EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: 04.06.2003 Bulletin 2003/23

(21) Application number: 98306230.8

(22) Date of filing: 05.08.1998

(54) Liquid crystal display device and electronic device using same
Flüssigkristallanzeigevorrichtung und diese verwendendes elektronisches Gerät
Dispositif d'affichage à cristal liquide et appareil électronique l'utilisant

(84) Designated Contracting States: DE GB

(30) Priority: 07.08.1997 JP 22443297

(43) Date of publication of application: 10.02.1999 Bulletin 1999/06

(73) Proprietor: Seiko Epson Corporation
Shinjuku-ku, Tokyo 163-0811 (JP)

(72) Inventor: Iijima, Chiyoaki
Suwa-shi, Nagano-ken 392-8502 (JP)

(74) Representative: Sturt, Clifford Mark et al
Miller Sturt Kenyon
9 John Street
London WC1N 2ES (GB)

(56) References cited:
EP-A- 0 576 303
WO-A-95/17692
WO-A-97/01789


Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

[0001] The present invention relates to a liquid crystal display device, particularly one provided with a retardation film for eliminating colouring caused on the liquid crystal display panel, and an electronic device such as a watch or a portable telephone using such a liquid crystal display device.

[0002] There is conventionally known a liquid crystal display device provided with a liquid crystal display panel such as an STN (Super-Twisted Nematic) liquid crystal, in which a retardation film such as a uniaxially drawn film is arranged on one side of the liquid crystal display panel (for example, see Japanese Examined Patent Publication No. 3-50249 previously proposed by the present inventors).

[0003] Fig. 9 is a descriptive view of a schematic configuration illustrating an example of the conventional liquid crystal display device provided with the retardation film as described above. In Fig. 9, 1 is an upper polariser; 2 is a retardation film; 3 is a liquid crystal display panel; 4 is a lower polariser; and 5 is a reflector. The liquid crystal display panel 3 has a pair of upper and lower substrate 31 and 32 holding a liquid crystal layer 33 in between.

[0004] As the above-mentioned retardation film, uniaxially drawn polymer film such as a polycarbonate film is used. Colouring produced on the liquid crystal display panel is eliminated by appropriately selecting a material and a thickness of the retardation film in response to the product of multiplication $\Delta n \cdot d$ of the anisotropy of refractive index $\Delta n$ of the liquid crystal display panel and the thickness d of the liquid crystal layer and other parameters. While Fig. 9 illustrates a reflective liquid crystal display device, a backlight is installed in place of the reflector 5 in a transmissive liquid crystal display device.

[0005] However, use of a retardation film as described above did not always ensure sufficient elimination of colouring caused by the liquid crystal display panel, and particularly, it was difficult to eliminate colouring in both ON-state and OFF-state.

[0006] The results of extensive studies on these problems revealed that colouring was further accelerated by the reflector. More specifically, as shown in Fig. 10 illustrating spectroscopic properties of an aluminium reflector commonly in use in conventional liquid crystal display devices, reflectivity is higher in the high-wavelength region than in the low-wavelength region of the visible light region, and this is accelerating colouring.

[0007] The present invention was developed in view of these problems and has an object to provide a liquid crystal display device using a retardation film as described above, which satisfactorily and certainly eliminates colouring in ON-state as well as in OFF-state and gives a good contrast, and an electronic device using the same.

[0008] To achieve the above-mentioned object, the present invention provides the following liquid crystal display device and electronic device.

[0009] More particularly, the invention provides a liquid crystal display device comprising: a liquid crystal display panel having a liquid crystal layer; a polarised light separator, arranged at least on one side of the liquid crystal display panel, having a ratio $R_{450}/R_{650}$ of the reflectivity at a wavelength of 450 nm to the reflectivity $R_{650}$ at a wavelength of 650 nm of at least 1; wherein the liquid crystal display device has a retardation film for eliminating colouring occurring in the liquid crystal display panel; and the ratio of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film is at least 1.02.

[0010] The ratio $R_{450}/R_{650}$ should be at least 1.0, and at the same time, should preferably be up to 3. It is possible to achieve a ratio $R_{450}/R_{650}$ of at least 1 by using a polarised light separator which has a first layer having birefringence and a second layer not having birefringence, and in which the refractive index on one side of the first layer is substantially equal to refractive index of the second layer. A liquid crystal display panel having a nematic liquid crystal layer twist-aligned by an angle within a range of from 180 to 360° may be used. As a retardation film, a polymer film such as a uniaxially drawn film may be employed. A reflector may be provided on a side of the liquid crystal display panel opposite to the polarised light separator.

[0011] The invention provides also an electronic device having a liquid crystal display device as the display section thereof, the liquid crystal display device comprising: a liquid crystal display panel having a liquid crystal layer; a polarised light separator, arranged at least on one side of the liquid crystal display panel, having a ratio $R_{450}/R_{650}$ of the reflectivity at a wavelength of 450 nm to the reflectivity $R_{650}$ at a wavelength of 650 nm of at least 1; wherein the liquid crystal display device has a retardation film for eliminating colouring occurring in the liquid crystal display panel; and the ratio of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film is at least 1.02.

[0012] In the liquid crystal display device provided with the retardation film as described above, a display of a good contrast is available by achieving a ratio $R_{LC}/R_{RF}$ of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film of at least 1.02. At the same time, colouring as described above can be satisfactorily eliminated by providing a first layer having birefringence and a second layer not having birefringence, and achieving a ratio $R_{450}/R_{650}$ of the reflectivity $R_{450}$ at a wavelength of 450 nm to the reflectivity $R_{650}$ at a wavelength of 650 nm of at least 1.

[0013] Embodiments of the present invention will now be described by way of further example with reference to the
The wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the retardation $R$ in the retardation film 2 should be at least 1.04, and it is possible to further improve contrast.

1.02. The wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the retardation $R$ in the retardation film 2. More preferably, the above-mentioned ratio $B_{LC}/B_{RF}$ of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 2 should be at least 1.02 of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 2.

A display of a good contrast is available by achieving a ratio $B_{LC}/B_{RF}$ of at least 1.02 of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 3 to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 2. More preferably, the above-mentioned ratio $B_{LC}/B_{RF}$ should be at least 1.04, and it is possible to further improve contrast.

As the above-mentioned diffusing plate 6, for example, a milk-white acrylic plate may be used. In place of the above-mentioned diffusing plate 6, there may be provided a diffusing layer incorporating a diffusing agent kneaded in an adhesive, and this diffusing layer may have a function of bond between the liquid crystal display panel and the polarised light separator, in addition to the diffusion effect. Under the effect of the diffusing plate 6 or the diffusing layer, it is possible to achieve this diffusing layer may have a function of bond between the liquid crystal display panel and the polarised light separator, and in addition to the diffusion effect. Under the effect of the diffusing plate 6 or the diffusing layer, it is possible to achieve a white display, not a mirror-like display. However, the diffusing plate 6 may as required be omitted.

A conventionally known polariser can be used as the above-mentioned upper polariser 1. The retardation film 2 serves as an optical anisotrope for colour compensation for eliminating colouring occurring on the liquid crystal display panel 3, and applicable materials for this purpose include uniaxial drawn films of PC (polycarbonate), PVA (polyvinyl alcohol), PA (polyarylate) and PSF (polysulfon). For all these films a to d, a longer wavelength corresponds to a smaller retardation $R$.

Fig. 2 illustrates ratios of retardation $R$ ($\Delta n$-$d$) for the individual wavelengths to retardation $R_{650}$ ($\Delta n$-$d_{650}$) at a wavelength 650 nm when using the above-listed films as the retardation films. In Fig. 2, a is PSF, b is PA, c is PC, and d is PVA. For all these films a to d, a longer wavelength corresponds to a smaller retardation $R$. As the liquid crystal display panel 3, any of TN-type and STN-type ones is appropriately applicable. Among others, an STN-type one, particularly an STN-type nematic liquid crystal having liquid crystal molecules twist-aligned by an angle within a range of from 180 to 360° can suitably be used.

In the present embodiment, an STN-type liquid crystal is employed.

Fig. 3 illustrates values of anisotropy of refractive index $\Delta n$ for the individual wavelengths of a plurality of kinds of liquid crystals A to H popularly used for liquid crystal display devices of this type; and Fig. 4 is a graph illustrating the ratio of anisotropy of refractive index $\Delta n$ to the wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 2 should be at least 1.02. The wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer means the ratio $\Delta n_{450}/\Delta n_{650}$ of the anisotropy of refractive index $\Delta n_{450}$ at a wavelength of 450 nm in the liquid crystal to the anisotropy of refractive index $\Delta n_{650}$ at a wavelength of 650 nm. The wavelength dispersion $B_{RF}$ means the ratio $R_{450}/R_{650}$ of the retardation $R_{450}$ ($\Delta n$-$d_{450}$) at a wavelength of 450 nm in the retardation film 2 to the retardation $R_{650}$ ($\Delta n$-$d_{650}$) at a wavelength of 650 nm.

A display of a good contrast is available by achieving a ratio $B_{LC}/B_{RF}$ of at least 1.02 of the wavelength dispersion $B_{LC}$ of anisotropy of refractive index $\Delta n$ in the liquid crystal layer to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 3 to the wavelength dispersion $B_{RF}$ of retardation in the retardation film 2. More preferably, the above-mentioned ratio $B_{LC}/B_{RF}$ should be at least 1.04, and it is possible to further improve contrast.

As the above-mentioned diffusing plate 6, for example, a milk-white acrylic plate may be used. In place of the diffusing plate 6, there may be provided a diffusing layer incorporating a diffusing agent kneaded in an adhesive, and this diffusing layer may have a function of bond between the liquid crystal display panel and the polarised light separator, in addition to the diffusion effect. Under the effect of the diffusing plate 6 or the diffusing layer, it is possible to achieve a white display, not a mirror-like display. However, the diffusing plate 6 may as required be omitted.

The above-mentioned polarised light separator 7 comprises a sequential lamination of a desired number of
first films 71 having birefringence and of second films 72 having birefringence, as shown in Fig. 5. Materials for the first and the second films may be appropriately selected, but the both films should have light transmissivity, and refractive index of the second film not having birefringence should substantially be equal to refractive index of any of the first films having birefringence.

[0024] The first film 71 comprises, for example, polyethylene naphthalate (PEN) drawn to desired magnifications. As the second film 72, copolyester of naphthalene dicarboxylic acid and terephthalic or isothalic acid (coPEN) may be used. The polarization in the drawing direction of the first film 71 has a refractive index nAX of 1.88, and the polarization in a direction at right angles to the drawing direction has a refractive index nAY of 1.64. The second film 72 has a refractive index nB of 1.64.

[0025] In the polarised light separator 7 formed by laminating the first films 71 having birefringence and the second films 72 not having birefringence, as described above, for example, when a light enters the separator 7 from above, a light L1 in a direction at right angles to the drawing direction passes through the polarised light separator 7 because there is no interface of refractive index between the first and the second films 71 and 72. Of a light L2 in a direction parallel with the drawing direction, only a prescribed wavelength is selectively reflected at the interface between the first and the second films, and the rest of the light L2 passes through the same. The wavelength λ of the reflected light L2 depends upon the refractive index values nAX and nB (where nB = nAY) of the first and the second films 71 and 72 and the thickness values dA and dB of the films 71 and 72.

[0026] These relations can be expressed by the following formulae (1) and (2):

\[ n_{AX}d_A = (1/4 + m/2)\lambda \]  
\[ n_{B}d_B = (1/4 + m/2)\lambda \]  

where m is 0 or a positive integer.

[0027] By appropriately selecting values of refractive index nAX and nB of the first and the second films 71 and 72 and thickness dA and dB of the films 71 and 72, therefore, it is possible to cause reflection of the light of a desired wavelength. It is possible to cause reflection of the light of a desired wavelength also by appropriately selecting any of the refractive index and the thickness, i.e., for example, by selecting appropriate values of thickness dA and dB with constant values of refractive index nAX and nB. Lamination of a plurality of first and second films having different thicknesses also permits reflection within a desired wavelength band. In this case, reflectivity of wavelength is higher according as the number of the first and the second films is larger. A desired reflectivity can be set for each wavelength by appropriately selecting this number. Such a polarised light separator is disclosed as a reflective polariser in International Unexamined Patent Publication WO/95/17692 and others.

[0028] In the invention, the ratio R450/R650 of reflectivity R450 at a wavelength of 450 nm of the polarised light separator 7 to reflectivity R650 should be at least 1. The above-mentioned colouring can be minimised by using such a polarised light separator. More preferably, the ratio R450/R650 should be at least 1.2, permitting further minimisation of colouring. Since a ratio R450/R650 of over 3.0 can give only a less remarkable effect, the ratio should preferably be up to 3.0.

[0029] Fig. 7 illustrates reflectivity properties of an example of polarised light separator 7 prepared so as to satisfy the above-mentioned conditions by using the first and the second films 71 and 72 comprising the materials as described above: the ratio R450/R650 of reflectivity R450 at a wavelength of 450 nm to reflectivity R650 at a wavelength of 650 nm is about 1.39.

[0030] Any material can be appropriately used as the light absorber 8 shown in Fig. 1 so far as it is black in colour for satisfactory light absorption. By forming a number of small holes in the absorber 8 and providing a backlight on the lower surface side, there is available a liquid crystal display device of the transmission type or combination transmission/reflection type.

[0031] A liquid crystal display device free from colouring and giving a good contrast is available as described above by appropriately combining the liquid crystal of the liquid crystal display panel 3, the retardation film 2 and the polarised light separator 7 so as to achieve a ratio BLC/BRF of at least 1.02 of the wavelength dispersion BLC of refractive index anisotropy in the liquid crystal to the wavelength dispersion BRF of retardation in the retardation film 2, and also to achieve a ratio R450/R650 of at least 1 of the reflectivity R450 at a wavelength of 450 nm of the polarised light separator to the reflectivity R650 at a wavelength of 650 nm.

[0032] The above-mentioned liquid crystal, retardation film 2 and polarised light separator 6 are examples only. An effect similar to the above is available also by using other liquid crystal, retardation film and polarised light separator.

[0033] By applying the above-mentioned liquid crystal display device, for example, to a display section A of a portable telephone T as shown in Fig. 8, it is possible to provide a portable telephone set giving a high display quality, and the
device of the invention is also applicable, not limited to a portable telephone set, but to a watch and various other electronic devices.

Examples

Example 1

[0034] The liquid crystal display device as shown in Fig. 1 was prepared as Example 1 of the invention. A uniaxial drawn film comprising PC as shown by c in Fig. 2 ($\Delta n \cdot d = 600 \text{ nm}$ at a wavelength of 589 nm) was used as the retardation film. As the liquid crystal display panel 3, a liquid crystal display panel having a cell thickness of 6.5 $\mu\text{m}$ and a twist angle of 240° was prepared by the use of the liquid crystal E shown in Figs. 3 and 4 ($\Delta n \cdot d = 0.136 \mu\text{m}$ at a wavelength of 589 nm). The ratio $B_{LC}/B_{RF}$ of the wavelength dispersion of refractive index anisotropy of the liquid crystal to the wavelength dispersion of retardation of the retardation film 2 was 1.07. The polarised light separator 7 comprised a lamination of a prescribed number of first films 71 prepared by drawing PEN to five magnifications and second films 72 made of coPEN. The polarised light separator had a reflectivity ratio $R_{450}/R_{650}$ of 1.2.

Comparative Example 1

[0035] For comparison purposes with the above-mentioned Example 1, a liquid crystal display device was prepared, as Comparative Example 1, under the same conditions as in Example 1, except that a retardation film made of PA as shown by b in Fig. 2 was employed. The ratio $B_{LC}/B_{RF}$ of the wavelength dispersion of refractive index anisotropy in the liquid crystal of the liquid crystal display panel 3 to the wavelength dispersion of retardation in the retardation film 2 was 1.01, and the polarised light separator 7 had a reflectivity ratio $R_{450}/R_{650}$ of 1.2.

Conventional Examples 1 and 2

[0036] For comparison purposes with the above-mentioned Example 1 and Comparative Example 1, conventional liquid crystal display devices as shown in Fig. 9 of Conventional Examples 1 and 2 were prepared by using retardation films made of PC and PA, respectively, shown by c and b in Fig. 2, making liquid crystal display panels 3 identical with those in Example 1 and Comparative Example 1, and arranging a polariser 4 with an aluminium reflector 5 on the lower surface side of the liquid crystal display panel.

[0037] Conditions for preparation and results of tests on display properties of the liquid crystal display devices prepared in Example 1, Comparative Example 1, and conventional Examples 1 and 2 are comprehensively shown in Table 1. In the liquid crystal display device using a polarised light separator, the colour in ON-state depends upon the colour of the absorber 8 of black. In Example 1 and Comparative Example 1, therefore, the colour of the absorber was adjusted so that the colour in ON-state becomes black. This was also the case with Example 2 and Comparative Example 2 described later.
<table>
<thead>
<tr>
<th></th>
<th>Example 1</th>
<th>Comparative Example 1</th>
<th>Conventional Example 1</th>
<th>Conventional Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower polarised light separator</td>
<td>Polarised separator with black absorber</td>
<td>Polarised separator with black absorber</td>
<td>Polariser with Al reflector</td>
<td>Polariser with Al reflector</td>
</tr>
<tr>
<td>Liquid crystal wavelength dispersion, $B_{LC}$</td>
<td>1.16</td>
<td>1.16</td>
<td>1.16</td>
<td>1.16</td>
</tr>
<tr>
<td>Material for retardation film</td>
<td>PC</td>
<td>PA</td>
<td>PC</td>
<td>PA</td>
</tr>
<tr>
<td>Retardation film dispersion, $B_{RF}$</td>
<td>1.08</td>
<td>1.15</td>
<td>1.08</td>
<td>1.15</td>
</tr>
<tr>
<td>Wavelength dispersion ratio, $B_{LC}/B_{RF}$</td>
<td>1.07</td>
<td>1.01</td>
<td>1.07</td>
<td>1.01</td>
</tr>
<tr>
<td>Reflectivity ratio of lower polarised light separator</td>
<td>1.2</td>
<td>1.2</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>7.4</td>
<td>6.3</td>
<td>7.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Colour in OFF-state</td>
<td>White</td>
<td>Blue-white</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Colour in ON-state</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
<td>Blue</td>
</tr>
</tbody>
</table>
In conventional Example 1, colouring was observed in OFF-state. This was considered to be attributable to a large ratio $\frac{B_{\text{LC}}}{B_{\text{RF}}}$, and the conditions as described above were selected with a view to bringing the ratio closer to 1 in Conventional Example 2. As a result, although colouring was eliminated in OFF-state, colouring was caused in ON-state, leading to a decrease in contrast. In Comparative Example, the display was slightly bluish in OFF-state, with a poorer contrast. In Example 1 of the invention, in contrast, a satisfactory monochromatic display was obtained both in ON-state and OFF-state with a good contrast.

Example 2

An liquid crystal display device as shown in Fig. 1 was prepared by using a liquid crystal different from that in Example 1 as Example 2 of the invention. With a retardation film 2 identical with that in Example 1, a liquid crystal display panel having a cell thickness of 5.6 $\mu$m and a twist angle of 260° was prepared by using a liquid crystal shown by B in Figs. 3 and 4 ($\Delta n \cdot d = 0.164 \mu$m at a wavelength of 589 nm) as the liquid crystal for the liquid crystal display panel 3. The ratio $\frac{B_{\text{LC}}}{B_{\text{RF}}}$ of the wavelength dispersion of refractive index anisotropy in the liquid crystal to the wavelength dispersion of retardation in the retardation film 2 was 1.10. The polarised light separator 7 comprised a lamination of a prescribed number of first and second films made of the same material as in Example 1, and had a reflectivity ratio of 1.39.

Comparative Example 2

In Comparative Example 2 to be compared with Example 2, a liquid crystal display device was prepared under the same conditions as in Example 2 except for the use of a retardation film comprising PSF as shown by a in Fig. 2. The ratio $\frac{B_{\text{LC}}}{B_{\text{RF}}}$ of the wavelength dispersion of refractive index anisotropy of the liquid crystal in the liquid crystal display panel 3 to the wavelength dispersion of retardation in the retardation film 2 was 0.98. The polarised light separator 7 had a reflectivity ratio $R_{450}/R_{650}$ of 1.39 just as in Example 2.

Conventional Examples 3 and 4

In Conventional Examples 3 and 4 to be compared with Example 2 and Comparative Example 2, conventional liquid crystal display devices as shown in Fig. 9 were prepared by using retardation films comprising PC and PSF, respectively, shown by c and a in Fig. 2, providing a liquid crystal display panel 3 identical with those in Example 2 and Comparative Example 2, and installing a polariser 4 with an aluminium reflector 5 on the lower surface side of the liquid crystal display panel.

Conditions of preparation and display performance of the liquid crystal display devices prepared in Example 2, Comparative Example 2 and Conventional Examples 3 and 4 are comprehensively shown in Table 2.
<table>
<thead>
<tr>
<th></th>
<th>Example 2</th>
<th>Comparative Example 2</th>
<th>Conventional Example 3</th>
<th>Conventional Example 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower polarised light separator</td>
<td>Polarised separator with black absorber</td>
<td>Polarised separator with black absorber</td>
<td>Polariser with Al reflector</td>
<td>Polariser with Al reflector</td>
</tr>
<tr>
<td>Liquid crystal wavelength dispersion, $B_{LC}$</td>
<td>1.19</td>
<td>1.19</td>
<td>1.19</td>
<td>1.19</td>
</tr>
<tr>
<td>Material for retardation film</td>
<td>PC</td>
<td>PSF</td>
<td>PC</td>
<td>PSF</td>
</tr>
<tr>
<td>Retardation film dispersion, $B_{RF}$</td>
<td>1.08</td>
<td>1.22</td>
<td>1.08</td>
<td>1.22</td>
</tr>
<tr>
<td>Wavelength dispersion ratio, $B_{LC}/B_{RF}$</td>
<td>1.10</td>
<td>0.98</td>
<td>1.10</td>
<td>0.98</td>
</tr>
<tr>
<td>Reflectivity ratio of lower polarised light separator</td>
<td>1.39</td>
<td>1.39</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Contrast ratio</td>
<td>10.7</td>
<td>9.3</td>
<td>10.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Colour in OFF-state</td>
<td>White</td>
<td>Blue-white</td>
<td>Yellow</td>
<td>White</td>
</tr>
<tr>
<td>Colour in ON-state</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
<td>Blue</td>
</tr>
</tbody>
</table>
[0043] In the liquid crystal display device of Example 2 according to the invention, as is clear from Table 2, colouring was not caused as in Comparative Example 2 and Conventional Examples 3 and 4, and further, a display of a good contrast was obtained. Particularly, in Conventional Example 3, while giving a relatively high contrast, the display was tinted with yellow in OFF-state, and coloured rather seriously. In Conventional Example 4, while the exterior view was white, the ON-state is tinted with blue, resulting in a decrease in contrast. In Comparative Example 2, the display was slightly bluish with a poor contrast. In Example 2 of the invention, on the contrary, a satisfactory monochromatic display was obtained in ON-state as well as in OFF-state, with a good contrast.

[0044] As a result of application of the above-mentioned liquid crystal display device according to the invention to a display section A of a portable telephone set as shown in Fig. 8 as an electronic device, an excellent display performance was obtained.

[0045] According to the liquid crystal display device of the invention and an electronic device using the same, as described above, there is available a display free from colouring with a good contrast, thus bringing about advantage of providing a liquid crystal display device and an electronic device giving a high display quality.

Claims

1. A liquid crystal display device comprising:
   a liquid crystal display panel (3) having a liquid crystal layer (33), and, a retardation film (2) for eliminating colouring occurring in said liquid crystal display panel, characterised in that the device further comprises;
   a polarised light separator (7), arranged at least on one side of said liquid crystal display panel, having a ratio R_{450}/R_{650} of the reflectivity R_{450} at a wavelength of 450 nm to the reflectivity R_{650} at a wavelength of 650 nm of at least 1; and
   the ratio of the wavelength dispersion B_{LC} of anisotropy of refractive index in said liquid crystal layer to the wavelength dispersion B_{RF} of retardation in said retardation film is at least 1.02.

2. A liquid crystal display device according to claim 1, wherein said ratio R_{450}/R_{650} is up to 3.

3. A liquid crystal display device according to claim 1, wherein said polarised light separator is provided with a first layer having birefringence and a second layer not having birefringence, and the refractive index parallel to one side in said first layer is substantially equal to the refractive index of said second layer.

4. A liquid crystal display device according to claim 1, wherein said liquid crystal layer is a nematic liquid crystal layer having a twisted alignment within a range of from 180 to 360°.

5. A liquid crystal display device according to claim 1, wherein said retardation film is a polymer film.

6. A liquid crystal display device according to claim 1, wherein the side of said liquid crystal display panel opposite to said polarised light separator is provided with a reflector.

7. An electronic device having a liquid crystal display device according to claim 1, as the display section thereof.

Patentansprüche

1. Flüssigkristallanzeigevorrichtung, umfassend:
   eine Flüssigkristallanzeigetafel (3) mit einer Flüssigkristallschicht (33), und
   eine Verzögerungsschicht (2) zum Eliminieren der Einfärbung, die in der Flüssigkristallanzeigetafel auftritt,
   dadurch gekennzeichnet, daß die Vorrichtung ferner umfaßt:

einen Polarisationslichtseparator (7), der wenigstens auf einer Seite der Flüssigkristallanzeigetafel angeordnet ist und ein Verhältnis R_{450}/R_{650} der Reflektivität R_{450} bei einer Wellenlänge von 450 nm zur Reflektivität R_{650} bei einer Wellenlänge von 650 nm von wenigstens 1 aufweist; wobei
   das Verhältnis der Wellenlängendispersion B_{LC} der Anisotropie des Brechungsindex in der Flüssigkristallschicht zur Wellenlängendispersion B_{RF} der Verzögerung in der Verzögerungsschicht wenigstens gleich 1,02
2. Flüssigkristallanzeigevorrichtung nach Anspruch 1, bei der das Verhältnis $R_{450}/R_{650}$ bis zu 3 beträgt.

3. Flüssigkristallanzeigevorrichtung nach Anspruch 1, bei der der Polarisationslichtseparator mit einer ersten Schicht, die eine Doppellbrechung aufweist, und einer zweiten Schicht, die keine Doppellbrechung aufweist, versehen ist, wobei der Brechungsindex in einer Richtung parallel zu einer Seite in der ersten Schicht im wesentlichen gleich dem Brechungsindex in der zweiten Schicht ist.

4. Flüssigkristallanzeigevorrichtung nach Anspruch 1, bei der die Flüssigkristallschicht eine nematische Flüssigkristallschicht mit einer verdrehten Ausrichtung innerhalb eines Bereiches von 180 bis 360° ist.

5. Flüssigkristallanzeigevorrichtung nach Anspruch 1, bei der die Verzögerungsschicht eine Polymerschicht ist.

6. Flüssigkristallanzeigevorrichtung nach Anspruch 1, bei der die Seite der Flüssigkristallanzeigetafel, die dem Polarisationslichtseparator gegenüberliegt, mit einem Reflektor versehen ist.

7. Elektronische Vorrichtung, die eine Flüssigkristallanzeigevorrichtung nach Anspruch 1 als Anzeigeabschnitt aufweist.

Revendications

1. Dispositif d'affichage à cristal liquide comprenant :
   un écran d'affichage à cristal liquide (3) ayant une couche de cristal liquide (33), et un film de retardement (2) pour l'élimination de la coloration se produisant dans ledit écran d'affichage à cristal liquide, caractérisé en ce que le dispositif comprend en outre :
   un séparateur de lumière polarisée (7), disposé sur au moins un côté dudit écran d'affichage à cristal liquide, ayant un rapport $R_{450}/R_{650}$ de réflectivité $R_{450}$ à une longueur d'onde de 450 nm jusqu'à une réflectivité $R_{650}$ à une longueur d'onde de 650 nm d'au moins 1 ; et le rapport de dispersion de longueur d'onde $B_{LC}$ d'anisotropie d'index de réfraction dans ladite couche de cristal liquide à la dispersion de longueur d'onde $B_{RF}$ de retardement dans ledit film de retardement est au moins de 1,02.

2. Dispositif d'affichage à cristal liquide selon la revendication 1, dans lequel ledit rapport $R_{450}/R_{650}$ vaut jusqu'à 3.

3. Dispositif d'affichage à cristal liquide selon la revendication 1, dans lequel ledit séparateur de lumière polarisée est fourni avec une première couche ayant une biréfringence et une deuxième couche n'ayant pas de biréfringence, et l'indice de réfraction dans une direction parallèle à une face dans ladite première couche est sensiblement égal à l'indice de réfraction de ladite deuxième couche.

4. Dispositif d'affichage à cristal liquide selon la revendication 1, dans lequel ladite couche à cristal liquide est une couche de cristal liquide nématique ayant un alignement torsadé dans un angle de l'ordre de 180 à 360°.

5. Dispositif d'affichage à cristal liquide selon la revendication 1, dans lequel ledit film de retardement est un film polymère.

6. Dispositif d'affichage à cristal liquide selon la revendication 1, dans lequel la face dudit panneau d'affichage à cristal liquide opposé au dit séparateur de lumière polarisée est fourni avec un réflecteur.

7. Dispositif électronique ayant un dispositif d'affichage à cristal liquide selon la revendication 1, comme la section d'affichage de celui-ci.