

Description

The invention relates to a liquid crystal display device comprising two parallel supporting plates which are kept spaced at a distance d and have facing surfaces, a pattern of line electrode being provided on one surface and a pattern of column electrodes being provided on the other surface in such manner that the line electrodes cross the column electrodes and the crossings form a matrix of picture cells, having between the supporting plates a layer of a nematic liquid crystal with a cholesteric addition, said liquid crystal having a positive dielectric anisotropy and a natural pitch p , the said surfaces comprising an orientation layer to provide a progressive molecular twist ϕ of the liquid crystal molecules (director) across the layer thickness d and to give the molecules at one surface an angle of tilt between 0° and 70° and those at the other surface an angle of tilt between 5° and 70° with respect to the surfaces in question, in which device upon applying an electric field the picture cells below an effective electric field strength E_1 are in a first stable state, above an effective field strength E_2 are in a second stable state differing optically herefrom and at an effective field strength E_H between E_1 and E_2 depending on the preceding stable state, may be either in the first stable state, or in the second stable state.

Such display devices are known from EP—A—98070 and are generally operated in multiplex drive with electric voltages according to the so-called r.m.s.-mode. The way of driving is described by Alt and Pleshko in I.E.E.E. Trans. El. Dev., Vol. ED 21, 1974, pp 146—155 and is considered to be the most currently used driving manner for liquid crystal display devices. The maximum number of lines n which can be driven with an acceptable contrast ratio by means of this method is determined by the relationship

$$n_{\max} = \left[\frac{V_2^2 + V_1^2}{V_2^2 + V_1^2} \right]$$

wherein V_2 is the required r.m.s. voltage across a display cell to switch it in the "on" state, and V_1 is the r.m.s. voltage at which the display cell is in the "off" state. According as V_2 and V_1 are closer together, a larger number of lines can be driven, but the time in which the desired contrast ratio is reached also increases. A steep threshold in the transmission/voltage characteristic of the display cell, however, does not say anything about the speed of the optical effect which brings a display cell from a first state to a second state differing optically therefrom. In certain known display devices, a dye is added to the liquid crystal material and there is switched directly between two effective voltage levels, in which the low voltage results in the "off" state, that is the non-light-transmitting state, of the display cell, and the high voltage results in the "on" state, that is the light-transmitting state of the display cell. The

transmission/voltage characteristic of such a display device shows hysteresis and in the said driving method the voltages V_1 and V_2 must be chosen to be on each side of the hysteresis range. The advantage of known display devices is that the displayed information can be observed at a large viewing angle while an acceptable contrast is maintained. As confirmed in the article "Highly Multiplexable Dyed Liquid Crystal Displays" by Waters, Brimmell and Raynes in Proceedings of Japan Display Conference '83, Kobe pp, 396—399, it is possible to achieve by means of standard r.m.s. driving techniques under ideal circumstances a multiplex ratio of at most 1:500 ($n_{\max}=500$). However, in this case the hysteresis effect in the transmission/voltage characteristic is the limiting factor with respect to the maximally possible number of lines which can be driven in time multiplex. The parameters of the liquid crystal, such as the electric constants (k_{11} , k_{22} , k_{33}) influence the width of the hysteresis loop. This should be restricted there to a minimum in order to be able to realize a high multiplex ratio. Another critical factor in the uniformity of the distance d across the surface of the supporting plates. Small thickness variations across the display device reduce the multiplex ratio considerably. Furthermore, the ratio distance/pitch d/p is adapted to the twist of the director across the layer thickness d . This means that the ratio d/p is equal to the ratio $\phi/2\pi$, where ϕ is the twist of the director in radians across the layer thickness d .

It is the object of the invention to provide a liquid crystal display device with which a number of lines which according to present-day concepts is extremely great, can be driven while maintaining a high contrast at a large viewing angle.

In contrast with known display devices in which the hysteresis in the transmission/voltage characteristic is experienced as disadvantageous, the invention uses said hysteresis and notably the fact that two stable states can consist within the hysteresis range at one and the same voltage.

These findings and the physical recognitions in the operation and properties of the liquid crystal display device according to the invention form the basis of the idea that such a display device, with a correct choice of the driving method, is excellently suitable for realizing a display device with a large number of lines which can be driven in time multiplex.

In a display device according to the invention therefore the ratio d/p has a value between 0.6 and 0.9, the twist ϕ of the director has a value between 1.2π and 1.7π , the values of d/p and $\phi/2\pi$ differing at most 10% from each other, the liquid crystal, starting from the first stable state and an effective field-strength E_H across the picture cells, shows a small energy threshold such that with a pulsatory field having an energy content above the said energy threshold a picture cell changes from the first stable state into the second stable state, whereas with a single pulse of the pulsatory field having an energy content below said threshold energy, a picture cell returns to the first

able state via an intermediate metastable state having a certain relaxation period, which device further comprises a line scanning circuit for periodically scanning the line electrodes with a line selection pulse of the voltage V_1 , and comprises column selection means for selecting those picture cells which are to be switched from the first stable state to the second stable state, which column selection means supply to each of the column electrodes a voltage of the value $\pm V_c$, the sign being controlled in such manner that of the picture cells which are connected to an instantaneously scanned line electrode, selected picture cells carry a voltage $V_1 + V_c$ and non-selected picture cells carry a voltage $V_1 - V_c$ while all cells of other lines carry a voltage $\pm V_c$, which voltage pulses of the value $V_1 \pm V_c$ have an energy content which exceeds the said energy threshold, those of the value $V_1 - V_c$ have an energy content lower than the said energy threshold, while the value V_c results in the effective field strength E_H , and which line selection pulse with which a picture cell is driven has a recurrence frequency not exceeding the reciprocal value of the relaxation period, the display device furthermore comprising means for supplying, prior to displaying new information, a blanking pulse to all picture cells in such manner that these are brought in the first stable state. Preferably the ratio d/p has a value between 0.7 and 0.8 and the twist ϕ has a value between 1.4π and 1.6π .

With such a method of driving, a display device according to the invention with more than 1,000 lines can be driven without any problems. With a suitable choice of the liquid crystal material and small tolerances in the manufacture of the display device, the number of lines can be increased to over 4,000. The method of driving does not permit picture cells which are in the "on" state, i.e. the second stable state, from being switched selectively to the "off" state, i.e. the first stable state. For this reason, a blanking pulse is applied to all picture cells with which these cells are brought in the first stable state. Of course this is necessary only at an instant a change has to be carried out in the displayed information.

The optical difference between picture cells in the "on" state and those in the "off" state consists of a difference in the light transmission of the cells. This is obtained by using dichroic dyes, polarisers or a combination thereof. As described in European Patent Application 98070, a dichroic dye may be added to the liquid crystal material so that a display device of the Guest-Host type is obtained. If necessary, for increasing the contrast, a polariser may be provided on the front side, i.e. the side where the light enters the display device. It is furthermore possible to use the display device in the transmission mode or in the reflection mode. This in combination or not in combination with a polariser provided on the front side. In the reflection mode a light-reflecting layer is present on the rear side of the display device. According to again another embodiment the liquid crystal material does not comprise a dic-

hroic dye, but the optical properties of the liquid crystal material, for example birefringence (Δn) and the rotation of the plane of polarization coupled thereto are used. In this case also, the display device may be operated optionally in the transmission mode or in the reflection mode. In the former case the display device is placed between two linear polarisers and the mutual spacing of the polarisers determines whether a selected display cell is displayed as a light cell or as a dark cell with respect to a non-selected display cell. In the latter case the display device comprises a polariser on the front side and a reflector on the rear side or an internal reflector on the inner surface of the rear supporting plate. It is also possible to use two polarisers of which the polariser placed on the rear side is reflecting. The mutual position of the polarisers then determines whether a selected display cell is displayed as light on a dark background or as dark on a light background. In the case of two linear polarisers there may be optimized on the desired colour contrast as a result of the birefracting properties of the liquid crystal material with the mutual position of the polarisers, that is the mutual angular rotation. With respect to a parallel or orthogonal position of the polarisers, deviations up to 45° from the said polariser positions may be necessary depending on the product $d \cdot \Delta n$ for an optimum contrast. With an effect which is partially based on birefringence, contrast is also observed, of course, when one polariser is used in combination with a reflector.

The invention is excellently suitable for liquid crystal display devices having a high information content. This is because more than 2,000 lines can be written within a period in the order of magnitude of 1 second by means of the driving according to the invention which differs essentially from the conventional r.m.s. driving.

The invention will now be described, by way of example, with reference to the drawings, in which:

Figure 1 is a sectional view of a display device according to the invention,

Figure 2 illustrates the operating principle of a display device in accordance with the invention,

Figure 3 shows the transmission/voltage characteristic of the display device shown in Figure 1,

Figures 4a and 4b show the transmission response of a display cell as a result of a voltage pulse having an energy content above the energy threshold, as well as that as a result of a voltage pulse having an energy content below the energy threshold,

Figure 5 illustrates the principle of the manner of driving a liquid crystal display device according to the invention.

The display device shown in Figure 1 comprises two glass supporting plates 1 and 2. The supporting plate 1 comprises a pattern of strip-shaped electrodes 3 consisting of indium-tin oxide. The supporting plate 2 also comprises a pattern of strip-shaped electrodes 4 consisting of indium-tin

10. The electrodes 3 cross the electrodes 4 and the crossings constitute the display cells which are arranged according to a matrix. A silicon layer is vapour-deposited over the surfaces of the supporting plates 1 and 2 comprising electrodes, the layer being deposited at an angle of 80° — 86° to the normal on the surface. The layers constitute the orientation layers 6 and 7. A liquid crystal material 8 consisting of a mixture of the nematic liquid crystal ZLI 1132 of Messrs. E. Merck and the cholesteric addition n-cyano-4'-(2-methyl)-isobutyl-biphenyl (CB 15) is present between the supporting plates. The spacing between the plates is $6.9 \mu\text{m}$ which is maintained by spacing means which are distributed regularly over the surfaces of the plates and are not shown in the drawing. A sealing edge 9 joins the plates together at their circumference. So much n-cyano-4'-(2-methyl)-isobutyl-biphenyl (obtainable under the name of CB 15 from Messrs. BHD-Chemicals) has been added to the nematic liquid crystal that the pitch p of the matrix over which the liquid crystal molecules perform a rotation of 2π radians is approximately $9.2 \mu\text{m}$. The ratio d/p hence is approximately 0.75. The director at the orientation layer 6 is rotated with respect to the director of the layer 7 over an angle ϕ equal to $3/2\pi$. As a result of the obliquely vapour-deposited silicon oxide layers, said directors are not parallel to the surface, but make an angle therewith, the so-called angle of tilt θ , of approximately 30° . Although in the present example the twist ϕ of the liquid crystal has been adapted to the wall condition determined by the orientation layers, this is no necessary condition. In other words, the ratio d/p need not be exactly equal to $\phi/2\pi$. The supporting plates 1 and 2 furthermore each comprise a linear polariser, namely a polariser 10 and a polariser 11. The display cell can be switched from a first stable state to a second stable state differing optically therefrom by driving the electrodes 3 and 4 in a suitable manner. With a parallel position of polariser and analyser, a selected display cell will be white (light-transmitting) on a dark background. By rotating one of the polarisers with respect to the other and a suitable choice of the product $d \cdot \Delta n$, contrasts from deep blue on white to pale yellow on black can optionally be realized by means of the device described.

The way in which switching between the optically mutually differing states can be carried out will now be described with reference to Figures 2 and 3.

Figure 2 gives the tilt θ_m of the director halfway the cell thickness as a function of an electric field E applied across the cell. Below a field strength E_1 the director is substantially parallel to the supporting plates 1 and 2. Above a field strength E_2 the director is rotated over an angle of approximately 90° , which means that the director is substantially at right angles to the supporting plates 1 and 2. When the polarisers are parallel, the display cell assumes the first state below E_1 which in the given position of the polarisers is

non-light-transmitting. This state represents the "off" state. Above a field strength E_2 the display cell assumes the second stable state which in the given position of the polarisers is light-transmitting. This state represents the "on" state. At a field strength between E_1 and E_2 the two states may occur simultaneously as a result of the hysteresis in the characteristic. The way in which this hysteresis is traversed at a field strength which first increases and then decreases is indicated in the characteristic by means of arrows. Coming from a high field strength, the "on" state will exist at the field strength E_H , whereas coming from a low field strength the "off" state will exist at the same field strength E_H . The invention uses this fact by the gained recognition that, starting from the first state and a retaining field E_H across the cell, the latter can be switched to the second state by means of a pulsatory field of low energy content. With a holding field E_H , the angle θ_m in the "off" state and the "on" state is smaller than approximately 18° and higher than approximately 70° , respectively. In order to cause the director of the liquid crystal at this holding field to rotate from 18° to more than 70° , an energy threshold must be overcome. It has been found that when a pulsatory field (pulsatory voltage) is applied, only a small rotation need be bridged, after which the system changes to the second stable state by itself. This means that a short-lasting pulse of a low energy content will suffice to realize a rapid transition from the first to the second state. These states are indicated by T_1 and T_2 in Figure 3, corresponding to the "off" and "on" stages, respectively, of a cell. Figure 3 is quite analogous to Figure 2 and represents the transmission/voltage characteristic of the display cells. Both Figure 2 and Figure 3 show statically taken characteristics in which the holding voltage V_H corresponds to the holding field E_H and a high transmission T corresponds to a large angle of tilt θ_m .

When a short-lasting pulse is applied to a display cell the energy content of which does not exceed the said energy threshold, θ_m and hence the transmission T will initially increase for a moment and will then return to the initial value with a given relaxation period. The two effects described are shown in Figures 4a and 4b. Both Figures show the response of a display cell to a voltage pulse having a pulse duration of 0.2×10^{-3} sec and a strength of 14V with respect to the holding voltage V_H which is approximately 1.6 Volts. The only difference between Figure 4a and Figure 4b is the time scale. Curve A shows the response of a selected display cell to which a voltage pulse of 0.2×10^{-3} sec of the value $(14+1.6)$ Volts has been applied. Said voltage pulse turned out to be sufficient to exceed the energy threshold so that the display cell is brought from the optical state T_1 into the optical state T_2 . Curve B shows the response of a non-selected display cell to which a voltage pulse of 0.2×10^{-3} sec of the value $(14-1.6)$ Volts has been applied. The energy threshold between the states

T_1 and T_2 was not exceeded with this pulse. The transmission initially increases but returns to the initial state T_1 via said metastable phase with a given relaxation period which in this case is approximately 200×10^{-3} sec. In order not to disturb this effect, a second pulse may not be applied to a non-selected cell during said relaxation period because, as appears from Figure 4b, the energy threshold can then yet be exceeded. In order to prevent this, the recurrence frequency with which a display cell is driven may not exceed the reciprocal value of the relaxation period. In the present case this means a maximum recurrence frequency of approximately 5 Hz. This is what the present invention hence distinguishes essentially from the standard r.m.s. driving.

Figure 5 shows the principle of the driving of a display device according to the invention. Three line electrodes K, L and M, as well as three column electrodes D, E and F are shown. A line selection pulse of the value V_l is applied successively to the line electrodes K, L, M, while voltage pulses of the value $\pm V_c$ are applied to all column electrodes. The voltage $\pm V_c$ correspond to the holding voltage V_H of Figure 3 and are approximately 1.6 Volts. The line selection pulses have a value of 14 Volts and a pulse duration of 0.2×10^{-3} sec. Of the display cells which are connected to an instantaneously scanned line electrode, a voltage $V_l + V_c = 15.6$ Volts is presented to the selected cells and a voltage $V_l - V_c = 12.4$ Volts is presented to the non-selected cells. The remaining cells remain at the voltage of 1.6 volts. In the Figure the non-selected cells are shaded with respect to the selected cells.

In the case in which the display device is to display fresh information changed with respect to old information, first all cells are brought in the "off" state by means of a short pulse. A pulse of zero volt and a pulse duration of 50×10^{-3} sec proves to be sufficient for this purpose.

Due to the short pulse duration of 0.2×10^{-3} sec, 5,000 lines can be written in a period of 1 second. Deviations in the cell thickness of the display device up to 2.5% of the nominal cell thickness in the positive or negative sense have no detrimental effect on the operation of the display device. In the case of larger deviations it may occur that the selection criterion with respect to the driving voltages is no longer satisfied because the holding voltage V_H is based on the nominal cell thickness. For cells having a deviating thickness, said holding voltages V_H then becomes located in a different place in or with respect to the hysteresis (see Figure 3).

The data of the embodiments described may be summarized as follows:

Liquid crystal material ZLI 1132 with 1.45% of CB 15 $d=6.9 \mu\text{m}$; $\phi=270^\circ$; $d/p=0.75$; $\theta=30^\circ$ on both surfaces and the holding voltage $V_H=1.6$ V. Other embodiments which satisfy the object of the invention are:

a) Liquid crystal material ZLI 1132+0.68% of CB 15 $d=9 \mu\text{m}$, $\phi=270^\circ$; $d/p=0.5$; $\theta=30^\circ$ on both surfaces and the holding voltage $V_H=1.8$ V.

b) Liquid crystal material ZLI 1132+1.16% of CB 15 $d=6.4 \mu\text{m}$; $\phi=270^\circ$; $d/p=0.6$; $\theta=1^\circ$ and $\theta_2=30^\circ$; holding voltage $V_H=2.3$ V.

c) Liquid crystal material ZLI 1132+1.16% of CB 15 $d=6.4 \mu\text{m}$; $\phi=247^\circ$; $d/p=0.6$; $\theta=30^\circ$ on both surfaces; $V_H=1.6$ V.

d) Liquid crystal material E 1840+1.45% of CB 15 $d=6.4 \mu\text{m}$; $\phi=270^\circ$; $d/p=0.75$; $\theta=30^\circ$ on both surfaces; $V_H=1.6$ V.

Claims

1. A liquid crystal display device comprising two parallel supporting plates which are kept spaced at a distance d and have facing surfaces, a pattern of line electrodes being provided on one surface and a pattern of column electrodes being provided on the other surface in such manner that the line electrodes cross the column electrodes and the crossings form a matrix of picture cells, having between the supporting plates a layer of a nematic liquid crystal with a cholesteric addition, said liquid crystal having a positive dielectric anisotropy and a natural pitch p , the said surfaces comprising an orientation layer to provide a progressive molecular twist ϕ of the liquid crystal molecules (director) across the layer thickness d , and to give the molecules at one surface an angle of tilt between 0° and 70° and those at the other surface an angle of tilt between 5° and 70° with respect to the surfaces in question, in which device upon applying an electric field the picture cells below an effective electric field strength E_1 are in a first stable state, above an effective field strength E_2 are in a second stable state differing optically herefrom and at an effective field strength E_H between E_1 and E_2 depending on the preceding stable state, may be either in the first stable state, or in the second stable state, the ratio d/p has a value between 0.6 and 0.9, the twist ϕ of the director has a value between 1.2π and 1.7π , the values of d/p and $\phi/2\pi$ differing at most 10% from each other, the liquid crystal, starting from the first stable state and an effective field strength E_H across the picture cells, shows a small energy threshold such that with a pulsatory field having an energy content above the said energy threshold a picture cell changes from the first stable state into the second stable state, whereas with a single pulse of the pulsatory field having an energy content below said energy threshold, a picture cell returns to the first stable state via an intermediate metastable state having a certain relaxation period, which device further comprises a line scanning circuit for periodically scanning the line electrodes with a line selection pulse of the voltage V_l , and comprises column selection means for selecting those picture cells which are to be switched from the first stable state to the second stable state, which column selection means supply to each of the column electrodes a voltage of the value $\pm V_c$ the sign being controlled in such manner that of the picture cells which are connected to an instantaneously scanned line electrode, selected picture cells carry a voltage

T_1 and T_2 was not exceeded with this pulse. The transmission initially increases but returns to the initial state T_1 via said metastable phase with a given relaxation period which in this case is approximately 200×10^{-3} sec. In order not to disturb this effect, a second pulse may not be applied to a non-selected cell during said relaxation period because, as appears from Figure 4b, the energy threshold can then yet be exceeded. In order to prevent this, the recurrence frequency with which a display cell is driven may not exceed the reciprocal value of the relaxation period. In the present case this means a maximum recurrence frequency of approximately 5 Hz. This is what the present invention hence distinguishes essentially from the standard r.m.s. driving.

Figure 5 shows the principle of the driving of a display device according to the invention. Three line electrodes K, L and M, as well as three column electrodes D, E and F are shown. A line selection pulse of the value V_l is applied successively to the line electrodes K, L, M, while voltage pulses of the value $\pm V_c$ are applied to all column electrodes. The voltage $\pm V_c$ correspond to the holding voltage V_H of Figure 3 and are approximately 1.6 Volts. The line selection pulses have a value of 14 Volts and a pulse duration of 0.2×10^{-3} sec. Of the display cells which are connected to an instantaneously scanned line electrode, a voltage $V_l + V_c = 15.6$ Volts is presented to the selected cells and a voltage $V_l - V_c = 12.4$ Volts is presented to the non-selected cells. The remaining cells remain at the voltage of 1.6 volts. In the Figure the non-selected cells are shaded with respect to the selected cells.

In the case in which the display device is to display fresh information changed with respect to old information, first all cells are brought in the "off" state by means of a short pulse. A pulse of zero volt and a pulse duration of 50×10^{-3} sec proves to be sufficient for this purpose.

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The data of the embodiments described may be summarized as follows:

Liquid crystal material ZLI 1132 with 1.45% of CB 15 $d=6.9 \mu\text{m}$; $\phi=270^\circ$; $d/p=0.75$; $\theta=30^\circ$ on both surfaces and the holding voltage $V_H=1.6$ V. Other embodiments which satisfy the object of the invention are:

a) Liquid crystal material ZLI 1132+0.68% of CB 15 $d=9 \mu\text{m}$, $\phi=270^\circ$; $d/p=0.5$; $\theta=30^\circ$ on both surfaces and the holding voltage $V_H=1.8$ V.

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c) Liquid crystal material ZLI 1132+1.16% of CB 15 $d=6.4 \mu\text{m}$; $\phi=247^\circ$; $d/p=0.6$; $\theta=30^\circ$ on both surfaces; $V_H=1.6$ V.

d) Liquid crystal material E 1840+1.45% of CB 15 $d=6.4 \mu\text{m}$; $\phi=270^\circ$; $d/p=0.75$; $\theta=30^\circ$ on both surfaces; $V_H=1.6$ V.

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$V_1 - V_0$ and non-selected picture cells carry a voltage $V_1 - V_0$ while all cells of other lines carry a voltage $\pm V_0$, which voltage pulses of the value $V_1 + V_0$ have an energy content which exceeds the said energy threshold, those of the value $V_1 - V_0$ have an energy content lower than the said energy threshold, while the value V_0 results in the effective field strength E_H , and which line selection pulse with which a picture cell is driven has a recurrence frequency not exceeding the reciprocal value of the relaxation period, the display device furthermore comprising means for supplying, prior to displaying new information, a blanking pulse to all picture cells in such manner that these are brought in the first stable state.

2. A liquid crystal display device as claimed in Claim 1, characterized in that the ratio d/p has a value between 0.7 and 0.8 and the twist ϕ has a value between 1.4π and 1.6π .

3. A display device as claimed in Claim 1 or 2, characterized in that a dichroic dye is added to the liquid crystal material.

4. A display device as claimed in Claim 3, characterized in that a polariser is provided on the front supporting plate.

5. A display device as claimed in Claim 3 or 4, characterized in that a reflecting layer is provided on one of the surfaces of the rear supporting plate.

6. A display device as claimed in Claim 1 or 2, characterized in that a polariser is provided on the front supporting plate and a reflecting layer is provided on one of the surfaces of the rear supporting plate.

7. A display device as claimed in Claim 1 or 2, characterized in that a polariser is provided on the front supporting plate and the rear supporting plate.

8. A display device as claimed in Claim 7, characterized in that a reflecting layer is provided on the rear supporting plate.

Patentansprüche

1. Flüssigkristallwiedergabeordnung mit zwei in einem Abstand d voneinander beabstandeten parallelen Trägerplatten mit einander zugewandten Oberflächen, wobei auf einer Oberfläche ein Muster von Zeilenelektroden und auf der anderen Oberfläche ein Muster von Spaltenelektroden derart vorgesehen ist, daß die Zeilenelektroden die Spaltenelektroden kreuzen und die Kreuzungen eine Matrix von Bildzellen bilden, wobei sich zwischen den Trägerplatten eine Schicht nematischen Flüssigkristalls mit einem cholesterischen Zusatz befindet, wobei dieser Flüssigkristall eine positive dielektrische Anisotropie und eine neutrale Ganghöhe p hat, wobei die genannten Oberflächen eine Orientierungsschicht aufweisen zum Bilden eines progressiven Dralls ϕ der Flüssigkristallmoleküle (Direktor) über die Schichtdicke d und zum Erteilen an den Molekülen einer Oberfläche einen Neigungswinkel zwischen 0° und 70° und denen der anderen Oberfläche einen Neigungswinkel zwischen 5°

und 70° gegenüber der betreffenden Oberfläche, wobei in dieser Anordnung beim Zuführen eines elektrischen Feldes die Bildzellen unterhalb einer effektiven elektrischen Feldstärke E_1 sich in einer ersten stabilen Lage befinden, oberhalb einer effektiven Feldstärke E_2 in einer zweiten stabilen Lage sind, die optisch von der ersten abweicht, und bei einer effektiven Feldstärke E_H zwischen E_1 und E_2 , abhängig von dem vorhergehenden stabilen Zustand, entweder in der ersten oder zweiten stabilen Lage, wobei das Verhältnis d/p einen Wert zwischen 0,6 und 0,9 hat, während der Drall ϕ des Direktors einen Wert zwischen $1,2\pi$ und $1,7\pi$ hat und die Werte von d/p und $\phi/2\pi$ um maximal 10% voneinander abweichen, wobei der Flüssigkristall, ausgehend von der ersten stabilen Lage und einer effektiven Feldstärke E_H über die Bildzellen, eine niedrige Energieschwelle zeigt, so daß bei einem impulsförmigen Feld mit einem Energieinhalt über der genannten Energieschwelle eine Bildzelle aus der ersten stabilen Lage in die zweite stabile Lage übergeht, während mit einem einfachen Impuls des impulsförmigen Feldes mit einem Energieinhalt unterhalb der genannten Energieschwelle, eine Bildzelle über eine metastabile Lage mit einer bestimmten Relaxationszeit in die erste stabile Lage zurückkehrt, wobei diese Anordnung weiterhin eine Zeilenabtastschaltung zum periodischen Abtasten der Zeilenelektroden mit einem Zeilenselektionsimpuls der Spannung V_1 aufweist, sowie Spaltenselektionsmittel zum Selektieren derjenigen Bildzellen, die aus der ersten stabilen Lage in die zweite stabile Lage umgeschaltet werden müssen, wobei die Spaltenselektionsmittel jeder der Spaltenelektroden eine Spannung mit dem Wert $\pm V_0$ zuführen, wobei das Vorzeichen derart gesteuert wird, daß von denjenigen Bildzellen, die mit einer augenblicklich abgetasteten Zeilenelektrode verbunden sind, selektierte Bildzellen eine Spannung $V_1 + V_0$ tragen und nicht-selektierte Bildzellen eine Spannung $V_1 - V_0$ tragen, während alle Zellen anderer Zeilen eine Spannung $\pm V_0$ tragen, deren Spannungsimpulse mit dem Wert $V_1 + V_0$ einen Energieinhalt aufweisen, der die genannte Energieschwelle überschreitet, während diejenigen mit dem Wert $V_1 - V_0$ einen Energieinhalt aufweisen, der niedriger ist als die genannte Energieschwelle, während der Wert V_0 zu der effektiven Feldstärke E_H führt, und wobei der Zeilenselektionsimpuls, mit dem eine Bildzelle gesteuert wird, eine Wiederholungsfrequenz hat, die den Reziprokwert der Kippschwingperiode nicht überschreitet, wobei die Wiedergabeordnung weiterhin Mittel aufweist um vor der Wiedergabe von neuer Information allen Zellen ein Austastimpuls zugeführt wird, derart, daß diese in die erste stabile Lage gebracht wird.

2. Flüssigkristallwiedergabeordnung nach Anspruch 1, dadurch gekennzeichnet, daß das Verhältnis d/p einen Wert zwischen 0,7 und 0,8 hat und der Drall ϕ einen Wert zwischen $1,5\pi$ und $1,6\pi$ hat.

3. Wiedergabeordnung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß dem Flüssigkristall



sigkristallmaterial ein dichroischer Farbstoff zuge-
setzt wird.

4. Wiedergabeordnung nach Anspruch 3,
dadurch gekennzeichnet, daß auf der vorderen
Trägerplatte ein Polarisator vorgesehen ist.

5. Wiedergabeordnung nach Anspruch 3 oder
4, dadurch gekennzeichnet, daß auf einer der
Oberflächen der hinteren Trägerplatte eine Refle-
xionsschicht vorgesehen ist.

6. Wiedergabeordnung nach Anspruch 1 oder
2, dadurch gekennzeichnet, daß auf der vorderen
Trägerplatte ein Polarisator und auf einer der
Oberflächen der hinteren Trägerplatte eine Refle-
xionsschicht vorgesehen ist.

7. Wiedergabeordnung nach Anspruch 1 oder
2, dadurch gekennzeichnet, daß auf der vorderen
Trägerplatte und auf der hinteren Trägerplatte ein
Polarisator vorgesehen ist.

8. Wiedergabeordnung nach Anspruch 7,
dadurch gekennzeichnet, daß auf der hinteren Trä-
gerplatte eine Reflexionsschicht vorgesehen ist.

Revendications

1. Dispositif d'affichage à cristal liquide compor-
tant deux plaques de support parallèles qui sont
maintenues espacées d'une distance d et qui
présentent des surfaces situées en vis-à-vis, une
configuration d'électrodes de ligne étant disposée
sur une surface et une configuration d'électrodes
de colonne étant disposée sur l'autre surface de
façon que les électrodes de ligne croisent les
électrodes de colonne et les croisements formant
une matrice de cellules image présentant, entre les
plaques de support, une couche en un cristal
liquide nématique avec une addition cholestéri-
que, ledit cristal liquide présentant une anisotropie
diélectrique positive et un pas naturel p , lesdites
surfaces comportant des couches d'orientation
pour conférer aux molécules de cristal liquide
(directeur) une torsion moléculaire progressive ϕ
sur l'épaisseur de couche d et pour conférer aux
molécules sur une surface un angle de bascule-
ment compris entre 0° et 70° et aux celles à l'autre
surface un angle de basculement compris entre 5°
et 70° par rapport aux surfaces en question,
dispositif dans lequel, lors de l'application d'un
champ électrique, au-dessous d'une intensité de
champ électrique effective E_1 , les cellules d'image
sont dans un premier état stable, lors de l'applica-
tion d'un champ électrique au-dessus d'une inten-
sité de champ effective E_2 , les cellules sont dans un
deuxième état stable qui en diffère optiquement et
à une intensité de champ effective E_H comprise
entre E_1 et E_2 suivant l'état stable précédent les
cellules sont soit dans le premier état stable, soit
dans le deuxième état stable, le rapport d/p
présente une valeur comprise entre 0,6 et 0,9, la
torsion ϕ du directeur ayant une valeur comprise
entre $1,2\pi$ et $1,7\pi$, les valeurs de d/p et de $\phi/2\pi$
diffèrent d'au maximum 10% l'une de l'autre, le
cristal liquide, partant du premier état stable et
d'une intensité de champ effective E_H aux extré-
mités des cellules d'image, montre un petit seuil
d'énergie tel qu'avec un champ pulsé présentant

une capacité énergétique supérieure audit seuil
d'énergie une cellule d'image passe du premier
état stable au deuxième état stable, alors qu'avec
une seule impulsion du champ pulsé présentant
une capacité énergétique inférieure à ladite éner-
gie de seuil, une cellule image retourne au premier
état stable via un état métastable intermédiaire
présentant une certaine période de relaxation, ce
dispositif présentant en outre un circuit de
balayage de ligne pour le balayage périodique des
électrodes de ligne avec une impulsion de sélec-
tion de lignes de la tension V_1 et comporte des
moyens de sélection des colonnes pour la sélec-
tion des cellules d'image devant être commutées
du premier état stable au deuxième état stable,
lesquels moyens de sélection de colonnes fournis-
sent à chacune des électrodes de colonne une
tension de la valeur $\pm V_0$, le signe étant réglé de
façon que les cellules d'image sélectionnées parmi
les cellules d'image reliées à une électrode de
ligne momentanément balayée présentent une
tension $V_1 + V_0$ et les cellules d'image non sélec-
tionnées présentent une tension $V_1 - V_0$, alors que
toutes les cellules des autres lignes présentent une
tension $\pm V_0$, lesquelles impulsions de tension de
la valeur $V_1 + V_0$ présentent une capacité énergi-
que qui dépasse ledit seuil d'énergie, celles des
valeurs $V_1 - V_0$ présentent une capacité énergi-
que inférieure audit seuil d'énergie, alors que la
valeur V_0 a pour résultat l'intensité de champ
effective E_H et l'impulsion de sélection des lignes
avec laquelle est commandée une cellule d'image
présente une fréquence de récurrence qui ne
dépasse pas la valeur réciproque de la période de
relaxation, le dispositif d'affichage comportant en
outre des moyens pour délivrer avant la reproduc-
tion de nouvelle information, une impulsion de
suppression à toutes les cellules d'image de façon
que celles-ci soient portées au premier état stable.

2. Dispositif d'affichage à cristal liquide selon la
revendication 1, caractérisé en ce que le rapport d/p
présente une valeur comprise entre 0,7 et 0,8 et la tor-
sion ϕ présente une valeur comprise entre $1,4\pi$ et $1,6\pi$.

3. Dispositif d'affichage selon la revendication 1
ou 2, caractérisé en ce qu'un colorant dichroïque
est ajouté au matériau cristallin liquide.

4. Dispositif d'affichage selon la revendication 3,
caractérisé en ce qu'un polariseur est disposé sur
la plaque de support avant.

5. Dispositif d'affichage selon la revendication 3
ou 4, caractérisé en ce qu'une couche réflectrice
est appliquée sur l'une des surfaces de la plaque
de support arrière.

6. Dispositif d'affichage selon la revendication 1
ou 2, caractérisé en ce qu'un polariseur est disposé
sur la plaque de support avant et une couche
réflectrice est appliquée sur l'une des surfaces de
la plaque de support arrière.

7. Dispositif d'affichage selon la revendication 1
ou 2, caractérisé en ce qu'un polariseur est appli-
qué sur la plaque de support avant et la plaque de
support arrière.

8. Dispositif selon la revendication 7, caractérisé
en ce qu'une couche réflectrice est appliquée sur la
plaque de support arrière.

