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D E C I S I O N
of 19 December 2000

Case Number: T 0913/95 - 3.4.1

Application Number: 86301406.4

Publication Number: 0193401

IPC: G09F 9/35

Language of the proceedings: EN

Title of invention:
Projection type liquid crystal display device

Applicant:
FUJITSU LIMITED

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 54, 56

Keyword:
"Novelty (yes) - after amendment"
"Inventive step (yes) - after amendment"

Decisions cited:
-

Catchword:
-

Case Number: T 0913/95 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 19 December 2000

Appellant: FUJITSU LIMITED
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 20 June 1995 refusing European patent application No. 86 301 406.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: M. G. L. Rognoni
U. G. O. Himmler

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal, received on 23 August 1995, against the decision of the Examining Division, dispatched on 20 June 1995, refusing the application No. 86 301 406.4 (publication No. 0 193 401). The fee for the appeal was paid on 24 August 1995 and the statement setting out the grounds of appeal was received on 30 October 1995.

II. In the decision under appeal, the Examining Division held that the subject-matter of claim 1 did not involve an inventive step within the meaning of Article 56 EPC, having regard to the following documents:

D1: US-A-3 895 866

D3: C. Tani *et al.* "Storage-Type Liquid -Crystal Matrix Display" Proceedings of the SID, Vol. 21/2 1980, pages 71 to 77

and that the subject-matter of claim 18 was not new over D3 (Article 54 EPC).

In the contested decision, the Examining Division further referred to the following state of the art:

D2: DE-A-21 30 504

III. In response to a communication from the Board, the appellant filed new claims 1 to 18, and new pages 3, 3a, 5, 6, 6a, 6b and 6c of the description with a letter dated 16 June 2000, received on 19 June 2000.

IV. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: Nos. 1 to 18 as filed with the letter dated 16 June 2000;

Description: pages 1, 2, 7, 8, 10, 11 and 13 to 15 as originally filed;
page 4 as filed with a letter dated 11 November 1993, received on 15 November 1993;
pages 9 and 12 as filed with a letter dated 29 November 1994, received on 5 December 1994;
pages 3, 3a, 5, 6, 6a, 6b and 6c as filed with the letter dated 16 June 2000;

Drawings: Sheets 1/5 to 5/5 as originally filed.

V. The wording of claim 1 reads as follows:

"1. A projection - type liquid crystal display device, comprising:

a first transparent substrate (13);

a second transparent substrate (14) substantially in parallel with the first transparent substrate;

a cholesteric - nematic phase transition type liquid crystal having positive dielectric anisotropy (11,12) and being disposed between the first and second transparent substrates (13 and 14);

sealing means sealing the liquid crystal between the first and second transparent substrates (13 and 14) said first and second transparent substrates and said sealing means forming an enclosed space, said first and second transparent substrates each having an internal surface facing the enclosed space;

first transparent electrode means (15) formed on the internal surface of said first transparent substrate (13);

second transparent electrode means (16) formed on the internal surface of said second transparent substrate (14); and

control means for the selective application of a predetermined sequence of voltage levels between the first and second electrodes in order to bring the liquid crystal at selected non-addressed portions of the device to a stable light - scattering state and to bring the liquid crystal in the remaining addressed portions of the device to a stable light - transmitting state,

characterised in that, said predetermined sequence of voltage levels comprises a first voltage level, a second intermediate voltage level higher than said first voltage level and a third voltage level higher than said second intermediate voltage level, such that when said first, low voltage level is applied between the electrodes, the liquid crystal in the device adopts a focal - conic state (F) associated with a cholesteric phase of the liquid crystal in which light incident on the device is scattered in the liquid crystal, the focal - conic state being stable at said first voltage level;

when the voltage level is increased from said first low voltage level to said second intermediate voltage level, the liquid crystal remains in said stable focal-conic state;

when the voltage level is increased from said second, intermediate voltage level to said third, higher voltage level, the liquid crystal in the device adopts a homeotropic state (H) associated with a nematic phase of the liquid crystal in which light incident on the device is transmitted by the liquid crystal, said homeotropic state being stable at said third voltage level;

when the voltage is reduced from said third, higher voltage level to said second, intermediate voltage level, the liquid crystal remains in said stable homeotropic state, so that the second intermediate, voltage level is associated both with a stable, transmitting state (H') as well as a stable, scattering state (F), the device thus having a bistable transmissivity at this voltage level:

and, when the voltage is reduced from said second intermediate voltage with liquid crystal in said stable, homeotropic state, to said first, low voltage level, the liquid crystal reverts to said stable focal - conic state (F),

whereby the liquid crystal device can be driven to form an image composed of bistable cholesteric (12) and nematic (11) phases respectively scattering and transmitting light incident thereon which can be stably maintained by holding the voltage level at said second intermediate voltage, said image being projectable onto a projection area by an optical system. "

The wording of claim 2 reads as follows:

"2. A remote communication system, comprising a projection - type liquid crystal display device as claimed in claim 1 and means (42 or 43) for transferring data from a remote location to driving means for generating said image on the device."

The wording of claim 3 reads as follows:

"3. An electronic conference system enabling conferencing between remote places, comprising communication means (42 or 45), located at each remote place for communicating said places through at least one of telephone cables and radio systems; and projection type liquid crystal display devices, as claimed in claim 1, each operatively connected to said communication means, at least one liquid crystal display device being used for display in each remote place."

The wording of claim 5 reads as follows:

"5. An overhead projector (51) which comprises a light source and a display device as claimed in claim 1."

The wording of claim 17 reads as follows:

"17. A display method using a liquid crystal panel (1) containing signal and scanning electrodes (X_1, X_2; Y_1, Y_2) and image elements formed of a cholesteric - nematic phase transition type liquid crystal with positive dielectric anisotropy (11,12) held in an enclosed space, the cholesteric - nematic phase transition type liquid crystal comprising a mixture of a nematic liquid crystal and a chiral nematic liquid crystal, having a high transparency nematic phase (11) in a first stable optical state and a low transparency cholesteric phase

(12) in a second stable optical state and having an applied voltage - transparency hysteresis with an extended width, comprising the steps of:

(a) applying a first voltage across each signal electrode (X_1, X_2) and each scanning electrode (Y_1, Y_2) to place all of the liquid crystal panel (1) into the first stable optical state (H);

(b) reducing the voltage applied to selected image elements where writing is to be conducted to a second voltage and holding this applied voltage at the second voltage for a predetermined period of time, said second voltage level being sufficiently low to bring the liquid crystal at the selected portions of the panel to a second stable optical state (F), while at the same time applying a third voltage to those image elements not selected for writing, the third voltage being sufficiently greater than the second voltage to maintain such non- selected image elements in the first stable optical state (H) and being less than the first voltage; and

(c), after step (b) has been completed, applying said third voltage to the selected and the non-selected image elements, to maintain said selected and non- selected image elements stably in their respective second and first stable states for as long as said third voltage is applied ."

Claims 4 and 6 to 16 depend directly or indirectly on claim 1; claim 18 is dependent on claim 17.

VI. The appellant's arguments may be summarised as follows:

Document D3 represented the closest prior art and related to liquid crystal cells which utilised the cholesteric-to-nematic phase transition, contained dielectrically positive liquid crystal material and exploited hysteresis and bistability effects of the liquid crystal. However, the fundamental difference between the disclosure of D3 and the present application was that the hysteresis curves were of different shape. In D3 at zero applied field, the liquid crystal material was bistable, having two possible stable states. Depending on its past history, it could either adopt an S-state (i.e. a Grandjean state), which transmitted light, or a focal - conic state, which scattered light. In the present application the device was monostable at zero applied field. The differences in the hysteresis curves lead to consequent differences in the driving sequences of the respective devices.

Document D2 also related to the same class of device as the present application, namely liquid crystal cells exploiting the cholesteric-to-nematic phase transition. However, the existence of hysteresis was not mentioned and its exploitation via bistability effects was not suggested, whereas both these features play a key role in the present application . The devices of D2 simply switched between two states (G and F) by changing the applied voltage between two values.

D1 related to a device that produced contrast by dynamic scattering or by the storage mode. These effects, associated with materials of negative dielectric anisotropy, were essentially different from the cholesteric-to nematic phase transition relied upon in the device according to the present invention.

Hence, the present invention was novel and inventive both through the properties of the liquid crystal material and through the driving sequences used to operate the device.

Reasons for the Decision

1. The appeal is admissible.

2.1 Claim 1 comprises the following definitions of the two possible states of a liquid crystal which do not appear *verbatim* in the application documents as originally filed:

(i) "when said first, low voltage level is applied between the electrodes, the liquid crystal in the device adopts a focal-conic state (F) associated with a cholesteric phase..." ; and

(ii) "when the voltage level is increased from said second, intermediate voltage level to said third, higher voltage level, the liquid crystal in the device adopts a homeotropic state (H) associated with a nematic phase of the liquid crystal in which light incident on the device is transmitted by the liquid crystal" (emphasis added).

2.2 As to (i), it is pointed out in the application as originally filed (page 11, lines 2 to 4) that by "stopping the application of a voltage..... the image elements ... become the F_0 state or cholesteric phase" (emphasis added). It is known in the art that a liquid crystal in the cholesteric phase can be either in the Grandjean state (i.e. with the helical axis perpendicular to the cell plane) and or in the focal-conic state (i.e. with the helical axis parallel to the cell plane). In the present application (page 11, lines 20 to 24), it is specified that in the cholesteric phase the helical axis of the liquid crystal is perpendicular to the incident light (i.e. parallel to the cell plane) "so that the incident light is scattered by the helical structure of the liquid crystal of the cholesteric phase". This implies that the transition referred to in this application is indeed between the focal-conic state, associated with the cholesteric phase, and the nematic phase.

As to (ii), a liquid crystal material with "positive dielectric anisotropy" necessarily adopts a "homeotropic state" (i.e. with the longitudinal axis perpendicular to the cell walls) when an electric field of sufficient strength is applied between the cell walls, because the liquid crystal molecules tend to align their axes with the applied field perpendicular to the planes of the electrodes (i.e. to the cell walls).

Hence, the Board considers that both (i) and (ii) are implicitly disclosed in the application documents as originally filed.

2.3 The other amendments made to the claims and the description are of minor importance and do not extend the application beyond its original content.

2.4 Hence, all amendments are admissible under Article 123(2) EPC.

3.1 The present application relates, *inter alia*, to a crystal display device comprising a liquid crystal of:

(a) the cholesteric-nematic phase transition type;

with:

(b) positive dielectric anisotropy.

3.2 Feature (a) means essentially that the crystal can be switched between two phases. In the cholesteric phase, the crystal molecules align themselves in separate planes with their longitudinal axes parallel to each other within each plane. The directions of the molecules are, however, twisted gradually from plane to plane. In the nematic phase, the longitudinal axes of the molecules are all parallel.

Feature (b) implies that the molecules tend to align themselves parallel to an applied field.

3.3 In the cholesteric state the liquid crystal molecules scatter incident light and, thus, show low transmittance. On the other hand, crystal molecules in the nematic state are transparent to incident light and, therefore, this state is associated with high transmittance.

A liquid crystal material comprising features (a) and (b) is switched into the nematic state (high transmittance) when a voltage higher than a certain threshold voltage is applied and remains in the cholesteric state (low transmittance) when no voltage or a low voltage is applied.

3.4 The gist of the invention as specified in claim 1 consists essentially in exploiting the hysteresis of the cholesteric-nematic transition of a liquid crystal material so that the material can be kept in one of the two states by an "intermediate voltage" located between the threshold voltage of the cholesteric-to-nematic transition and the threshold voltage of the nematic-cholesteric transition.

4.1 D3, which is considered to represent the closest prior art document, relates explicitly to a reflective mode display (Figure 10) in which light scattered by the scattering regions (i.e. by the regions in the focal-conic state) is seen by the viewer. In a projection-type display according to the present invention, however, (cf. Figure 2B of the present application) the light beams traveling through the transparent portions of the display (i.e. the portions in the nematic state) are focused by an optical system and projected onto a screen, whereas the regions in the focal-conic state scatter the incoming light beams and, thus, appear dark on the screen. On the other hand, it is implicit to a person skilled in the art that the LCD panel structure shown in Figure 9 of D3 can be used as a projection-type LCD.

Furthermore, the liquid crystal device according to D3 comprises the features (a) and (b) referred to above (see 3.1), and is operated between two stable states.

4.2 Hence, document D3 anticipates the combination of features recited in the preamble of claim 1.

4.3 Though the transmission/voltage curve of D3 (see Figure 3) has extended hysteresis, there is no suggestion in D3 to exploit hysteresis and to operate the liquid crystal as a bistable device by using an "intermediate voltage" which would hold the liquid crystal in the state defined by the previously applied voltage. The device according to D3 has two stable states, defined as "scattering texture F_0" and "transparent texture S", which do not require a holding voltage. S is reached through a "rapid passage" (D3, Figure 1) from the transmissive nematic state H' when the applied voltage is switched off. When a voltage pulse lower than a threshold voltage is applied after a time interval greater than the nematic-cholesteric transition time and then removed, the state F_0 is obtained.

4.4 Hence, the subject-matter of claim 1 differs from the device according to D3 essentially in the way the display is driven between two stable states and kept in one of these states by means of the voltage levels specified in the characterising part of claim 1.

5. D2 relates, inter alia, to a display comprising a liquid crystal material which is in the cholesteric-nematic phase transition temperature range and assumes a nematic phase when its molecules align themselves with an applied field. The image portions correspond to the nematic state, whereas complementary background portions are kept in the cholesteric state.

D2 does not mention any hysteresis effect; the initial image is formed by applying an electric field across selected portions of the liquid crystal layer, whereas a "holding field" below the cholesteric-nematic transformation threshold is applied across the entire surface area of the liquid crystal layer in order to maintain the liquid crystal composition in a partially transformed or partially aligned state and, thus, facilitate "reimaging" of the liquid crystal. Hence, the holding field referred to in D2 is not meant to keep selected portions of the liquid crystal in one of two stable states, but it merely controls the image memory and image relaxation characteristics of the whole liquid crystal layer.

6. D1 is less relevant because it relates to a liquid crystal device with negative dielectric anisotropy and does not show any hysteresis effect which could be exploited to make a bistable device.

7. None of the further prior art documents on file suggests using the sequence of low, intermediate and higher voltage levels specified in claim 1 to drive a cholesteric-nematic liquid crystal display device between a cholesteric state of low transmittance and a nematic state of high transmittance and to maintain it in one of these two stable states by exploiting the hysteresis of the transmittance / voltage curve.

8. Hence, the subject-matter of claim 1 involves an inventive step within the meaning of Article 56 EPC.

9.1 Claims 2, 3 and 5 relate to different applications of a liquid crystal display according to claim 1.

The method claim 17 is based essentially on the subject-matter of claim 1 expressed in terms of the steps required to control the phase transitions of a cholesteric-nematic liquid crystal.

9.2 Claims 4, 6 to 16 and 18 are dependent and, therefore, their subject-matters also involve an inventive step.

10. In summary, the Board finds that the appellant's

request complies with the requirements of the EPC and that a patent can be granted on the basis thereof.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of the first instance with the order to grant a patent on the basis of the following documents:

Claims: Nos. 1 to 18 as filed with the letter dated 16 June 2000;

Description: pages 1, 2, 7, 8, 10, 11 and 13 to 15 as originally filed;
page 4 as filed with the letter dated 11 November 1993;
pages 9 and 12 as filed with the letter dated 29 November 1994;
pages 3, 3a, 5, 6, 6a, 6b and 6c as filed with the letter dated 16 June 2000;

Drawings: Sheets 1/5 to 5/5 as originally filed.

The Registrar: The Chairman:

R. Schumacher G. Davies