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B−7−2 A New Display Device Using the Depolarization in a Twisted Nematic Liquid Crystal Layer

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The liquid crystal display devices which have been put to practical use are of twisted nematic type [1] and of dynamic scattering type [2] (abbreviated as TN-cell and DS-cell, respectively). But their viewing angles are not wide because of coloration by birefringence in the TN-cell viewed from oblique direction and brilliance in the DS-cell viewed from the direction at which the light source can be directly seen. Then, the authors developed a new type of the display device with very wide viewing angle. This device consists of two polarizers, the DS-cell with 90°-twisted alignment and one diffuser. The operation of the device depends upon depolarization of the incident polarized light induced by the dynamic scattering. Then, we termed this device "DTN-cell" which is an abbreviation of "depolarization in twisted nematic layer."

The structure of the transmissive DTN-cell is shown in Fig.1. The molecular alignment in liquid crystal cells and directions of polarization of polarizers P_1 and P_2 are shown in Fig.2.

The operation mechanism of the DTN-cell can be explained as follows. While no voltage is applied to the cell, the plane of polarization of lignt transmitted through P_1 is rotated through 90° along the twisted alignment of liquid crystal molecules, but its direction meets at right angles with the direction of polarization of P_2. Then, no light transmitted through the device can be seen. When a higher voltage than the threshold voltage of the electrohydrodynamic instability [3] is applied to the cell, it becomes light scattering state. In this state, the incident polarized light is depolarized and its component being able to pass through P_2 arises. Then the bright pattern can be displayed on the dark background by applying the voltage to the cell.

The relationship between applied square wave voltage of 50Hz and transmittance of the transmissive DTN-cell with an opal glass as the diffuser, is shown by the solid line in Fig.3. The broken lines in Fig.3 show the properties of the cell with homogeneous or 45°-twisted alignment. The liquid crystal used in this experiment is a mixture of MBBA*1 (50wt%) and EBBA*2 (50wt%), and its conductivity is adjusted to be 2×10^{-9} mho/cm. The liquid crystal layer is 12um thick and the surfaces of cell substrates are treated with N-β(aminoethyl)γ-aminopropyltrimethoxysilane(AAMS) [4] to align liquid crystal molecules parallel to the surface. As shown in Fig.3, the DTN-cell is clarified to be excellent as the display device, because the threshold can be definitely observed and then the transmittance at a low voltage above the threshold is very high. The cells with the other twist angle were also examined and it was confirmed that their thresholds were less distinct than that of the DTN-cell.

Next, the effect of addition of a small amount of a cholesteric liquid crystal on the properties of the DTN-cell were also examined. Fig.4 shows the voltage dependence of transmittance of the DTN-cell with various additive amounts of cholesteric liquid crystal, where cholesteryl chloride(CC) was used as a cholesteric liquid crystal. It is obvious in this figure that the characteristic of the DTN-cell is improved in decrease and clearness of threshold voltage by addition of CC. However, the excess addition of CC gave poor contrast because the twist angle of the molecular alignment increased discretely from 90° to 270° and the rotatory dispersion occured. Then, optimal concentration of CC was found to be about 0.4wt%.

From experimental results as described above, features of the DTN-cell are summerized as follows. (1) Contrast of the DTN-cell is comparable to that of the TN-cell. (2) Viewing angle is very wide. (3) Sharp threshold can be obtained. (4) The DS-cell needs a hood or a louver but the new DTN-cell does not. (5) Display of the reflection mode is somewhat dark in comparison with that of the TN-cell, because utility factor of incident light is relatively low. These features suggest that the DTN-cell is useful for a matrix display device.

*1. p-methoxybenzylidene-p'-n-butylaniline *2. p-ethoxybenzylidene-p'-n-butylaniline

References

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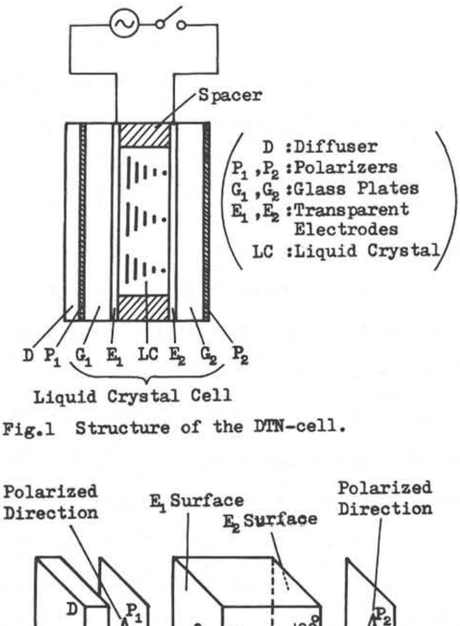

Fig.1 Structure of the DTN-cell.

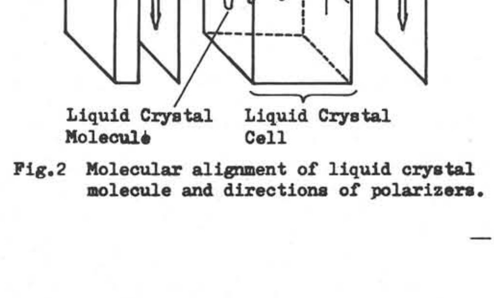

Fig.2 Molecular alignment of liquid crystal molecule and directions of polarizers.

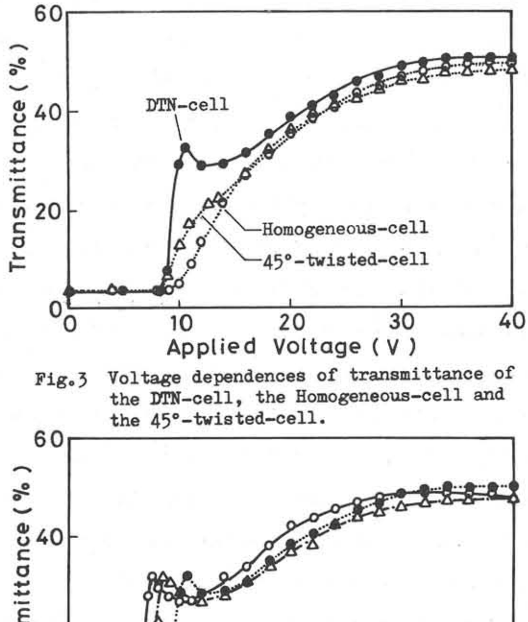

Fig.3 Voltage dependences of transmittance of the DTN-cell, the Homogeneous-cell and the 45°-twisted-cell.

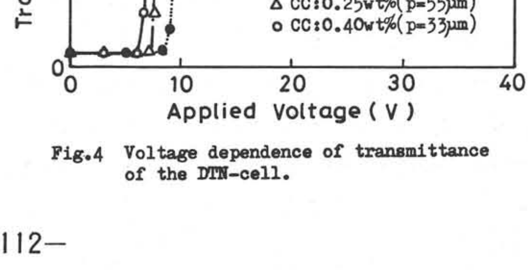

Fig.4 Voltage dependence of transmittance of the DTN-cell.