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(54) SMECTIC DISPLAY CELL

(71) We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of 190 Strand, London, W.C.2, England, 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 cells and in particular to such cells filled with a smectic material that exhibits positive dielectric anisotropy.

According to the present invention there is provided an internally electroded liquid crystal display cell having a layer of a smectic material that exhibits positive dielectric anisotropy in which a pleochroic dye has been dispersed, which layer is sanwiched between two electroded plates having electrodes that overlap at least in part, at least one of which plates is transparent, wherein the surfaces of the plates are such that, when the layer is taken into a smectic phase from a less-ordered non-smectic phase by cooling in the absence of an applied electric field, the layer is caused to assume parallel pseudo-homogeneous (as hereinafter defined) alignment.

There follows a description of smectic liquid crystal display cell embodying the invention in a preferred form. The description refers to the drawings accompanying the Provisional Specification in which:—

Figure 1 depicts a schematic perspective view of the cell, and

Figure 2 depicts diagrammatically the two types of stable state that regions of the cell may assume.

Two glass sheets 1, 2 are secured together with a perimeter seal 3 to form an envelope for a layer 5 of liquid crystal medium and pleochroic dye mixture to be hermetically sealed within the cell. The cell is filled via an aperture formed by an interruption in the perimeter of the seal 3, and, after the cell has been filled, this aperture is sealed off with a plug 4 for instance of indium. Alternatively solder is used, the aperture having been previously metalised.

Before they are secured together, the inwardly facing surfaces of the two sheets are provided with transparent electrodes (not shown) of appropriate layout for the required display to enable an electric field to be applied across the thickness of at least selected portions of the liquid crystal layer. For this purpose portions of the electrodes extend beyond the region of the seal to permit external connection.

The inwardly major surface of at least one, and preferably both, of the sheets 1 and 2 are provided with a coating or other surface treatment that will cause the liquid crystal molecules to assume pseudo-homogeneous alignment when the cell is taken by cooling into a smectic phase from a less ordered non-smectic phase in the absence of any electric field applied across the thickness of the layer.

It is preferred to make the perimeter seal 3 by fusing glass frit because, with the appropriate choice of glass frit, the liquid crystal is less liable to contamination by material leached from the seal than is generally the case of seals made of certain other materials such as epoxy resins. A disadvantage of using a glass frit seal is that certain alignment techniques need to be applied before assembly of the cell, but cannot withstand being taken to the temperature needed to fuse the frit. In this particular example however the necessary alignment surfaces are made by the oblique evaporation of silicon monoxide, and this will satisfactorily withstand firing temperatures in the region 450°–500°C. Therefore before the sheets 1 and 2 are assembled their inwardly facing surfaces are coated with silicon monoxide alignment layers evaporated at an angle of about 25° to the substrate so as to produce pseudo-homogeneous parallel alignment without a tilt angle.

It will be noted that the alignment is achieved in the same way as parallel homogeneous alignment is achieved for a nematic material. The alignment of the smectic material is superficially similar, which is why the smectic alignment has been termed parallel pseudo-homogeneous. Close examination of the alignment reveals however that the smectic has in fact assumed a focal-conic state with relatively long slender cones that, instead of being randomly oriented, are oriented in a preferred direction. Typically the aspect ratio of these cones is approximately 10 to 1.

The cell is next assembled with the alignment directions of the two sheets parallel with each other, and then the perimeter seal 3 is made by fusing the glass frit. At this stage the cell is ready for filling. A particular example of a suitable smectic A filling is 4-cyano-4′-n-octylbiphenyl. In order to make a red display a pleochroic azo dye may be added to the smectic. For certain applications where a blue display is desired the azo dye may be replaced with a pleochroic anthraquinone dye. A typical filling used approximately 1·3% of the blue dichroic dye 1-(4′-butyloxyaniline)-4-hydroxyanthraquinone together with approximately 0·05% of Waxoline Yellow A. The Waxoline Yellow, which is an isotropic dye, is added to compensate the residual blue of the display in its homeotropic state caused by the ordering within the smectic host being less than 100%. The presence of the yellow converts this residual blue to a substantially neutral grey. The optical density of the grey is relatively slight so that by eye its appearance is scarcely distinguishable from transparent.

The cell may be set into its pseudo-homogeneous state, in which it appears blue, by heating the cell to cause the filling to go through a phase change from the smectic phase to a less ordered phase, and then allowing the cell to cool again back to the smectic phase in the absence of an applied field. To convert the portion of the cell lying between the electrodes into the homotropic state, in which it appears as substantially neutral grey, an electric field of suitable field strength and frequency is applied between the electrodes. In the case of a cell with a 20 μm thick smectic layer the application of 180 volts 500 Hz alternating potential caused the cell to switch after a delay of about 0·1 sec. and with a rise-time (10 to 90%) of about 0·3 secs. This was with the device at a temperature of between 17 and 20°C. The response time is very temperature dependent and also frequency dependent. By reducing the frequency to 30 Hz the delay time was more than halved and the rise time reduced by a factor of about four.

Although the foregoing specific description has related to experiments with a single example of a smectic material it is to be understood that the invention is not limited to the use of that specific material. Furthermore although only a smectic A material has been exemplified, it is expected that smectic B materials can be made to work in the same way but at increased voltages, similarly other suitable smectic classes may also work, provided that such materials exhibit the appropriate positive dielectric anisotropy.

Since the cell is switched into the pseudo-homogeneous state by the action of heat, selective switching into the pseudo-homogeneous state can be achieved by the use of localised heating, such as that provided by the intensity modulation of a focused laser beam as it is scanned over the surface of the cell. For this purpose the wavelength of the laser would be chosen so that it is absorbed either by the liquid crystal medium and its added dye or by other material added to the smectic material, or by material adjacent the liquid crystal, such as the material of one of the electrode layers.

It has been found that a cell with some portions in one state and the remainder in the other state will remain for long periods of time without apparent degradation, and hence it is believed that the storage is indefinite.

WHAT WE CLAIM IS:—

1. An internally electroded liquid crystal display cell having a layer of smectic material that exhibits positive dielectric anisotropy in which a pleochroic dye has been dispersed, which layer is sandwiched between two electroded plates having electrodes that overlap at least in part, at least one of which plates is transparent, wherein the surfaces of the plates are such that when the layer is taken into smectic phase from a less-ordered non-smectic phase by cooling in the absence of an applied electric-field, the layer is caused to assume 'parallel pseudo-homogeneous' (as hereinbefore defined) alignment.

2. A display cell as claimed in claim 1 wherein said surfaces of the plates that cause said assumption of parallel pseudo-homogeneous alignment are provided by material deposited by oblique evaporation.

3. A display cell as claimed in claim 2 wherein said material deposited by oblique evaporation is silicon monoxide.

4. A display cell as claimed in claim 2 or 3 wherein said oblique evaporation is performed at an angle providing parallel pseudo-homogeneous alignment with substantially zero tilt angle.

5. A display cell substantially as described with reference to the drawings accompanying the Provisional Specification.

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1569688 PROVISIONAL SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1.

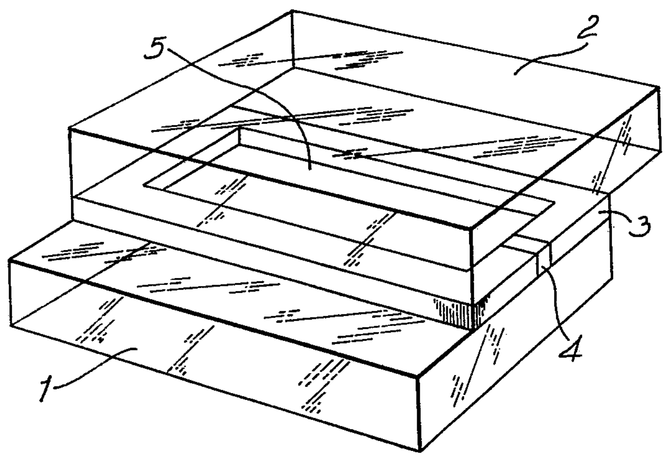
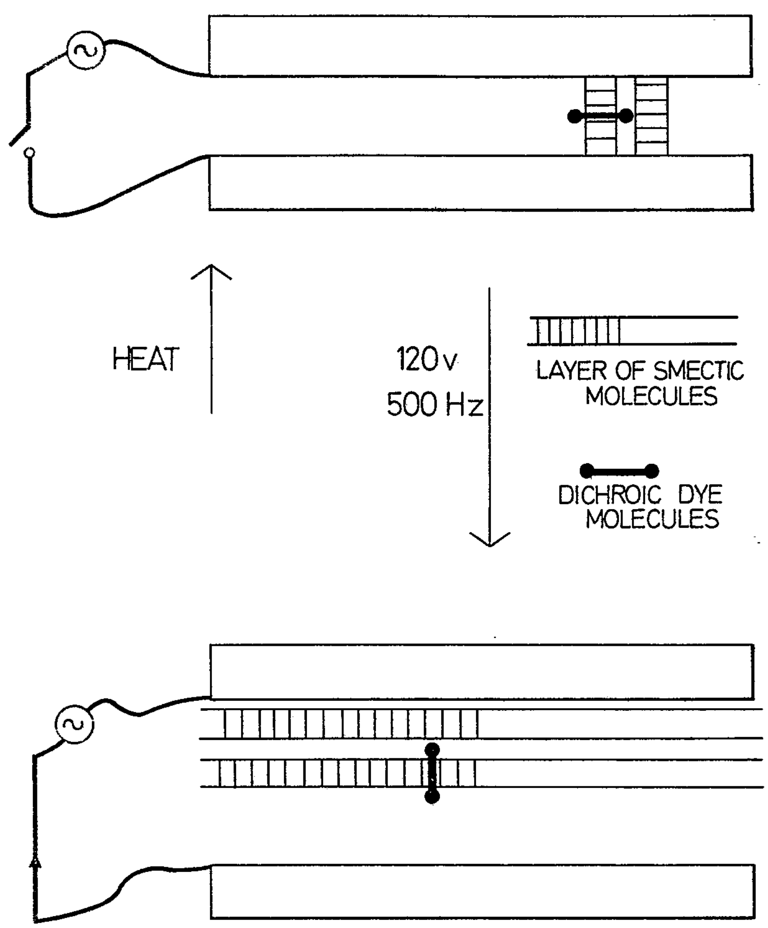


Fig.2.


HEAT
120v
500 Hz
LAYER OF SMECTIC MOLECULES
DICHROIC DYE MOLECULES