

PATENT SPECIFICATION

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(54) LIQUID CRYSTAL DISPLAY DEVICE

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company of 3—4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid crystal display devices.

Liquid crystal display devices possess a number of advantages not found in other types of display devices. For example, liquid crystal display devices have a relatively low power consumption, produce a relatively readable display even in bright ambient light conditions because they are of the passive type, and are relatively inexpensive to produce.

However, liquid crystal display devices up until now have had the serious disadvantage that they are not durable. This disadvantage makes it difficult to use liquid crystal display devices in wrist watches where they must operate for a considerable period of time, or portable electronic desk top calculators which tend to be subjected to rough handling. It has been found from experiment that the relatively short life of conventional liquid crystal display devices is caused, in the main, by permeation of vapour from the ambient air into the liquid crystal material, by chemical breakdown of the liquid crystal material by relatively short wavelength light, and by lowering of polarisation activity of polarising plates which may form part of the liquid crystal display device.

According to one aspect of the present invention there is provided a liquid crystal display device comprising a liquid crystal display cell consisting of a pair of electrode plates between which is disposed a liquid crystal material, and at least one polarising plate disposed adjacent to the liquid crystal display cell, at least a part of the or one polarising plate being coated or dyed so to act as a filter with a transmittance threshold wavelength in the region between 3,800 Å

and 5,500 Å so that light having a wavelength shorter than the transmittance threshold wavelength is substantially absorbed by the polarising plate.

In the preferred embodiment the liquid crystal display cell is sandwiched between a pair of polarising plates, one of which is dyed or coated so as to act as said filter. Thus reflecting means may be provided on or adjacent to the other polarising plate on the side remote from the liquid crystal display cell.

According to a further aspect of the present invention there is provided a timepiece, for example a wrist watch, having a liquid crystal display device as recited above.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 is a cross-section of one embodiment of a liquid crystal display device according to the present invention;

Figure 2 shows in greater detail the construction of a polarising plate of the liquid crystal display device of Figure 1;

Figure 3 illustrates graphically the spectral transmittance characteristics of a typical liquid crystal material; and

Figure 4 is a cross-section of a second embodiment of a liquid crystal display device according to the present invention.

Figure 1 is a cross-section of one embodiment of a liquid crystal display device according to the present invention and comprises a liquid crystal display cell consisting of a glass upper electrode plate 1, a glass lower electrode plate 2 each of which have transparent conductive films (not shown) on the surfaces which face one another. Thus each electrode plate, together with its transparent conductive film constitutes an electrode plate. A liquid crystal material 4 is sandwiched between the plates 1, 2 which are maintained spaced apart by a spacer 3. The liquid crystal display cell is sandwiched between a pair of polarising plates 5, 6. A light scattering

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reflector 7 is disposed on or adjacent to the polarising plate 6.

5 The polarising plate 5, that is to say the polarising plate upon which the light is incident, is at least partially dyed so as to act for a filter for light of a wavelength shorter than a predetermined wavelength. The polarising plate 5 is illustrated in greater detail in Figure 2 and comprises a pair of transparent plates 8, 10 of plastics material between which is sandwiched a polarising film 9. At least one of the transparent plates 8, 10 is dyed prior to the polarising film being sandwiched therebetween.

15 Figure 3 illustrates the spectral transmittance characteristics of a typical liquid crystal material. As will be appreciated, absorption of light by the liquid crystal material begins at a wavelength of 5,000 Å or so and light at a wavelength of 3,700 Å and less is absorbed completely. It is known that light absorbed by a liquid crystal material causes chemical breakdown thereof. Accordingly, if the polarising plate 5 is such as to act as a filter, light of a wavelength which would otherwise be harmful to the liquid crystal material will be absorbed. However, the greater the bandwidth of wavelengths absorbed by the polarising plate 5, the darker becomes the display produced by the liquid crystal display device. If, for example, the polarising plate 5 absorbs light of a wavelength of 5,500 Å or less the display produced by the liquid crystal display device appears dark red and this is not altogether satisfactory from the point of view of contrast of the display. Where the polarising plate 5 absorbs light of a wavelength of 3,800 Å or less, light of a wavelength harmful to the liquid crystal material may well pass through the polarising plate.

45 Thus it has been found advantageous if the polarising plate 5 is dyed to act as a sharp cut-off filter with a transmittance threshold wavelength in the range between 3,800 Å and 5,500 Å.

50 Figure 4 shows, in cross-section, another embodiment of a liquid crystal display device according to the present invention. Like parts in Figures 1 and 4 have been designated by the same reference numerals. The polarising plate 5, instead of being dyed to act as a filter, includes a coating 11 for the same purpose, the coating at least partially covering the polarising plate. The coating 11 may be applied, for example, by a spraying technique or a brushing technique. The coating is so chosen that the polarising plate 5 acts as a sharp cut-off filter with a transmittance threshold wavelength in the range between 3,800 Å and 5,500 Å. Thus light of a wavelength

which would otherwise be harmful to the liquid crystal material is absorbed by the polarising plate 5 and yet the liquid crystal display device produces a readily visible display.

It will be appreciated that the polarising plate 6 may be treated, i.e. dyed or coated, in a similar manner to the polarising plate 5.

It is known in Japan to provide a filter plate, for example of plastics material, in addition to the polarising plates in a conventional liquid crystal display device for the purpose of absorbing the light of a wavelength which would otherwise be harmful to the liquid crystal material. However, the addition of this filter plate increases the thickness and weight of this conventional liquid crystal display device and this makes it difficult to use it in wrist watches where space to house the components thereof is at a premium. Furthermore, this type of conventional liquid crystal display device has the disadvantage that the contrast of the display produced thereby is reduced due to reflection of light by the interface between the polarising plate and the filter plate.

In contrast, the liquid crystal display devices according to the present invention described above are relatively thin because the required filter characteristics are "built into" the polarising plate 5, produce a display having relatively good contrast, and have a relatively long useful life since the liquid crystal material is not subjected to light of a wavelength harmful thereto. Thus liquid crystal display devices according to the present invention are particularly suitable for use in timepieces, for example wrist watches.

WHAT WE CLAIM IS:—

1. A liquid crystal display device comprising a liquid crystal display cell consisting of a pair of electrode plates between which is disposed a liquid crystal material, and at least one polarising plate disposed adjacent to the liquid crystal display cell, at least a part of the or one polarising plate being coated or dyed so to act as a filter with a transmittance threshold wavelength in the region between 3,800 Å and 5,500 Å so that light having a wavelength shorter than the transmittance threshold wavelength is substantially absorbed by the polarising plate.

2. A liquid crystal display device as claimed in claim 1 in which the liquid crystal display cell is sandwiched between a pair of polarising plates, one of which is dyed or coated so as to act as said filter.

3. A liquid crystal display device as claimed in claim 2 in which reflecting

reflector 7 is disposed on or adjacent to the polarising plate 6.

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2. A liquid crystal display device as claimed in claim 1 in which the liquid crystal display cell is sandwiched between a pair of polarising plates, one of which is dyed or coated so as to act as said filter.

3. A liquid crystal display device as claimed in claim 2 in which reflecting





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means are provided on or adjacent to the other polarising plate on the side remote from the liquid crystal display cell.

having a liquid crystal display device as claimed in any preceding claim.

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5 4. A liquid crystal display device substantially as herein described with reference to and as shown in the accompanying drawings.

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5. A timepiece, for example a wristwatch,

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