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D E C I S I O N
of 7 December 1995

Case Number: T 0905/93 - 3.4.2

Application Number: 83103623.1

Publication Number: 0092181

IPC: G02F 1/137, G02F 1/133

Language of the proceedings: EN

Title of invention:
Method for driving liquid crystal element employing
ferroelectric liquid crystal

Patentee:
Hitachi, Ltd.

Opponent:
Avabridge Limited

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), (3), 84, 52(1), 54, 56

Keyword:
"Inventive step - no"

Decisions cited:
-

Catchword:
-



Case Number: T 0905/93 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 7 December 1995

Appellant:
(Opponent)

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Decision under appeal:

**Decision of the Opposition Division of the
European Patent Office dated 6 May 1993 posted
26 July 1993 rejecting the opposition filed
against European patent No. 0 092 181 pursuant to
Article 102(2) EPC.**

Composition of the Board:

Chairman: E. Turrini
Members: R. Zottmann
L. C. Mancini

Summary of Facts and Submissions

- I. The appellant (opponent) lodged an appeal against the decision of the Opposition Division on the rejection of the opposition against the patent No. 0 092 181 (application No. 83 103 623.1).

Opposition was filed against the patent as a whole and based on Article 100(a) EPC in conjunction with Articles 52(1), 54 and 56 EPC.

The Opposition Division held that the grounds for opposition mentioned in Article 100(a) EPC did not prejudice the maintenance of the patent unamended, having regard inter alia to following documents:

- D4: Technology Reports of the Osaka University, Vol. 27, Nos. 1364-1393, October 1977, Faculty of Engineering, Osaka University, Osaka, Japan, K. Yoshino et al.: "Electrical Properties of Ferroelectric Liquid Crystals", No. 1378, pages 427 to 435,
- D8: Applied Physics Letters, Vol. 36, No. 11, 1 June 1980, N.A. Clark et al.: "Submicrosecond bistable electro-optic switching in liquid crystals", pages 899 to 901,
- D9: EP-A-0 032 362, and
- D10: Journal of Applied Physics, Vol. 49, No. 3, March 1978, A. Sussman: "Transport of residual ions and rectification in liquid-crystal displays", pages 1131 to 1138.

- II. The appellant requested that the decision under appeal be set aside and that the patent be revoked.

- III. The respondent (patentee) requested that the appeal be dismissed and that the patent be maintained on the basis of the following documents:

claims:

Nos.: 1, 2 and 3 received during oral proceedings on 7 December 1995,

description:

pages: 2 to 7 of the patent specification, to be adapted to the claims,

drawings:

sheets: 1/10 to 10/10 of the patent specification, to be adapted to the claims.

- IV. The wording of Claims 1 to 3 reads as follows:

"1. A method for driving a liquid crystal element including a ferroelectric liquid crystal (1) interposed between a pair of substrates (121, 122) which have electrodes (11) on their confronting surfaces, characterized in that said method comprises: inducing and maintaining the light transmitting state of said liquid crystal element by applying to said ferroelectric liquid crystal a periodic train of DC voltage pulses, the absolute height of said DC voltage pulses being larger than the threshold voltage (V_c) of said ferroelectric liquid crystal, and applying to said ferroelectric liquid crystal in each period a voltage signal which renders the average value of voltages applied to said ferroelectric crystal during said period equal to zero, said voltage signal having the same absolute value as compared with said DC voltage

pulse and ("and" added by the Board) being applied as compared with the length of the period for a short time immediately before said DC voltage pulse, a polarizer (131, 132) being placed adjacent to at least one of said substrates and wherein the polarization direction (31) of said polarizer adjacent to one of said substrates is made to nearly coincide with the direction of the long molecular axis of said ferroelectric liquid crystal when an electric field exceeding the threshold voltage (V_c) of said ferroelectric liquid crystal is applied.

2. A method according to Claim 1, wherein said ferroelectric liquid crystal includes one selected from a group consisting chiral smectic C-phase liquid crystal and chiral smectic H-phase liquid crystal.

3. A method according to Claim 1, wherein a dichroic dye is mixed into said ferroelectric liquid crystal."

V. The appellant essentially argued as follows:

The subject-matter of the amended Claim 1 lacks clarity in respect to the following points:

- should the case of a bistable LC (liquid crystal) element fall within the scope of the claim, there would be no need of "maintaining the light transmitting state" once it has been induced;
- the expression "threshold voltage" is not clear because ferroelectric LC elements switch in response to the time integral of the driving voltage pulse;

- unclear is also the feature that the "absolute height" of the DC voltage pulses is larger than the threshold voltage of the ferroelectric LC;
- the meaning of the expression "absolute value" with regard to the voltage signal is not defined, in particular with regard to the disclosed preferred embodiments.

The subject-matter of Claim 1 does not involve an inventive step with regard to D8 (or D9) which is considered as the closest prior art. This document discloses a bistable thin ferroelectric LC element. The skilled person having to develop a driving system for such an element will have to consider the problem of degradation of the LC material subjected to DC voltages. He knows that the mechanism of degradation does not depend on whether the element is ferroelectric or nematic, but upon the electro-chemical conditions to which the active material is subjected. In order to avoid said degradation, it would be obvious to balance the DC driving component and to drive the element by means of an AC voltage. Moreover, if the element to be driven is astable, this possibility being covered by Claim 1, the obvious measure of refreshing the LC material by means of a train of pulses would be applied.

VI. The respondent essentially argued as follows:

The present invention relates to a method for driving a ferroelectric LC element which works both in a bistable and an astable regime. None of the cited prior art documents concerning ferroelectric LC elements (see, in particular, D4, D8 and D9) deals with the problem of driving the element, more specifically with the problem of degradation of the LC material. Bipolar balanced driving pulses are known with regard to the nematic

elements. They cannot, however, give a hint at using similar bipolar pulses for ferroelectric LC elements because of the differences between the behaviours of these two kinds of elements: whereas the optical response of ferroelectric LC elements depends on the polarity of the driving signal, in the case of nematic elements the optical response is determined by the root mean square (RMS) of the applied signal.

Reasons for the Decision

1. The appeal is admissible.
2. *Allowability of the amendments (Article 123(2), (3) EPC)*
 - 2.1 Present Claim 1 essentially corresponds to Claim 1 as originally filed with the addition of the following features disclosed in the original application:
 - the light transmitting state of the LC element is induced and maintained by means of a periodic train of DC voltage pulses, the absolute height of which is larger than the ferroelectric LC threshold voltage. This feature is disclosed in Figure 6 and the corresponding description relating to the driving waveforms of an astable ferroelectric LC element, the electro-optical characteristic of which is represented in Figure 5 and the corresponding description;
 - in each period the balancing voltage signal has the same absolute value as compared with the driving DC voltage pulse and is applied, as compared with the length of the period, for a short time immediately before the DC voltage pulse. This feature is supported by the embodiment according to Figure 7;

- a polarizer is placed adjacent to at least one of the substrates of the LC element, the polarization direction of the polarizer being made to nearly coincide with the direction of the long molecular axis of the ferroelectric LC material when an electric field exceeding the threshold voltage of the ferroelectric LC material is applied. This feature is disclosed in the original Claims 8 and 9.

Claims 2 and 3 correspond to the original Claims 6 and 7.

- 2.2 As compared to Claim 1 as granted, the amendments of present Claim 1 consists in the deletion of the alternative that the absolute height of the balancing voltage signal is smaller than the threshold voltage of the ferroelectric LC material, and in the addition of the features concerning the height of the driving DC voltage pulses and the polarizer(s).

The said amendments, therefore, do not result in an extension of the scope of protection.

- 2.3 Accordingly, the amended version of the claims, on the basis of which the respondent requests that the patent be maintained, does not contravene the requirements of Article 123(2) and (3) EPC.

3. *Clarity (Article 84 EPC)*

- 3.1 The appellant states that there would be no need of maintaining the induced light transmitting state if the LC element has a recovery time tending to infinite. In such a case, disclosed on page 6, lines 60 to 63, of the patent in suit, the fact of having to maintain the induced state would be misleading.

This view is not shared by the Board. According to the intention of the respondent, Claim 1 should cover both cases of astable and bistable ferroelectric LC elements. The step of maintaining the induced state is thus essential for LC elements having a finite recovery time and superfluous, but not misleading, in the other case.

- 3.2 The appellant's other objections (see point V. above) concerning the "threshold voltage" of the ferroelectric LC material as well as the "absolute height" and "absolute value" of the applied voltage pulses, although justified from a formal point of view, are not such that a skilled person would not understand the subject-matter of Claim 1 when reading it in the light of the description (Article 69 EPC).

As to the "threshold voltage", it appears from D9 (see page 13, lines 6 to 20) that switching of a ferroelectric LC element driven by a rectangular voltage pulse is actuated depending on the value of the product of the pulse amplitude by the pulse duration. Nevertheless, it is clear that the amplitude will represent the threshold parameter if the duration of the pulse is determined. This can be inferred from the patent in suit (see page 3, lines 13 to 15) stating that ferroelectric LC molecules my respond to a voltage pulse having a pulse width in the order of microsecond if an electric field of sufficient magnitude is applied to the molecules.

As regards the meaning of the expressions "absolute height" and "absolute value", it can be understood in the light of the description, in particular the various embodiments, keeping in mind the threshold behaviour of

the ferroelectric LC elements, as peak value irrespective of the sign of the voltage (see Figures 4 to 6 and page 4, line 47, to page 5, line 2, and, respectively, Figure 7 and page 5, lines 15 to 38).

3.3 Therefore, Claim 1 is sufficiently clear (Article 84 EPC).

4. *Novelty (Article 54 EPC)*

4.1 D4, D8 and D9 relate to ferroelectric LC elements. None of them, however, deals with a method for driving the LC element, in particular taking into account the problem of degradation of the LC material when subjected to DC voltages.

4.2 The other documents cited do not come closer to the claimed subject-matter.

4.3 Therefore, the subject-matter of Claim 1 is new over the cited prior art within the meaning of Article 54 EPC.

5. *Inventive step (Article 56 EPC)*

5.1 Claim 1 refers to a method for driving a ferroelectric LC element. The astable or bistable state in which the element is driven depends on the choice of parameters like the thickness of the LC layer and the operating temperature, which are left undefined in the claim. According to the respondent's submission, the claimed method is, however, intended to cover both cases of astable states, as supported by the electro-optical characteristic according to Figure 5, and bistable states with recovery time tending to infinite, as disclosed on page 6, lines 60 to 63, of the patent in suit.

Depending on the operating state, D4 is considered as the closest prior art for the astable case and D9 (or D8) for the bistable one.

D4 describes a LC element including a ferroelectric LC interposed between a pair of substrates which have electrodes on their confronting surfaces (see Abstract, Section 2, Figures 10 to 12, Table 1). This known LC element essentially corresponds to that of the present invention as the following comparison shows:

- the LC material is L-DOBAMBC and L-DDOBAMBC exhibiting smectic C-phase and smectic H-phase. These materials are also mentioned in the present patent on page 1, lines 5, 6, and Table 1,
- the LC thickness is 9 μm . A gap of approximately 10 μm between the substrates is mentioned in the present patent on page 3, line 65,
- the operating temperature is above 73°C (smectic C-phase) or below 53°C (smectic H-phase). According to the present patent, page 4, lines 1 and 2, the DOBAMBC is operated at 73 to 90°C, at which temperatures it takes the chiral smectic C-phase,
- the applied voltages are up to 30 V. On page 4, line 59, and page 5, line 24, of the present patent voltages up to 15 V and 20 V are envisaged,
- the LC element is placed between crossed nicols, which are equivalent to the polarizers used in the method according to the patent in suit.

D9 (see page 5, line 21, to page 6, line 31, page 13, lines 6 to 20, page 14, lines 19 to 25, page 15, line 18) discloses a LC element including an about 1.2

to 1.5 μm thin ferroelectric LC layer interposed between a pair of cross-polarized substrates which have electrodes on their surfaces. One polarizer is disposed with regard to the direction of the long molecular axis of the ferroelectric LC in the same way as according to Claim 1. The element is bistable, i.e. either of two states may be selected by an appropriate electric field and is stable in the absence of the field, and exhibits a threshold behaviour consisting in that the change from no switching response to full switching response is made over a very small range in the amplitude and duration of the applied field.

D8 is a literature article concerning the same ferroelectric LC element disclosed in D9. The disclosure of D8 is thus equivalent to that of D9.

5.2 Starting from the ferroelectric LC element known from D4 or D9 (or D8), the problem to be solved consists in providing a method for driving the LC element - in an astable or bistable state -, in which degradation of the LC material is prevented.

According to the method of Claim 1, this problem is solved by the steps of inducing and maintaining the light transmitting state by means of a periodic train of above threshold DC voltage pulses and balancing these pulses by applying a voltage signal which renders the average value of voltages applied during each period equal to zero.

The feature concerning the polarizer(s), although placed in the characterizing part of the claim, does not contribute to the solution of the problem. It rather represents a measure permitting to obtain dark and

bright states, which is already known in the prior art (see D9, page 14, lines 19 to 25, D8, page 900, right-hand column, lines 12 to 18, D4, page 428, last paragraph, the crossed nicols acting as polarizers).

5.3 A skilled person wishing to drive an astable LC element, such as known from D4, would realise that the light transmitting state, once induced, has to be maintained, otherwise it would decay (see Figure 5 of the patent in suit). This requirement means that a train of pulses has to be supplied to the element, whereby as far as the choice of the amplitude and duration of the pulses is concerned account must be taken of the known threshold behaviour of ferroelectric LC materials. According to D9 (see page 13, lines 6 to 20), in a 1.5 μm thick HOBACPC element at 88 °C (HOBACPC being a Schiff base which can be used in the present invention - see Table 1, second case, $n = 6$), pulses over the range (0.2 V, 4 μs) to (55 V, 500 ns) actuate switching. It is thus clear that, if DC voltage pulses are used having a given duration, for instance in the order of microsecond according to the present patent, page 3, lines 13 to 15, the amplitude of the driving pulses should be larger than the threshold voltage of the ferroelectric LC material.

In case of a bistable LC element, such as known from D9 (or D8), there is no need of maintaining the induced state because it does not decay. The skilled person would nevertheless consider the possibility of applying a train of driving pulses for two reasons: to avoid undue complications in the driving circuit and to be sure that the induced state is maintained independently of the operation of the element which could vary with the temperature.

Moreover, in both cases of astable and bistable states a train of DC pulses is necessary for driving LC elements in matrix-addressed displays, this possibility falling within the scope of Claim 1.

- 5.4 Due to the application of the driving DC pulses, the LC material is subjected to electro-chemical degradation (see D10).

The appellant has filed with the letter of 27 April 1993, a statutory declaration of Mr P. R. Nailor, a skilled person in the field of the design and manufacture of LC displays using nematic as well as ferroelectric LC materials. On page 6, last paragraph, Mr. Nailor states that the mechanism of degradation of LC materials does not depend upon whether the element is ferroelectric or nematic, but upon the electro-chemical conditions to which the active material is subjected.

During the oral proceedings on 7 December 1995 the respondent, invited to give his opinion on this subject, submitted that at the priority date of the patent in suit ferroelectric LC materials were known, that the phenomenon of degradation of LC materials, in particular Schiff bases referred to in Table 1 of the patent, when subjected to DC voltages was also known, and that the degradation does not depend on the choice of the particular LC material.

Therefore, it is obvious for the skilled person to balance the said DC voltage pulses so that the resulting voltage, in other words the time integral of the voltage applied to the LC element during each period is equal to zero. Such a measure is already used for the nematic LC elements driven by symmetric bipolar pulses. However, a symmetric bipolar signal, the second half of which acts as component balancing the first half inducing the

desired state, would be unsuitable to drive a ferroelectric LC crystal element because the said second half would switch the element. Indeed, a main difference between a nematic and a ferroelectric element consists in the fact that the former shows an electro-optical response depending on the root mean square of the applied signal, whereas the latter is characterized by a response depending on the polarity of the driving signal. The skilled person will, therefore, take care of avoiding that a switch of the LC element be caused by the balancing pulse. In doing this, he will use in each period either a balancing pulse below the ferroelectric LC threshold, which could be placed at any position between two contiguous driving pulses, but not superposed thereon (see, for example, Figure 10 of the patent in suit), or a balancing pulse such as the claimed one which indeed could switch the LC element. In the latter case, the skilled person will place it a short time immediately before the driving pulse, because he will rely on the known fact that the switching caused by the balancing pulse immediately preceding the switching caused by the drive pulse could not be remarked by the human eye.

5.5 It is thus a matter of routine for the skilled person to conceive a method for driving a ferroelectric LC element, as known from D4 or D9 (or D8), comprising the steps of applying a periodic train of drive DC voltage pulses beyond the threshold typical of the LC material and balancing them, as claimed, to avoid the known phenomenon of degradation of the material.

5.6 In the light of the foregoing, the subject-matter of Claim 1 does not involve an inventive step with regard to the document D4 or D9 (or D8) and the knowledge of the skilled person.

6. Since Claim 1 is not allowable, it is not necessary to examine the remaining Claims 2 and 3.
7. The respondent's request is not allowable.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:

P. Martorana

E. Turrini