

PATENT SPECIFICATION

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(54) ELECTRO-OPTICAL DISPLAY DEVICE

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3—4, 4-chome, Ginza, Chou-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 electro-optical display devices.

A nematic liquid crystal compound or an admixture of such compounds forming a nematic liquid crystal material is one which exhibits electro-optical properties, that is to say, when an electric field is applied thereto it will scatter light. Many electro-optical display devices employing nematic liquid crystal compounds or materials can be contemplated. Such display devices have the following advantages:

- 1) Their power consumption is very low.
- 2) Their cost is low.
- 3) The brighter the ambient conditions the clearer is the display.

However, up till now, such display devices have had the disadvantage that they have had to employ unstable organic nematic liquid crystal compounds or materials. That is to say, the life of the nematic liquid crystal compound or material has been too short and so display devices, especially in the case where they were operated by direct current, have had little commercial use.

However, it has been found that nematic liquid crystal compounds having an azo-bond are extremely stable chemically.

Most types of conventional nematic liquid crystal compounds are the so-called annealing type, i.e. having a —CN=N— coupling or bond. Compounds having this type of bond are non-symmetrical and some have been reported to be in the nematic phase at room temperature. Accordingly, there is little difficulty in providing a nematic liquid crystal material composed of an admixture of such compounds. But the annealing-type of nematic liquid crystal compounds have a peculiar instability in their structure and small amounts of impurity or moisture cause a natural decomposition. When an electric field is applied, the

decomposition is especially marked and represents a considerable disadvantage for practical purposes.

In general, nematic liquid crystal compounds having an azo-bond (hereinafter referred to as azo-type nematic liquid crystal compounds or materials) have a colour between yellow and brown and absorb light in a band of wavelengths lying somewhere below 6000 Å. When an azo-type nematic liquid crystal compound absorbs light, the temperature at which the compound ceases to be nematic and becomes isotropic is changed. Though the mechanism of this change is not fully understood, it is believed that the change comes about by virtue of the energy of the absorbed light. The change is reversible and causes no damage to the nematic liquid crystal compound.

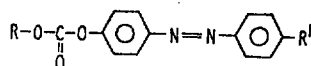
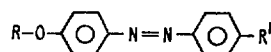
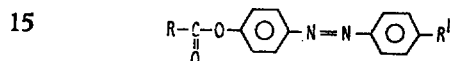
The stability of azo-type nematic liquid crystal compounds is apparent from the results of many experiments. For example, even if a 50 volt DC electric field is applied to a thin layer (for example 12 microns) of an azo-type nematic liquid crystal compound or material for up to 5 months, no decomposition or deterioration is visible. Azo-type nematic liquid crystal compounds or materials withstand DC operations for much longer periods than conventional nematic liquid crystal compounds or materials, this illustrating their higher stability.

However, such azo-type nematic liquid crystal compounds or materials have one defect. This defect is that, as shown by their colour, they absorb light in a band of wavelengths lying somewhere below 6000 Å. Since it is believed that the energy of the absorbed light causes the temperature at which the azo-type nematic liquid crystal compound or material ceases to be nematic and become isotropic to be changed an azo-type nematic liquid crystal compound or material may cease to be nematic at room temperature upon exposure to strong light.

According to the present invention there is provided an electro-optical display device comprising: two spaced apart electrode means at least one of which is transparent and

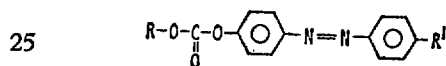
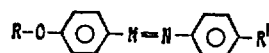
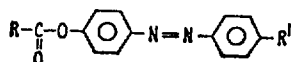
between which there is either a nematic liquid crystal compound of the type comprising two benzene rings linked by an azo-bond or a nematic liquid crystal material including a nematic liquid crystal compound comprising two benzene rings linked by an azo-bond; and filter means for preventing light which is in the band of wavelengths absorbed by the nematic liquid crystal compound or material, when an electric field is not applied thereacross, from being transmitted to the nematic liquid crystal compound or material.

The nematic liquid crystal compound preferably is of one of the general formulae:



where R, R' are alkyl groups.

The nematic liquid crystal material preferably comprises, in admixture two or more nematic liquid crystal compounds, each of which is of one of the general formulae:



where R, R' are alkyl groups.

In one embodiment at least one of the electrode means comprises a transparent plate on which a transparent electrode is provided, said plate constituting the filter means.

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

Figure 1 shows graphically the spectral characteristics of an azo-type nematic liquid crystal compound or material; and

Figure 2 shows schematically, partly in cross-section, an electro-optical display device according to the present invention.

Referring first to Figure 1, there is shown

graphically the spectral characteristics, at room temperature, of an azo-type nematic liquid crystal compound or material, the transparency ratio being plotted on the abscissa and the wavelength of the light on the ordinate. The azo-type nematic liquid crystal compound or material under consideration begins to absorb light when the wavelength of the light is about 6000 Å, although other compounds or materials may absorb light at more or less than this wavelength depending upon the spectral characteristics of a given azo-type nematic liquid crystal compound or material. Thus, if a filter which does not transmit light of a wavelength less than 6000 Å is used, the azo-type nematic liquid crystal compound or material under consideration will always exhibit electro-optical properties no matter what the ambient light conditions.

Figure 2 shows schematically an electro-optical display device according to the present invention. An azo-type nematic liquid crystal compound or material is inserted in a space 5 between two flat plates 1, 3, at least one of which is transparent. Electrically conductive electrodes 2, 2' are provided on the facing surfaces of the plates 1, 3 respectively. Either or both of the electrodes may be transparent depending upon whether or not their respective plate is transparent. The plates 1, 3 are maintained in spaced apart relationship by means of an insulating spacer 4 made of, for example, polyester film, polytetrafluoroethylene film, mica, etc. The electrodes 2, 2' are connected in an electric circuit with a power source 6 (e.g. a battery as shown) and a switch 7. When the switch 7 is closed an electric field is applied across the azo-type nematic liquid crystal compound or material so it scatters light instant upon it. However, before ambient light is instant upon the azo-type nematic liquid crystal compound or material it is filtered and to this end, either or both of the plates may be made of brownish filter glass. Alternatively, a transparent plastics material filter, e.g. made of cellophane (Trade Mark) may be provided. Alternatively, the filter may be constituted by a further liquid crystal compound or material. The filter will, in all cases, be such as to absorb light in the same band of wavelengths as the azo-type nematic liquid crystal material when the latter does not have an electric field applied thereacross.

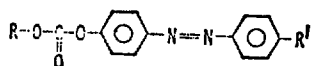
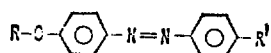
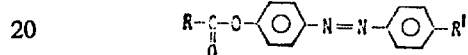
The display device described above has the advantage that it exhibits electro-optical properties regardless of the ambient light conditions. The display device may be used in a pocket-size or desk electronic calculator. If the calculator is portable it is especially important that the display device will operate in strong light conditions so that, for example, it can be used outside. The display device may also be used in connection with wrist watches and other timepieces.



WHAT WE CLAIM IS:—

1. An electro-optical display device comprising: two spaced apart electrode means at least one of which is transparent and between
5 which there is either a nematic liquid crystal compound of the type comprising two benzene rings linked by an azo-bond or a nematic liquid crystal material including a nematic liquid crystal compound comprising two benzene rings linked by an azo-bond; and filter
10 means for preventing light which is in the band of wavelengths absorbed by the nematic liquid crystal compound or material, when an electric field is not applied thereacross, from being transmitted to the nematic liquid crystal compound or material.

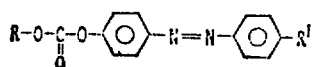
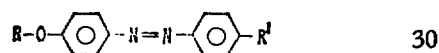
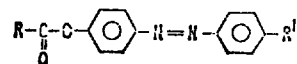
2. A device as claimed in claim 1 in which the nematic liquid crystal compound is of one of the general formulae:



where R, R' are alkyl groups.

3. A device as claimed in claim 1 in which

the nematic liquid crystal material comprises, in admixture, two or more nematic liquid crystal compounds, each of which is of one of the general formulae:



where R, R' are alkyl groups.

4. A device as claimed in any preceding claim in which at least one of the electrode means comprises a transparent plate on which a transparent electrode is provided, said plate constituting the filter means.

5. An electro-optical display device substantially as herein described with reference to and as shown in Figure 2 of the accompanying drawings.

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