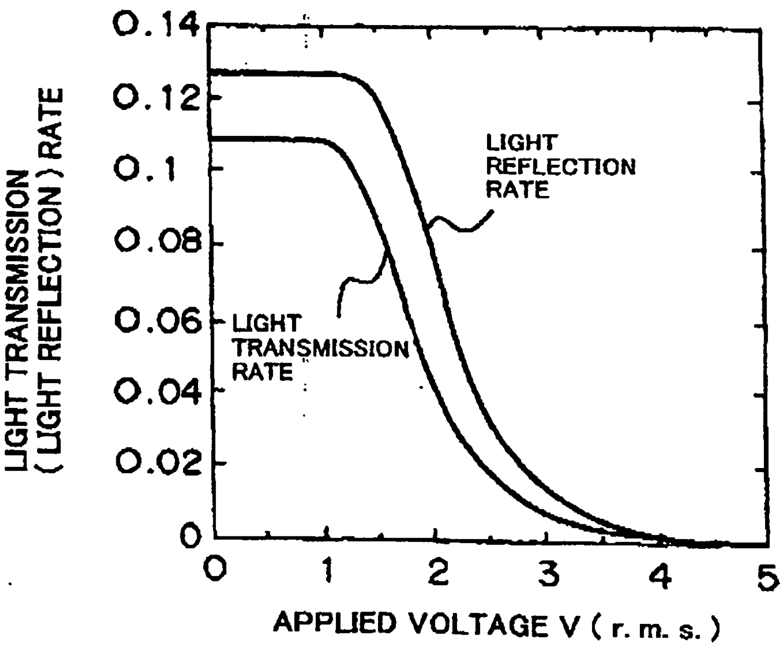

LIGHT TRANSMISSION (LIGHT REFLECTION) RATE
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
LIGHT REFLECTION RATE
LIGHT TRANSMISSION RATE
0
1
2
3
4
5
APPLIED VOLTAGE V (r. m. s.)

FIG.5A

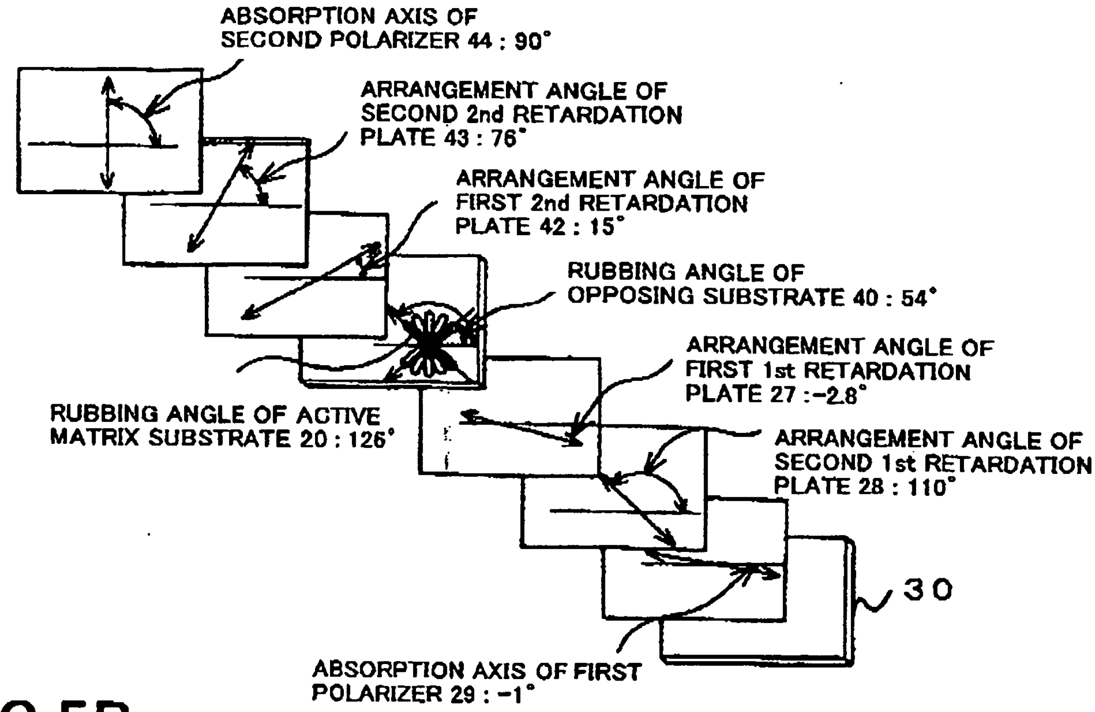

ABSORPTION AXIS OF
SECOND POLARIZER 44 : 90°
ARRANGEMENT ANGLE OF
SECOND 2nd RETARDATION
PLATE 43 : 76°
ARRANGEMENT ANGLE OF
FIRST 2nd RETARDATION
PLATE 42 : 15°
RUBBING ANGLE OF
OPPOSING SUBSTRATE 40 : 54°
ARRANGEMENT ANGLE OF
FIRST 1st RETARDATION
PLATE 27 :-2.8°
RUBBING ANGLE OF ACTIVE
MATRIX SUBSTRATE 20 : 126°
ARRANGEMENT ANGLE OF
SECOND 1st RETARDATION
PLATE 28 : 110°
30
ABSORPTION AXIS OF FIRST
POLARIZER 29 : -1°

FIG.5B

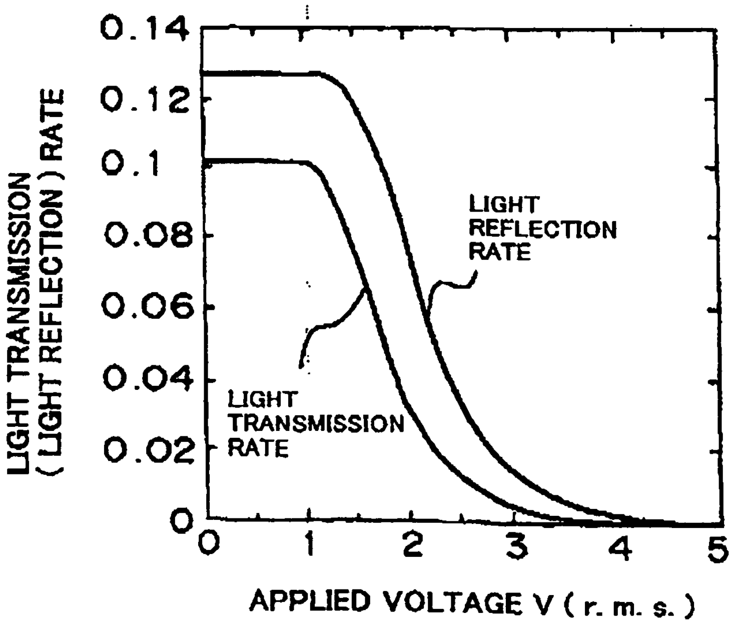

0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
LIGHT TRANSMISSION
(LIGHT REFLECTION) RATE
LIGHT
REFLECTION
RATE
LIGHT
TRANSMISSION
RATE
0
1
2
3
4
5
APPLIED VOLTAGE V (r. m. s.)

FIG.6A

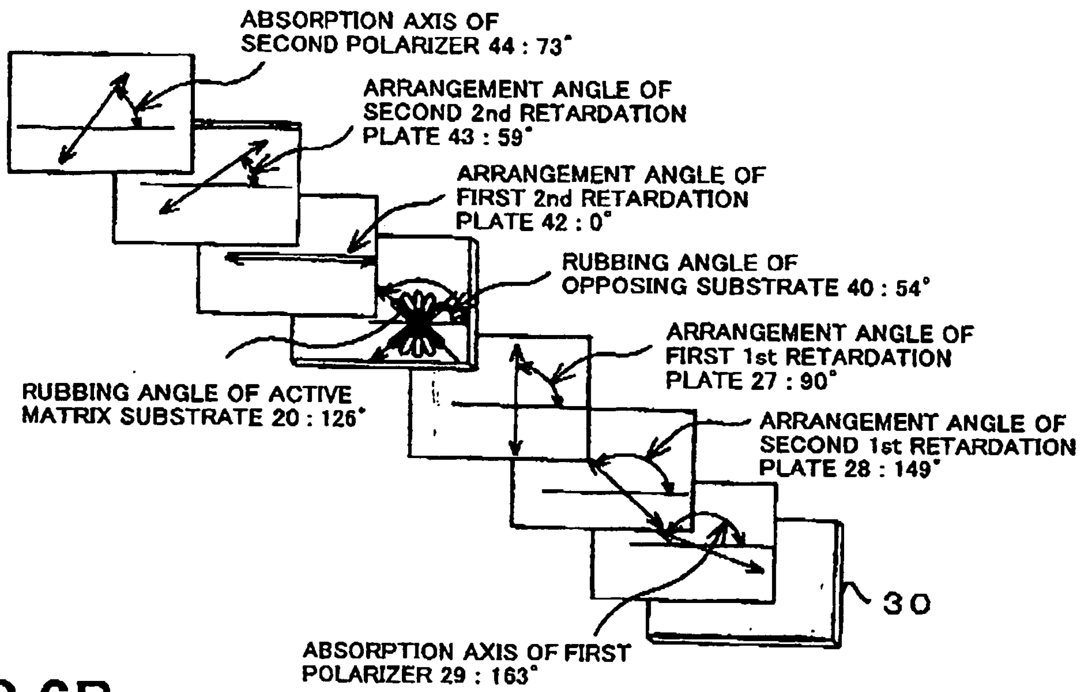

ABSORPTION AXIS OF SECOND POLARIZER 44 : 73°
ARRANGEMENT ANGLE OF SECOND 2nd RETARDATION PLATE 43 : 59°
ARRANGEMENT ANGLE OF FIRST 2nd RETARDATION PLATE 42 : 0°
RUBBING ANGLE OF OPPOSING SUBSTRATE 40 : 54°
ARRANGEMENT ANGLE OF FIRST 1st RETARDATION PLATE 27 : 90°
RUBBING ANGLE OF ACTIVE MATRIX SUBSTRATE 20 : 126°
ARRANGEMENT ANGLE OF SECOND 1st RETARDATION PLATE 28 : 149°
30
ABSORPTION AXIS OF FIRST POLARIZER 29 : 163°

FIG.6B

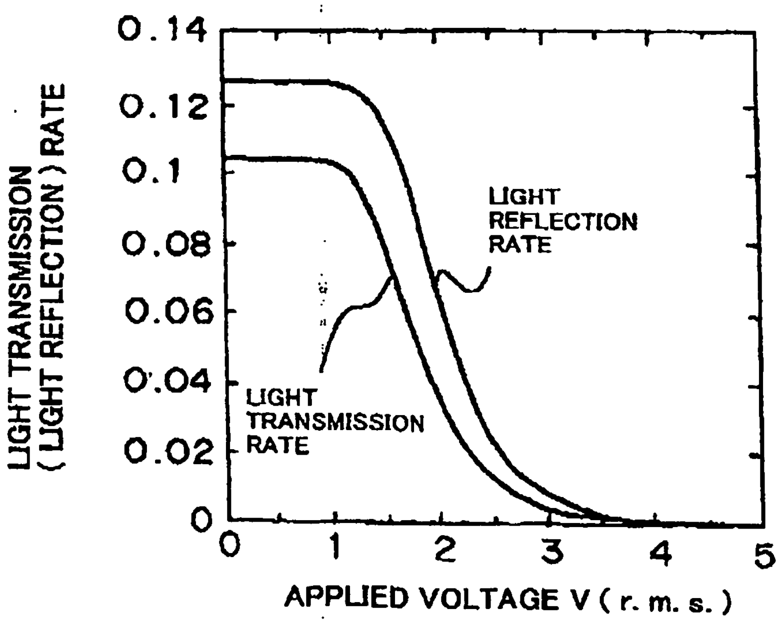
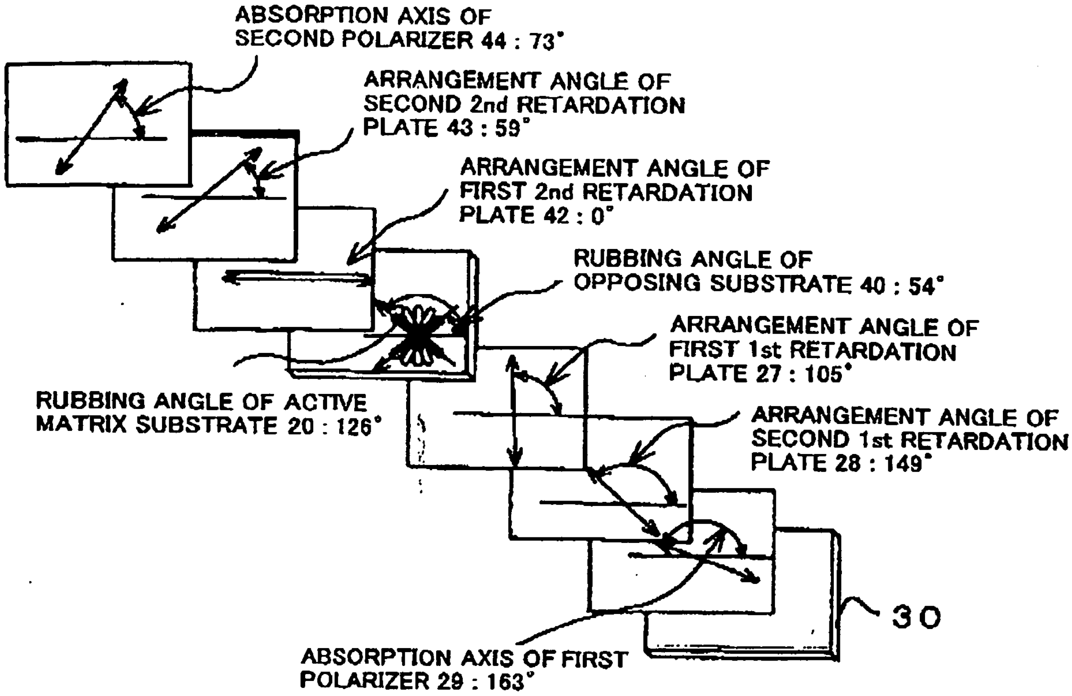
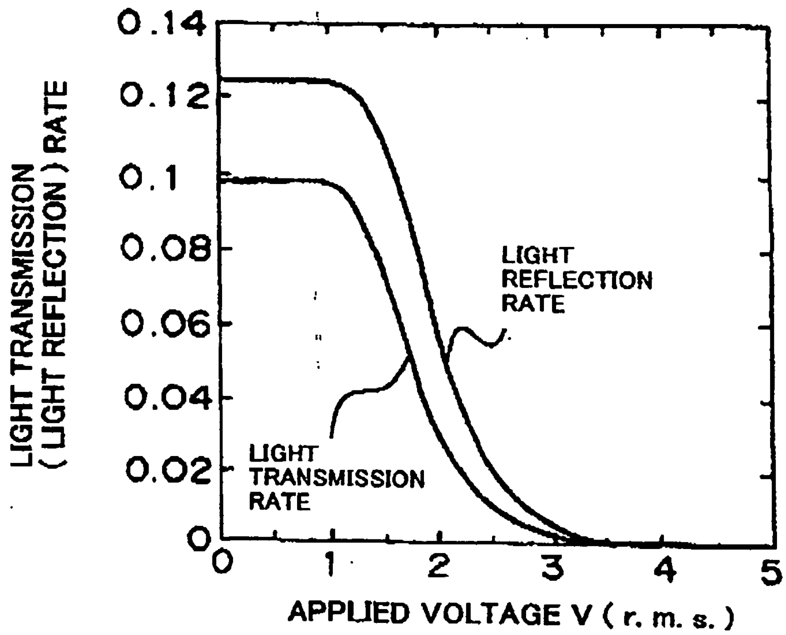

LIGHT TRANSMISSION (LIGHT REFLECTION) RATE
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
LIGHT REFLECTION RATE
LIGHT TRANSMISSION RATE
0
1
2
3
4
5
APPLIED VOLTAGE V (r. m. s.)

FIG.7A



ABSORPTION AXIS OF SECOND POLARIZER 44 : 73°
ARRANGEMENT ANGLE OF SECOND 2nd RETARDATION PLATE 43 : 59°
ARRANGEMENT ANGLE OF FIRST 2nd RETARDATION PLATE 42 : 0°
RUBBING ANGLE OF OPPOSING SUBSTRATE 40 : 54°
ARRANGEMENT ANGLE OF FIRST 1st RETARDATION PLATE 27 : 105°
RUBBING ANGLE OF ACTIVE MATRIX SUBSTRATE 20 : 126°
ARRANGEMENT ANGLE OF SECOND 1st RETARDATION PLATE 28 : 149°
30
ABSORPTION AXIS OF FIRST POLARIZER 29 : 163°

FIG.7B



LIGHT TRANSMISSION (LIGHT REFLECTION) RATE
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
LIGHT REFLECTION RATE
LIGHT TRANSMISSION RATE
0
1
2
3
4
5
APPLIED VOLTAGE V (r. m. s.)

FIG.8A

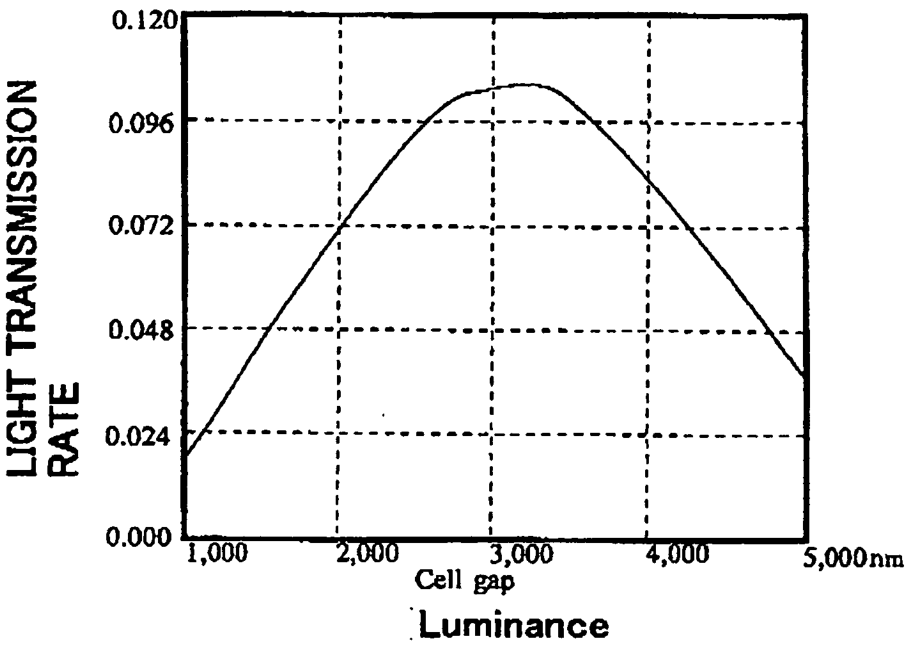

LIGHT TRANSMISSION RATE
0.120
0.096
0.072
0.048
0.024
0.000
1,000
2,000
3,000
4,000
5,000nm
Cell gap
Luminance

FIG.8B

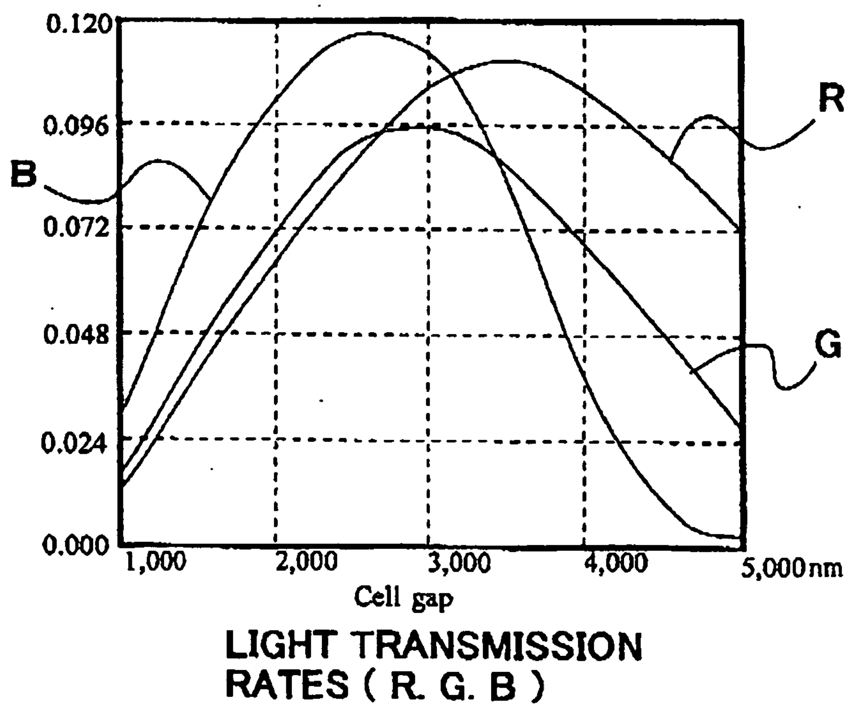

0.120
0.096
0.072
0.048
0.024
0.000
B
R
G
1,000
2,000
3,000
4,000
5,000nm
Cell gap
LIGHT TRANSMISSION RATES (R. G. B)

FIG. 9

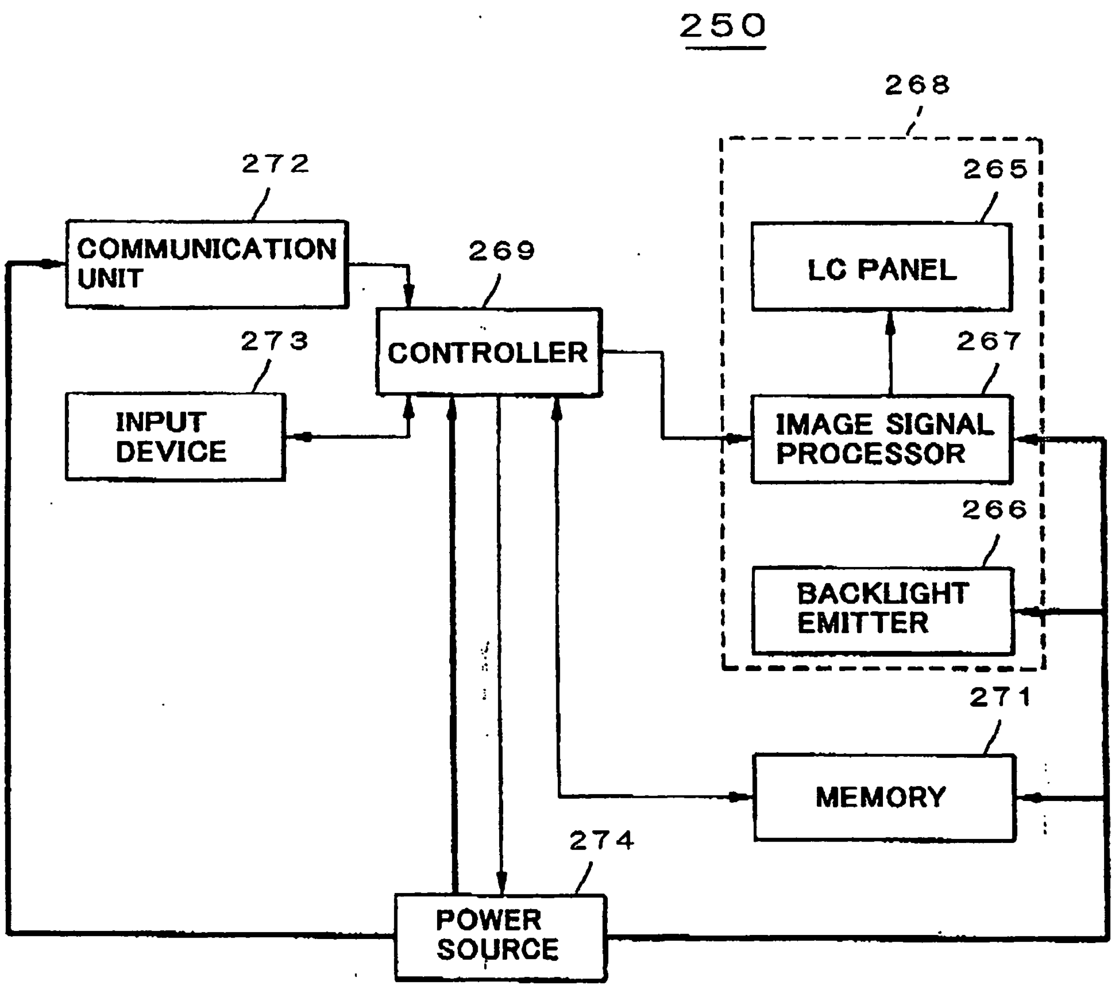
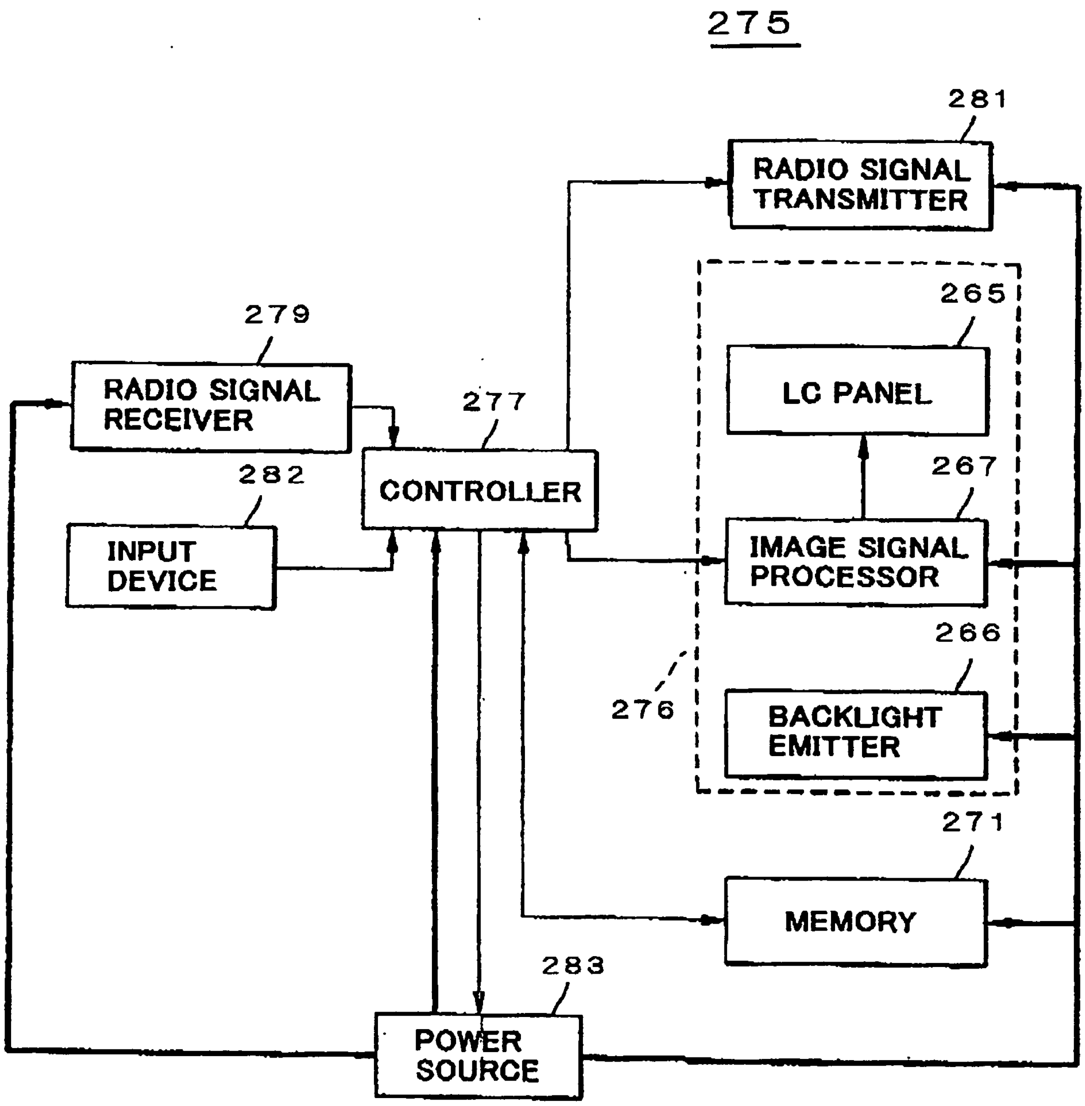

250
268
265
272
COMMUNICATION UNIT
269
LC PANEL
273
CONTROLLER
267
INPUT DEVICE
IMAGE SIGNAL PROCESSOR
266
BACKLIGHT EMITTER
271
MEMORY
274
POWER SOURCE

FIG.10


275
281
RADIO SIGNAL TRANSMITTER
265
LC PANEL
267
IMAGE SIGNAL PROCESSOR
266
BACKLIGHT EMITTER
276
271
MEMORY
279
RADIO SIGNAL RECEIVER
277
CONTROLLER
282
INPUT DEVICE
283
POWER SOURCE

专利名称(译)	液晶显示装置		
公开(公告)号	[EP1255154B1](EP1255154B1)	公开(公告)日	2007-04-11
申请号	EP2002009485	申请日	2002-04-25
申请(专利权)人(译)	NEC公司		
当前申请(专利权)人(译)	NEC液晶技术有限公司. NEC公司		
[标]发明人	IKENO HIDENORI SAKAMOTO MICHIAKI WATANABE TAKAHIKO SUZUKI TERUAKI		
发明人	IKENO, HIDENORI SAKAMOTO, MICHIAKI WATANABE, TAKAHIKO SUZUKI, TERUAKI		
IPC分类号	G02F1/1335 G02F1/13363 G02B5/30 G02F1/1333		
CPC分类号	G02F1/133555 G02F1/133371 G02F1/133553 G02F1/13363 G02F2001/133638 G02F2001/1398 G02F2202/40 G02F2413/04 G02F2413/08		
优先权	2001132744 2001-04-27 JP		
其他公开文献	EP1255154A3 EP1255154A2		
外部链接	Espacenet		

摘要(译)

一种液晶显示装置，包括第一基板（20），第二基板（40）和夹在第一和第二基板（20,40）之间的液晶层（50）。第一基板（20）包括布置在第一透明基板（21）上的第一至第N第一延迟板（27,28），第二基板（40）包括第一至第N第二延迟板（42,43）。 ）布置在第二透明基板（41）上。假设第一至第N延迟板（27,28）中的延迟板具有相对于参考方向以第一角度布置的光轴和第一至第N第二延迟板（42）中的延迟板。对应于第一至第N延迟板（27,28）中的延迟板，具有相对于参考方向以第二角度布置的光轴，第一角度和第二角度彼此不同大约90度。

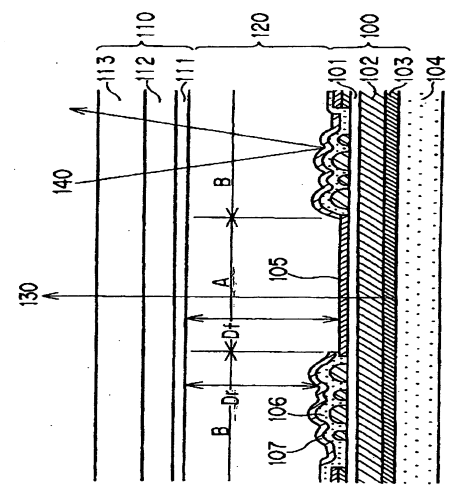


FIG.1
PRIOR ART