

Description

The invention relates to supertwist liquid crystal displays (SLD) having very short switching times and good steepness and angle dependence, and also to the novel nematic liquid crystal mixtures used therein.

SLD according to the preamble are known, for example from EP 0,131,216 B1; DE 3,423,993 A1; EP 0,098,070 A2; M. Schadt and F. Leenhouts, 17th Freiburger Arbeitstagung Flüssigkristalle [Freiburg Working Meeting on Liquid Crystals] (8.-10.04.87); K. Kawasaki et al., SID 87 Digest 391 (20.6); M. Schadt and F. Leenhouts, SID 87 Digest 372 (20.1); K. Kato et al., Japanese Journal of Applied Physics, volume 26, No. 11, L 1784-L 1786 (1987); F. Leenhouts et al., Appl. Phys. Lett. 50 (21), 1468 (1987); H.A. van Sprang and H.G. Koopman, J. Appl. Phys. 62 (5), 1734 (1987); T.J. Scheffer and J. Nehring, Appl. Phys. Lett. 45 (10), 1021 (1984), M. Schadt and F. Leenhouts, Appl. Phys. Lett. 50 (5), 236 (1987) and E.P. Raynes, Mol. Cryst. Liq. Cryst. Letters volume 4 (1), pages 1-8 (1986). The term SLD here comprises any more highly twisted display element with an amount of twist angle between 100° and 600°, such as, for example, the display elements according to Waters et al. (C.M. Waters et al., Proc. Soc. Inf. Disp. (New York) (1985) (3rd Intern. Display Conference, Kobe, Japan), the STN-LCD (German Offenlegungsschrift 3,503,259), SBE-LCD (T.J. Scheffer and J. Nehring, Appl. Phys. Lett. 45 (1984) 1021), OMI-LCD (M. Schadt and F. Leenhouts, Appl. Phys. Lett. 50 (1987), 236, DST-LCD (European Published Application 0,246,842) or BW-STN-LCD (K. Kawasaki et al., SID 87 Digest 391 (20.6)).

Compared with standard twisted nematic displays, SLD of this type are distinguished by substantially better steepness of the electro-optical characteristic and thus associated better contrast values and by a substantially smaller angle dependence of the contrast. SLD with very short switching times are here of particular interest, especially also at relatively low temperatures. To achieve short switching times, the

viscosities of the liquid crystal mixtures have hitherto been optimized with the use of, in most cases, monotropic additives having a relatively high vapour pressure. However, the switching times achieved were not adequate
5 for some applications.

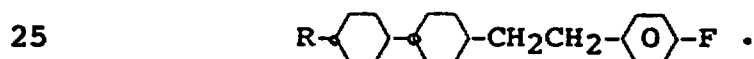
To achieve a steep electro-optical characteristic, the liquid crystal mixtures should have relatively wide values for K_3/K_1 and relatively small values for $\Delta\epsilon/\epsilon_{\perp}$.

10 Beyond the optimization of the contrast and switching times, mixtures of this type have to meet further important demands:

1. a wide d/p window
2. a high chemical fatigue stability
- 15 3. a high electrical resistance
4. a low frequency dependence of the threshold voltage.

The parameter combinations achieved are not yet nearly sufficient, in particular for high-multiplex STN (1/400). In part, this is to be ascribed to the fact that
20 the various demands are affected in opposite directions by material parameters.

In EP 0,366,985, liquid crystal mixtures for STN displays are described, which have terminally fluorinated compounds of the formula



The mixtures described therein do not, however, meet all technical requirements. This also applies to the STN displays described in EP 0,261,614, whose liquid crystal mixtures contain compounds which are terminally substituted by NCS.
30

In EP 0,365,962, liquid crystal mixtures for active matrix applications are proposed which, however, have a relatively low content of cyano compounds and therefore frequently show disadvantageous values for the
35 threshold voltage.

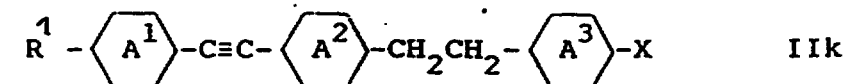
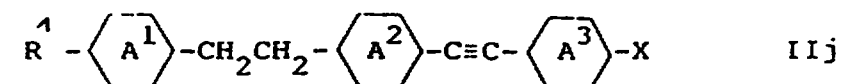
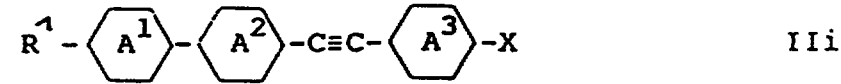
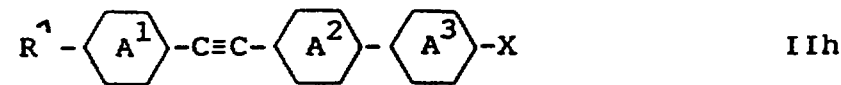
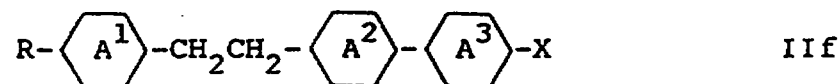
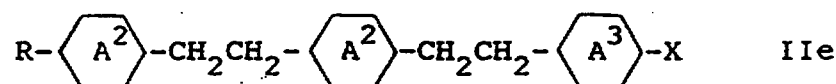
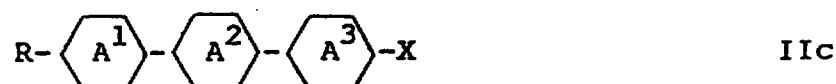
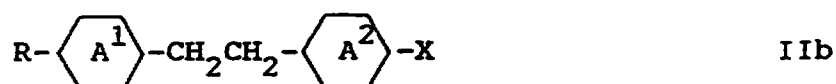
There is thus still a great demand for SLD which have very short switching times coupled with, at the same

time, a wide range of working temperatures, high steepness of the characteristic, good angle dependence of the contrast and low threshold voltage and which meet the demands given above.

- 5 The invention is based on the object of providing SLD which show the above-indicated disadvantages only to a smaller extent or not at all and, at the same time, have very short switching times.

10 It has now been found that this object can be achieved if the nematic liquid crystal mixture

- a) is based on component A containing one or more compounds selected from group A comprising compounds of the formulae IIa-IIc and IIe-IIk:



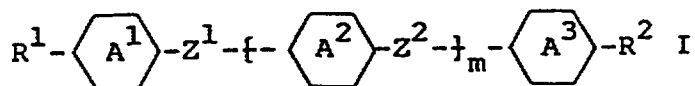
15 in which R is n-alkyl or n-alkenyl having up to 9 C atoms,

X is F, Cl, $-\text{CF}_3$, $-\text{CHF}_2$, $-\text{OCF}_3$, $-\text{OCHF}_2$,

-OCF₂CF₂H or -OC₂F₅, and

the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene, or one of the rings A¹, A² and A³ can also be 1,4-cyclohexenylene, 2,3-difluoro-1,4-phenylene, pyridine-2,5-diyl or pyrimidine-2,5-diyl,

- b) contains 0-40% by weight of a liquid-crystalline component B, consisting of one or more compounds having a dielectric anisotropy of -1.5 to +1.5, of the general formula I



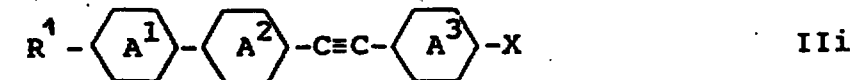
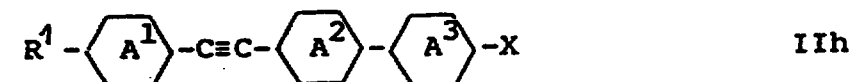
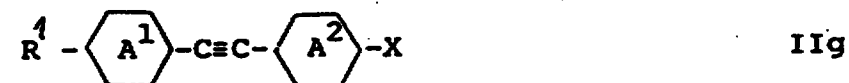
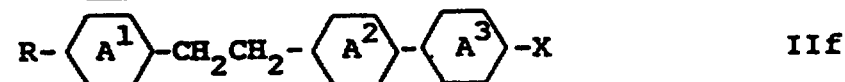
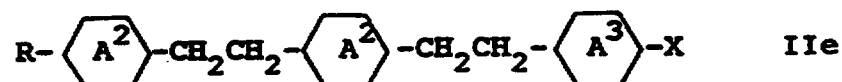
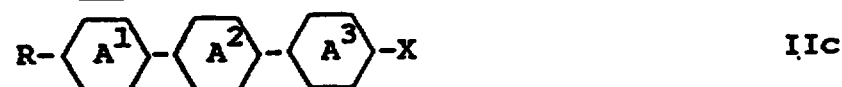
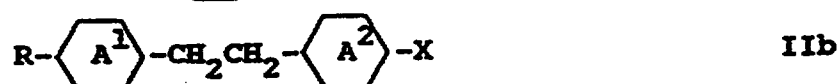
in which R¹ and R² each independently of one another are n-alkyl, n-alkoxy, n-oxa-alkyl, ω-fluoroalkyl or n-alkenyl having up to 9 C atoms, the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, trans-1,4-cyclohexylene or 1,4-cyclohexenylene, Z¹ and Z² each independently of one another are -CH₂CH₂-, -C≡C- or a single bond, and m is 0, 1 or 2,

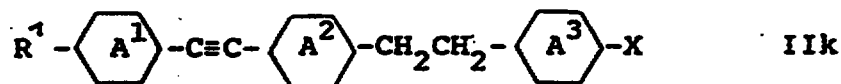
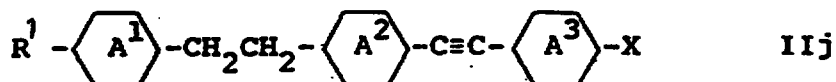
- c) contains 0 = [sic] 20% by weight of a liquid-crystalline component C consisting of one or more compounds having a dielectric anisotropy below -1.5, and
- d) contains an optically active component D in such a quantity that the ratio of cell thickness (spacing of the plane-parallel carrier plates) to the natural pitch of the chiral nematic liquid crystal mixture is approximately 0.2 to 1.7 and in particular approximately 0.2-1.3,
- the nematic liquid crystal mixture has a nematic phase range of at least 60°C, a viscosity of not

more than 35 mPa.s and a dielectric anisotropy of at least +1, the dielectric anisotropies of the compounds and the parameters relating to the nematic liquid crystal mixture referring to a temperature of 20°C.

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- The invention thus relates to an SLD with
- two plane-parallel carrier plates which, with a frame, form a cell,
 - a nematic liquid crystal mixture, located in the cell, having a positive dielectric anisotropy,
 - 10 - electrode layers with superposed orientation layers on the insides of the carrier plates,
 - a tilt angle of about 1 degree to 30 degrees between the longitudinal axis of the molecules at the surface of the carrier plates and the carrier plates,
 - 15 and
 - a twist angle of the liquid crystal mixture in the cell from orientation layer to orientation layer of an amount between 100 and 600°, characterized in that the nematic liquid crystal mixture
 - 20 a) is based on component A containing one or more compounds selected from group A comprising compounds of the formulae IIa-IIc and IIe-IIk:



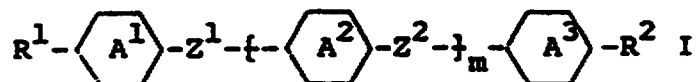


in which R is n-alkyl or n-alkenyl having up to 9 C atoms,

X is F, Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₃H or -OC₂F₅, and

the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene, or one of the rings A¹, A² and A³ can also be 1,4-cyclohexenylene, 2,3-difluoro-1,4-phenylene, pyridine-2,5-diyl or pyrimidine-2,5-diyl,

b) contains 0-40% by weight of a liquid-crystalline component B, consisting of one or more compounds having a dielectric anisotropy from -1.5 to +1.5, of the general formula I



in which R¹ and R² each independently of one another are n-alkyl, n-alkoxy, n-oxaalkyl, ω-fluoroalkyl or n-alkenyl having up to 9 C atoms, the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, trans-1,4-cyclohexylene or 1,4-cyclohexenylene,

Z¹ and Z² each independently of one another are -CH₂CH₂-, -C≡C- or a single bond, and

m is 0, 1 or 2,

c) contains 0-20% by weight of a liquid-crystalline component C consisting of one or more compounds having a dielectric anisotropy below -1.5, and

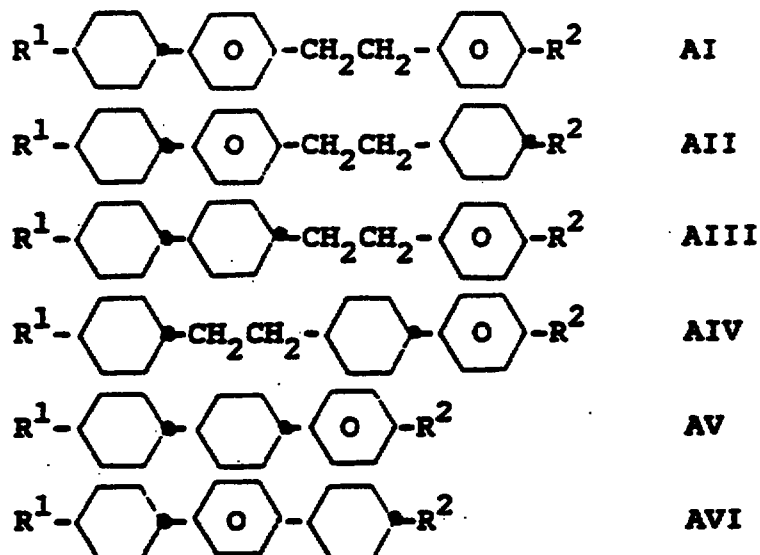
- d) contains an optically active component D in such a quantity that the ratio of cell thickness (spacing of the plane-parallel carrier plates) to the natural pitch of the chiral nematic liquid crystal mixture is about 0.2 to 1.7 and in particular 0.2 to 1.3, and
- in that the nematic liquid crystal mixture has a nematic phase range of at least 60°C, a viscosity of not more than 35 mPa.s and a dielectric anisotropy of at least +1, the dielectric anisotropies of the compounds and the parameters relating to the nematic liquid crystal mixture referring to a temperature of 20°C.

The invention also relates to liquid crystal mixtures of the composition given with the definition of the SLD according to the invention, characterized in that these have a high dielectric anisotropy of $\Delta\epsilon > 5$ and a high content of cyano compounds of more than 20% by weight and less than 50% by weight.

The individual compounds of, for example, the formulae I and IIa to IIk or also other compounds which can be used in the SLD according to the invention are either known or can be prepared analogously to the known compounds.

Preferred liquid crystal mixtures contain

- a) at least one component selected from group B4 comprising compounds of the formulae AI to AVI:

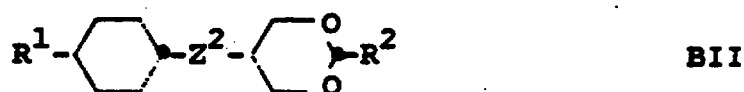


in which R¹ and R² each independently of one another are R and

R is alkyl having 1-12 C atoms, and in which one or two non-adjacent CH₂ groups can also be replaced

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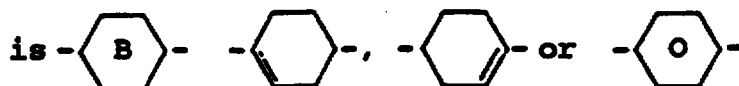
b) by -O-, -CH=CH-, -CO-, -O-CO- or -CO-O-, and/or at least one component selected from group B1 comprising the compounds of the formulae BI to BIV:



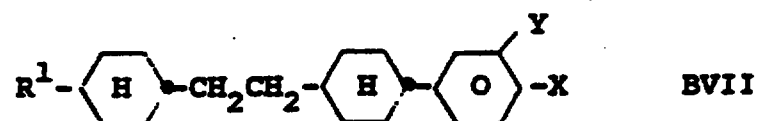
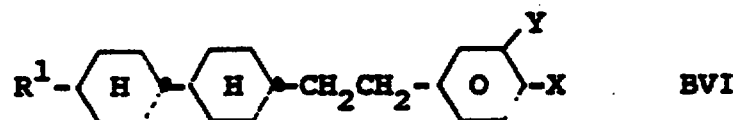
in which R¹ and R² each independently of one another have the meaning given for R,

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Z² is -CH₂CH₂-, -CO-O-, -O-CO- or a single bond, and



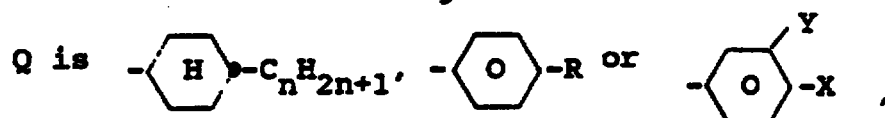
and/or at least one component selected from group B2 comprising the compounds of the formulae BV to BVII:



in which R¹ has the meaning given for R,

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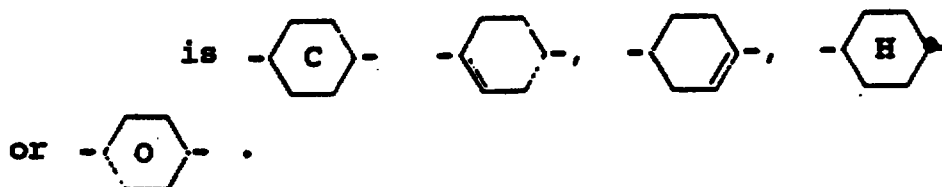
Z⁰ is -CH₂CH₂- or a single bond and



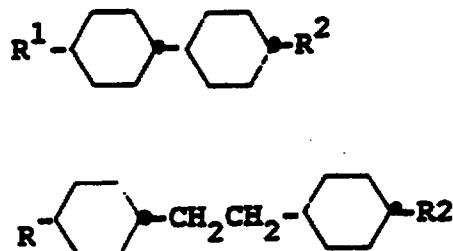
n being 1 to 9, X being CN or F and Y being H or F, and/or at least one component selected from group B3 comprising the compounds of the formulae BVIII and BIX:



in which R¹ and R² each independently of one another have the meaning given for R, and



10 Particularly preferred compounds of the formula BIII are those of the following partial formulae:



in which

R¹ is CH₃-(CH₂)_n-O-, CH₃-(CH₂)_t-, trans-H-(CH₂)_r-CH=CH-(CH₂CH₂)_s-CH₂O- or trans-H-(CH₂)_r-CH=CH-(CH₂CH₂)_s-,

R² is CH₃-(CH₂)_t-,

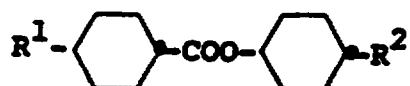
n is 1, 2, 3 or 4,

r is 0, 1, 2 or 3,

s is 0 or 1 and

20 t is 1, 2, 3 or 4.

Those compounds of the partial formula



in which R^1 and R^2 have the meanings given above, are also preferred.

The proportion of the compounds of the formula BIII of the above-indicated partial formulae is preferably about 5% to 45%, especially preferably about 10% to 35%. Particularly preferred compounds of the formula BIV are those of the following partial formula:



in which

R^1 is $\text{CH}_3 - (\text{CH}_2)_n - \text{O} -$ or
 10 $\text{trans-H} - (\text{CH}_2)_r - \text{CH} = \text{CH} - (\text{CH}_2\text{CH}_2)_s - \text{CH}_2\text{O} -$ and R^2 is
 $\text{CH}_3 - (\text{CH}_2)_t -$,
 n being 1, 2, 3 or 4,
 r being 0, 1, 2 or 3,
 s being 0 or 1 and
 15 t being 1, 2, 3 or 4.

The proportion of these compounds or of the compounds of the formula BIV is preferably about 5% to 40%, especially preferably about 10% to 35%.

Preferably, the mixtures contain compounds of the formula III, in particular those of the partial formula



In a particularly preferred embodiment, the mixtures simultaneously contain compounds of the formulae BIII and BIV, the total proportion of components of group B1 remaining unchanged.

If compounds of the formulae BI and/or BIII are present, R^1 and R^2 preferably each independently of one another are n -alkyl having 1 to 7 C atoms or (trans)- n -alkenyl having 3 to 7 C atoms. Z^2 is preferably a single bond. BI is particularly preferred.

Those mixtures according to the invention are also preferred which contain one or more compounds of the

formula BIV, in which

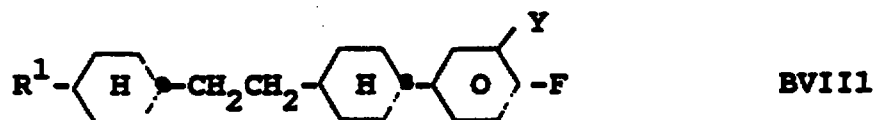
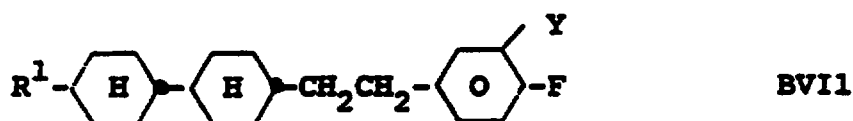
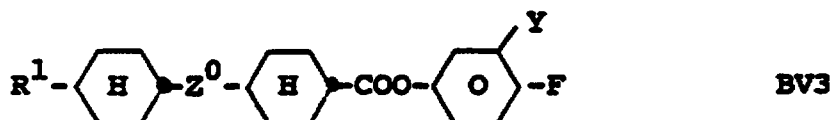
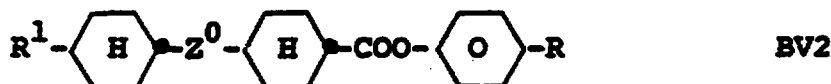
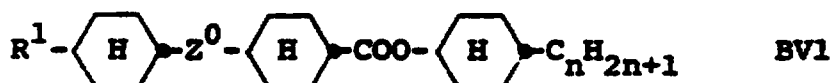
is ,  or  and R¹ and R² have one of the preferred meanings given above, especially preferably n-alkyl having 1 to 7 C atoms.

5 In any case, the total proportion of components of group B1 remains unchanged.

The proportion of compounds of group B2 is preferably about 5% to 45%, especially preferably 5% to 20%. The proportion (preferred ranges) of BV to BVII is
10 as follows:

BV about 5% to 30%, preferably about 5% to 15%
total of BVI and BVII: about 5% to 25%, preferably about 10% to 20%.

15 Preferred compounds of group B2 are indicated below:

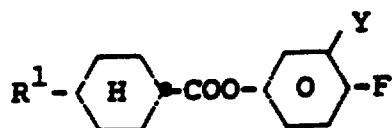
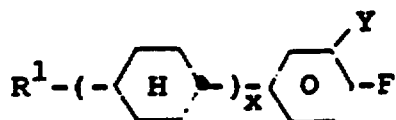


R¹ is preferably n-alkyl having 1 to 7 C atoms or (trans)-n-alkenyl having 3 to 7 C atoms. Z⁰ is preferably a single bond. R preferably has the preferred meaning given above for R¹ or is fluorine. Y is preferably
20 fluorine.

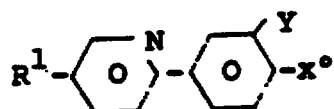
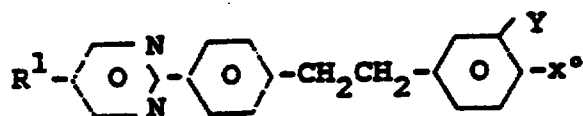
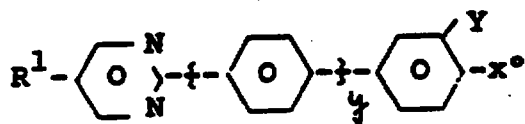
Preferably, the mixtures according to the invention contain one or more compounds selected from the group comprising BV3, BVII and BVIII in a total

proportion of about 5 to 35%.

In a particularly preferred embodiment, the mixtures according to the invention contain, in addition to BV3, BVII, BVIII and BV2 (R = A), further terminally
5 fluorinated compounds selected, for example, from the group comprising:



and/or polar heterocycles selected from the group comprising



10 in which R¹ is preferably n-alkyl having 1 to 7 C atoms or (trans)-n-alkenyl having 3 to 7 C atoms, x is 1 or 2, x[°] is F, Cl, CF₃, -OCF₃, or -OCHF₂, y is 0 or 1 and Y is H or F.

15 The total proportion of all the terminally fluorinated compounds is preferably about 5% to 65%, especially about 15% to 40%.

The proportion of the compounds from group B3 is preferably about 5% to 30%, especially preferably about 10% to 20%. R¹ is preferably n-alkyl or n-alkoxy each

having 1 to 9 C atoms. R² is preferably n-alkyl having 1 to 9 C atoms. However, analogous compounds with alkenyl or alkenyloxy groups can also be used. Compounds of the formula BVIII are preferred.

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 is preferably 1,4-phenylene.

The mixtures according to the invention contain compounds from at least one of groups B1, B2 and B3. Preferably, they contain one or more compounds from group B1 and one or more compounds from group B2 and/or B3.

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Isothiocyanates, for example of the formula

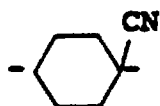


C atoms or n-alkenyl having 3 to 7 C atoms, are also preferred.

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In a particularly preferred embodiment, the mixtures according to the invention contain preferably about 5% to 20% of one or more compounds having a dielectric anisotropy below -1.5 (component D). Compounds of this type are known, for example derivatives of 2,3-dicyanohydroquinone or cyclohexane derivatives having the structural element

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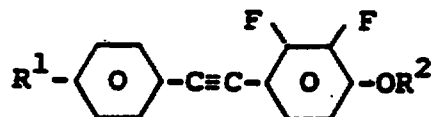
according to German Offenlegungsschrift

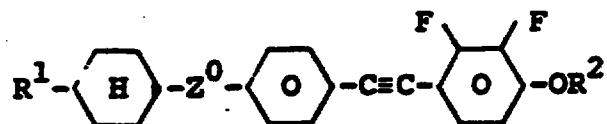
3,231,707 or 3,407,013.

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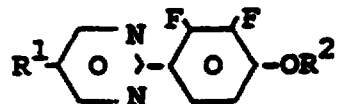
Preferably, however, compounds having the structural element 2,3-difluoro-1,4-phenylene are selected, for example compounds according to German Offenlegungsschriften 3,807,801, 3,807,861, 3,807,863, 3,807,864 or 3,807,908. Particularly preferred are tolans having the structural element according to International Patent Application PCE/DE 88/00,133, in particular those of the formulae

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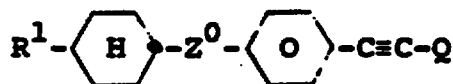


in which R^1 and R^2 each independently of one another are preferably n-alkyl having 1 to 7 C atoms or n-alkenyl having 3 to 7 C atoms and Z^0 is $-\text{CH}_2\text{CH}_2-$ or a single bond, and phenylpyrimidine of the formula



5 corresponding to German Offenlegungsschrift 3,807,871.

In a particularly preferred embodiment, the mixtures contain about 5% to 35%, especially preferably about 10% to 20%, of liquid-crystalline tolan compounds. As a result, it is possible to use smaller cell thick-
 10 nesses (about 5-6 μm), whereby the switching times are markedly shortened. Particularly preferred tolanes are shown below:



R^1 is preferably n-alkyl or n-alkoxy having 1 to 7 C atoms,

15 Z^0 is $-\text{CH}_2\text{CH}_2-$ or a single bond,

Q is $-\text{C}_6\text{H}_4 - \text{R}^2$, $-\text{C}_6\text{H}_4 - \text{X}$ or $-\text{C}_6\text{H}_3\text{F}_2 - \text{X}$,

X being F, Cl or OCF_3 ,

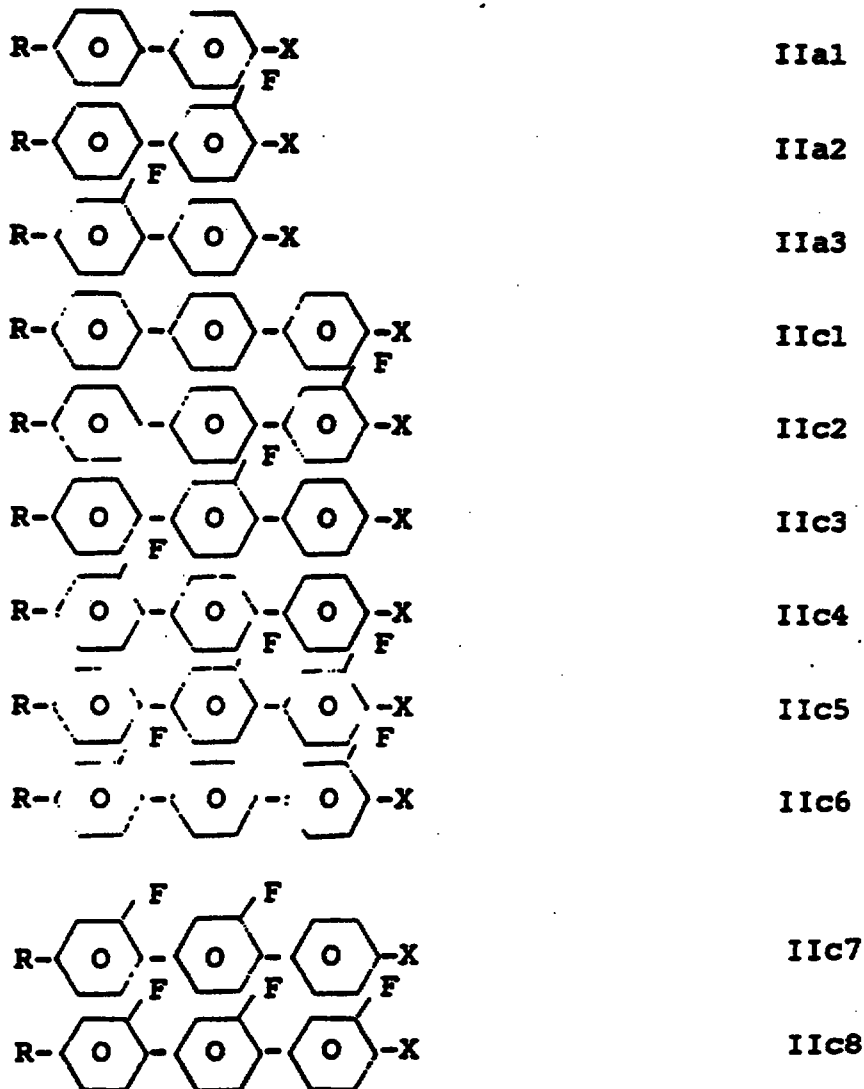
R^2 being n-alkyl or n-alkoxy each having 1 to 7 C atoms or n-alkenyl or n-alkenyloxy each having 3 to 7 C
 20 atoms.

Further particularly preferred embodiments are given below:

- component A contains compounds of the formulae IIa to IIg, in which X is cyano, and compounds of the
 25 formulae IIa to IIg, in which X is $-\text{NCS}$, F, Cl, $-\text{CF}_3$, $-\text{CHF}_2$, $-\text{OCF}_3$, $-\text{OCHF}_2$, $-\text{OCF}_2\text{CF}_2\text{H}$ or $-\text{OC}_2\text{F}_5$, and the proportion of the cyano compounds in component

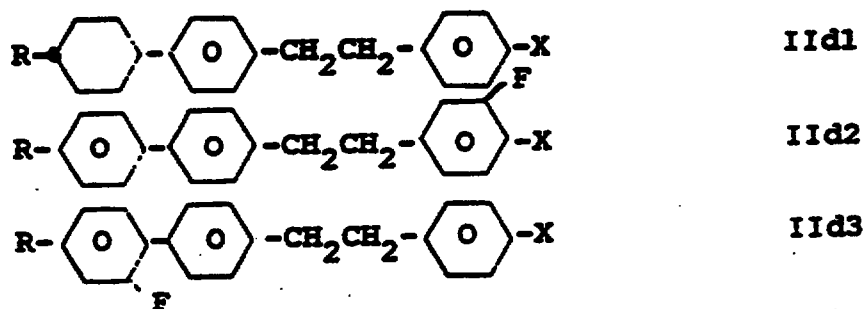
A is 0 to 50% by weight,

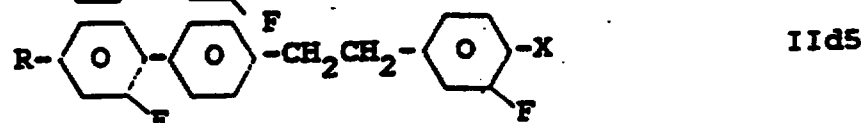
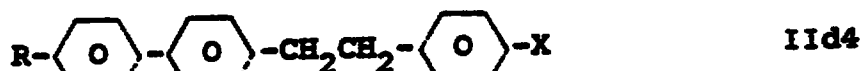
component A contains one or more compounds of the formulae IIa1-IIa3 and IIc1-IIc8



in which R is n-alkyl, n-alkoxy or n-alkenyl having 1-9 C atoms and X is F, Cl or OCF₃.

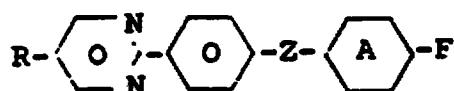
Component A contains at least one compound of the formula IIId1-IIId5





in which R is $\text{C}_n\text{H}_{2n+1}$ or $\text{C}_n\text{H}_{2n+1}-\text{C}_6\text{H}_4-$ with $n = 1-10$ and X is F, Cl or OCF_3 , and very especially F.

- Component A contains no compounds of the formulae IIa to IIf, in which X is cyano,
- 5 - Component A contains one or more compounds of the formula



in which

10 R is n-alkyl, n-alkoxy or n-alkenyl having 1-9 C atoms or

Z is $-\text{CH}_2\text{CH}_2-$ or a single bond and

$-\text{A}-$ is 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or 1,4-cyclohexylene.

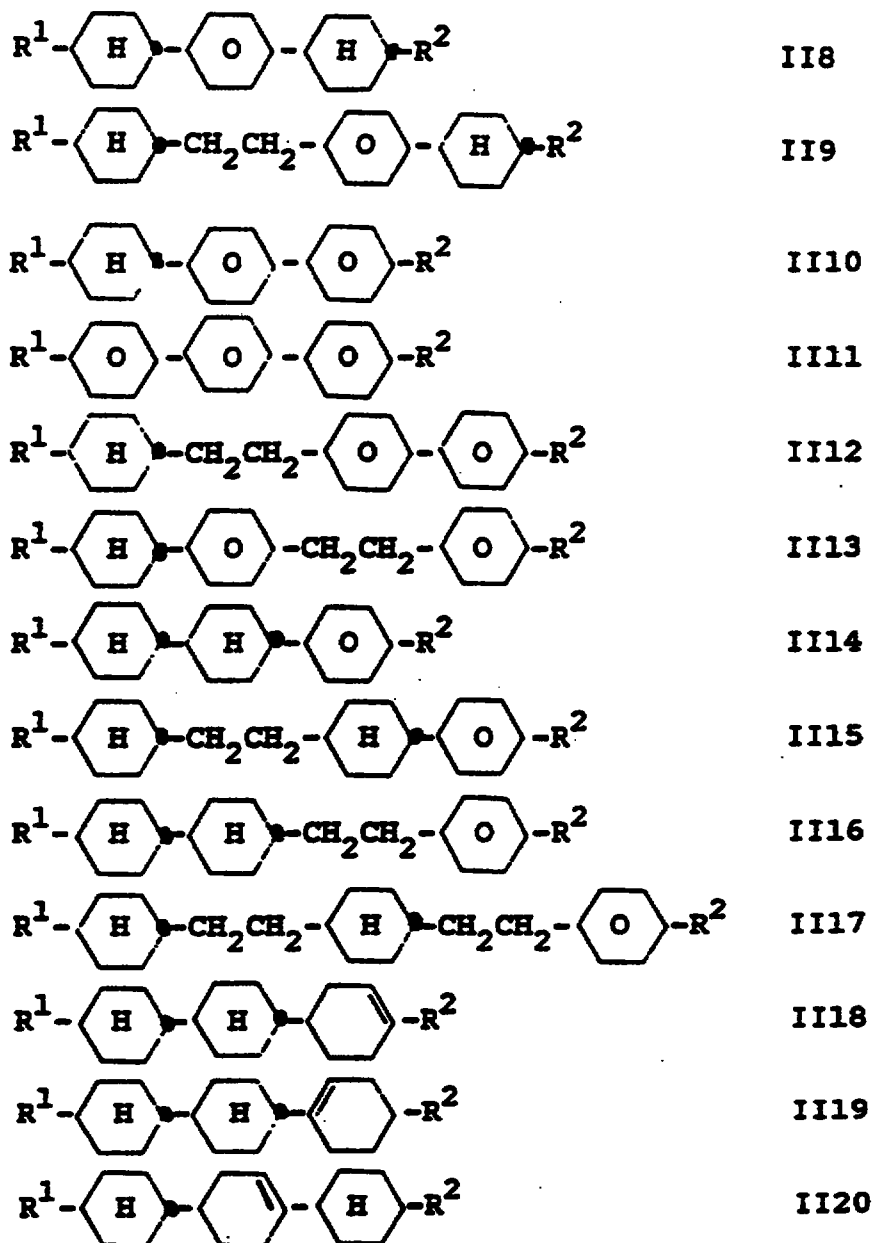
- X is F, Cl, CF_3 , $-\text{OCF}_3$, OCHF_2 or CHF_2 ,
- 15 - component B contains one or more compounds selected from the group comprising III1 to III7:



in which R^1 and R^2 have the meanings given in Claim 1.

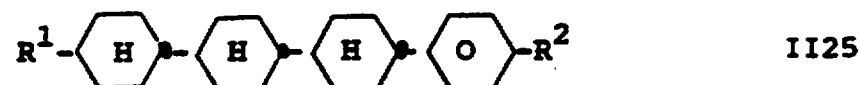
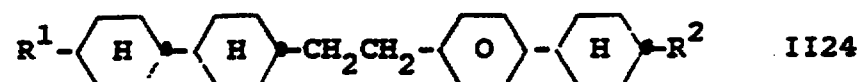
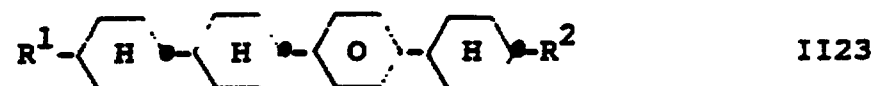
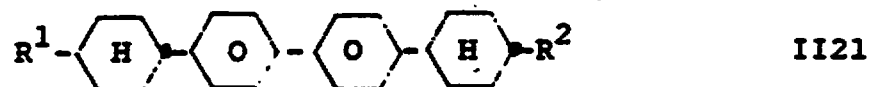
- Component B additionally contains one or more compounds selected from the group comprising II8 to II20:

5



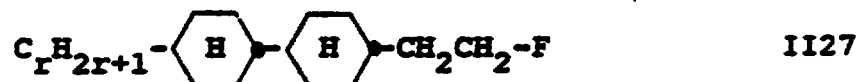
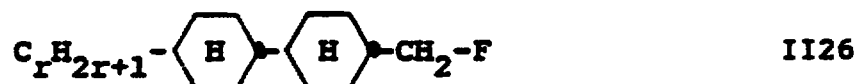
in which R^1 and R^2 have the meanings given in Claim 1 and the 1,4-phenylene groups in II8 to II17 each independently of one another can also be mono- or poly-substituted by fluorine.

- Component B additionally contains one or more compounds selected from the group comprising II21 to II25:



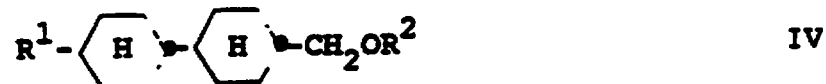
- 5 in which R^1 and R^2 have the meanings given in Claim 1 and the 1,4-phenylene groups in II21 to II25 each independently of one another can also be mono- or poly-substituted by fluorine.

- Component B contains one or more compounds selected from the group comprising II26 and II27:



- 10 in which $C_{r+1}H_{2r+1}$ is a straight-chain alkyl group having up to 7 C atoms.

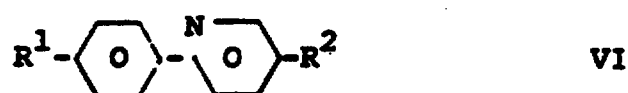
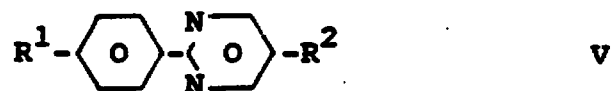
- The liquid crystal mixture additionally contains, apart from components A, B and C, one or more compounds selected from the group comprising III and IV:



15

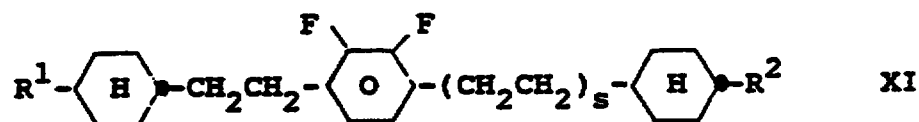
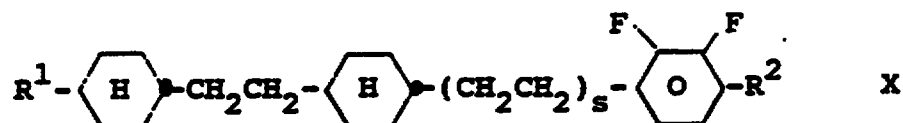
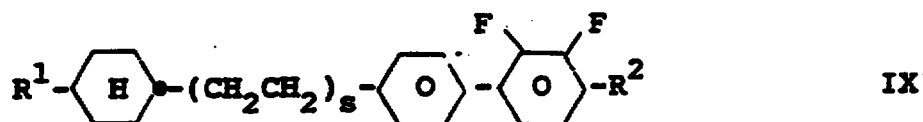
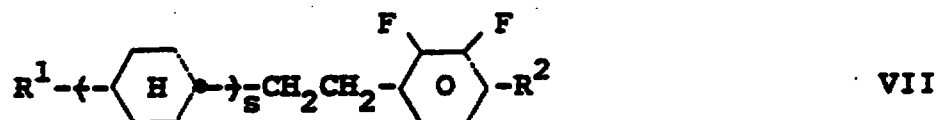
in which R¹ and R² have the meanings given in Claim 1.

- 5 - The liquid crystal mixture additionally contains, apart from components A, B and C, one or more compounds selected from the group comprising V and VI:



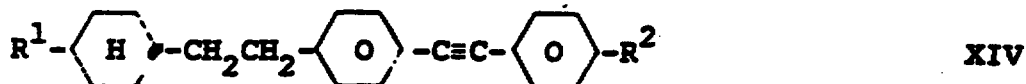
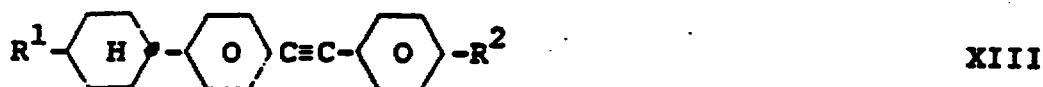
in which R¹ and R² have the meanings given in Claim 1.

- Component C contains one or more compounds selected from the group comprising VII to XI:



10 in which R¹ and R² have the meanings given in Claim 1 and S [sic] is 0 or 1.

- Component B contains one or more compounds selected from the group comprising XII to XIV:

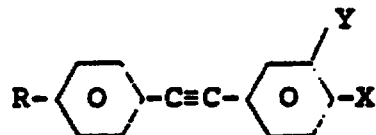


in which R^1 and R^2 have the meanings given in Claim 1.

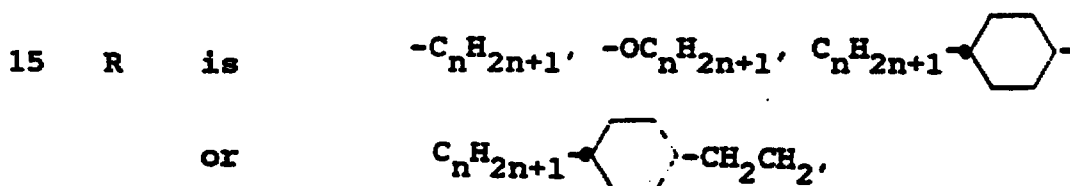
Those mixtures are preferred which exclusively contain compounds of the formulae IIa to IIh (group A) and component C, i.e. no compounds of component B.

The preferred mixtures containing terminally halogenated compounds of the formulae IIa to IIk ($X = F, Cl, -CF_3, -CHF_2, -OCF_3$ or $-OCHF_2$) show particularly advantageous parameter combinations and, at the same time, a wide d/p window.

Liquid crystal mixtures according to the invention whose component A contains at least one compound of the formula



in which



n is an integer of 1-15,

Y is H or F and

X is F, Cl or OCF_3 ,

20 and/or contains a compound of the formulae IIId2-IIId5, IIa1-IIa3 and/or IIc1-IIc8, have advantageous values of the threshold voltage $V_{10/0/20}$ and of the flow viscosity η and are distinguished by fairly high or high values of the optical anisotropy. These mixtures are preferred.

25 For component D, a large number of chiral doping substances, some of which are commercially obtainable, are available to those skilled in the art. The choice of

these is not critical per se.

The liquid crystal mixtures used in the SLD according to the invention are dielectrically positive with $\Delta\epsilon \geq 1$. Liquid crystal mixtures with $\Delta\epsilon \geq 3$ are particularly preferred, and very particularly those with $\Delta\epsilon \geq 5$.

The liquid crystal mixtures according to the invention show advantageous values for the threshold voltage $V_{10/90/20}$ and for the flow viscosity η . If the value for the optical path difference $d\Delta n$ is given, the value for the layer thickness d is determined by the optical anisotropy Δn . Particularly with relatively high or high values for $d\Delta n$, the use of liquid crystal mixtures according to the invention having a relatively high or high value for the optical anisotropy is in general preferred, since the value for d can then be chosen to be relatively small, which leads to more advantageous values for the switching times. However, even those liquid crystal displays according to the invention which contain liquid crystal mixtures according to the invention having smaller values for Δn are characterized by advantageous values for the switching times. The liquid crystal mixtures according to the invention are furthermore characterized by advantageous values for the steepness of the electrooptical characteristic and can be operated at high multiplexing rates. Moreover, the liquid crystal mixtures according to the invention have a high stability and advantageous values for the electrical resistance and the frequency dependence of the threshold voltage. The liquid crystal displays according to the invention have a wide working temperature range and a good angle dependence of the contrast.

The structure of the liquid crystal display elements according to the invention from polarizers, electrode base plates and electrodes with such a surface treatment that the preferential orientation (director) of the adjoining liquid crystal molecules from one electrode to the other is in each case twisted usually by an amount of 160° to 360° relative to one another, corresponds to

the type of construction which is conventional for such display elements. The term conventional type of construction is here used in a wide meaning and also comprises all variations and modifications of the supertwist cell, and in particular also matrix display elements and the display elements containing additional magnets according to German Offenlegungsschrift 2,748,738. The surface tilt angles at the two carrier plates can be equal or different. Equal tilt angles are preferred.

However, an essential difference between the display elements according to the invention and the hitherto conventional ones on the basis of the twisted nematic cell resides in the choice of the liquid crystal components of the liquid crystal layer.

The liquid crystal mixtures which can be used according to the invention are prepared in a manner conventional per se.

As a rule, the desired quantity of the components used in a smaller amount is dissolved in the components representing the main constituent, advantageously at an elevated temperature. It is also possible to mix solutions of the components in an organic solvent, for example in acetone, chloroform or methanol, and, after thorough mixing, to remove the solvent again, for example by distillation.

The dielectrics can also contain further additives known to those skilled in the art and described in the literature. For example, 0-15% of pleochroic dyes can be added.

The examples which follow are intended to explain the invention, without limiting it.

In the examples:

S-N	is the smectic/nematic phase transition temperature,
35 c.p.	is the clearing point,
visc.	is the viscosity (mPa.s),
T _{on}	is the time from switching on until 90% of the maximum contrast is reached, and
T _{off}	is the time from switching off until 10% of the

maximum contrast is reached.

The SLD is activated in multiplex operation (multiplexing ratio 1:100, bias 1:11, operating voltage 18.5 volt).

5 Above and below, all temperatures are given in °C. The percentage figures are percent by weight. The values of the switching times and viscosities refer to 20°C.

Example 1

10 An SLD of the STN type having the following parameters:

twist angle 240°

tilt angle 5°

d/p 0.54

15 d.An 0.860,

containing a liquid crystal mixture having the following parameters:

clearing point: 91°

An: 0.1254

20 Ae: +8.1

viscosity (20°C): 16 mPa.s

and consisting of a base mixture of

18% of p-trans-4-propylcyclohexane-benzonitrile,

8% of trans-1-p-methoxyphenyl-4-propylcyclohexane,

25 5% of 2-p-fluorophenyl-5-propylpyrimidine,

5% of 2-p-trifluoromethoxyphenyl-5-pentylpyrimidine,

5% of 2-p-trifluoromethoxyphenyl-5-heptylpyrimidine,

9% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl] trifluoromethoxybenzene,

30 8% of p-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene,

8% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane,

7% of 1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane,

35 5% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(3,4-difluorophenyl)-ethane,

5% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-

hexyl]-2-(p-fluorophenyl)-ethane,
 7% of 4-trifluoromethoxy-4'-(trans-4-propylcyclohexyl)-
 biphenyl,
 3% of 4-(trans-4-propylcyclohexyl)-4'-methoxytolan,
 5 3% of 4-(trans-4-propylcyclohexyl)-4'-ethoxytolan and
 4% of 4-(trans-4-propylcyclohexyl)-4'-propoxytolan
 and a chiral component (2-octyl p-(p-n-hexylbenzoyloxy)-
 benzoate) shows the following switching times: 105 ms
 (1/16 D, 1/5 b), 198 ms (1/240 D, 1/14.5 b), $V_{10/0/20}$
 10 2.31 volt, $V_{90/0/20}$ 2.51 volt and a Δ d/p (d/p window) of
 0.21.

Example 2

An SLD of the STN type having the following
 parameters:

15	twist angle	240°
	tilt angle	5°
	d/p	0.56
	d. Δ n	0.85,

containing a liquid crystal mixture having the following
 20 parameters:

	clearing point:	87°
	An:	0.1222
	A _c :	+8.5
	viscosity (20°C):	16 mPa.s

25 and consisting of a base mixture of

	18% of p-trans-4-propylcyclohexane-benzonitrile,
	8% of trans-1-p-methoxyphenyl-4-propylcyclohexane,
	5% of 2-p-fluorophenyl-5-propylpyrimidine,
	5% of 2-p-trifluoromethoxyphenyl-5-pentylpyrimidine,
30	5% of 2-p-trifluoromethoxyphenyl-5-heptylpyrimidine,
	9% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclo- hexyl]-trifluoromethoxybenzene,
	8% of p-[trans-4-(trans-4-pentylcyclohexyl)-cyclo- hexyl]-trifluoromethoxybenzene,
35	8% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo- hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
	7% of 1-[trans-4-(trans-4-pentylcyclohexyl)-cyclo- hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
	5% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-

hexyl]-2-(3,4-difluorophenyl)-ethane,
5% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(p-fluorophenyl)-ethane,
7% of 4-trifluoromethoxy-4'-(trans-4-propylcyclohexyl)-
5 biphenyl,
5% of 4-(trans-4-propylcyclohexyl)-2',3'-difluoro-4'-
ethoxytolan and
5% of 4-(trans-4-pentylcyclohexyl)-2',3'-difluoro-4'-
ethoxytolan
10 and a chiral component (2-octyl p-(p-n-hexylbenzoyloxy)-
benzoate) shows the following switching times:
114 ms (1/16 D, 1/5 b), 236 ms (1/240 D, 1/14.5 b), $V_{10/0/20}$
2.35 volt, $V_{90/0/20}$ 2.53 volt and a $\Delta d/p$ (d/p window) of
0.20.
15 Example 3
An SLD of the STN type containing a liquid
crystal mixture having the following parameters:
clearing point: 106°
An: 0.1322
20 Ae: +6.9
and consisting of a base mixture of
18% of p-trans-4-propylcyclohexane-benzonitrile,
8% of trans-1-p-methoxyphenyl-4-propylcyclohexane,
9% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
25 hexyl]-trifluoromethoxybenzene,
8% of p-[trans-4-(trans-4-pentylcyclohexyl)-cyclo-
hexyl]-trifluoromethoxybenzene,
8% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
30 7% of 1-[trans-4-(trans-4-pentylcyclohexyl)-cyclo-
hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
7% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(3,4-difluorophenyl)-ethane,
6% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
35 hexyl]-2-(p-fluorophenyl)-ethane,
7% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(p-trifluoromethylphenyl)-ethane,
7% of 4-trifluoromethoxy-4'-(trans-4-propylcyclohexyl)-
biphenyl,

2% of 4-(trans-4-propylcyclohexyl)-4'-methoxytolan,
2% of 4-(trans-4-propylcyclohexyl)-4'-ethoxytolan,
3% of 4-(trans-4-propylcyclohexyl)-4'-propoxytolan,
4% of 4-methyl-4'-ethoxytolan and
5 4% of 4-ethyl-4'-methoxytolan
and a chiral component (2-octyl p-(p-n-hexylbenzoyloxy)-
benzoate) shows short switching times.

Example 4

10 An SLD of the STN type containing a liquid
crystal mixture having the following parameters:

clearing point: 81°
An: 0.1130
Ae: +6.5

and consisting of a base mixture of

15 20% of p-trans-4-propylcyclohexane-benzonitrile,
10% of trans-1-p-methoxyphenyl-4-propylcyclohexane,
5.6% of trans-1-p-trifluoromethoxyphenyl-4-propyl-
cyclohexane,
5.6% of trans-1-p-trifluoromethoxyphenyl-4-butylcyclo-
20 hexane,
5.6% of trans-1-p-trifluoromethoxyphenyl-4-pentyl-
cyclohexane,
7% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-trifluoromethoxybenzene,
25 6.3% of p-[trans-4-(trans-4-pentylcyclohexyl)-cyclo-
hexyl]-trifluoromethoxybenzene,
6.3% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
5.6% of 1-[trans-4-(trans-4-pentylcyclohexyl)-cyclo-
30 hexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
5.6% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(3,4-difluorophenyl)-ethane,
5.6% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclo-
hexyl]-2-(p-trifluoromethyl)-ethane,
35 7% of 4-trifluoromethoxy-4'-(trans-4-propylcyclo-
hexyl)-biphenyl,
3.5% of 4-(trans-4-propylcyclohexyl)-4'-methoxytolan,
2.8% of 4-(trans-4-propylcyclohexyl)-4'-ethoxytolan
and

3.5% of 4-(trans-4-propylcyclohexyl)-4'-propoxytolan and a chiral component (2-octyl p-(p-n-hexylbenzoyloxy)-benzoate) shows short switching times.

Example 5

5 An SLD of the STN type, containing a liquid crystal mixture having the following parameters:

clearing point: 73°
An: 0.1252
Δε: +8.7

10 and consisting of a base mixture of

20% of p-trans-4-propylcyclohexane-benzonitrile,
10% of trans-1-p-methoxyphenyl-4-propylcyclohexane,
5.6% of 2-p-fluorophenyl-5-propylpyrimidine,
5.6% of 2-p-fluorophenyl-5-pentylpyrimidine,
15 5.6% of 2-p-trifluoromethoxyphenyl-5-pentylpyrimidine,
5.6% of 2-p-trifluoromethoxyphenyl-5-heptylpyrimidine,
7% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene,
6.3% of p-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene,
20 6.3% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
5.6% of 1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane,
25 5.6% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(3,4-difluorophenyl)-ethane,
5.6% of 1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethyl)-ethane,
3.5% of 4-(trans-4-propylcyclohexyl)-4'-methoxytolan,
30 3.5% of 4-(trans-4-propylcyclohexyl)-4'-ethoxytolan
and
4.2% of 4-(trans-4-propylcyclohexyl)-4'-propoxytolan
and a chiral component (2-octyl p-(p-n-hexylbenzoyloxy)-benzoate) shows short switching times.

35 In the following table, physical data of further mixtures M1 to M41 according to the invention are given, the composition of which is to be found after the table:

			c.p.	V _{10/0/20}	Δn	Δε
	89-263	M1	120	5.1	0.1267	1.09
	89-220	M2	89	3.0	0.1173	
5	89-172	M3	110	3.3	0.0905	2.3
	89-83	M4	93	2.1	0.1049	5.0
	89-25	M6	90	3.7	0.1159	1.6
	89-15	M7	80	3.5	0.0922	1.7
	ZLI-4582	M9	98	2.5	0.1008	3.2
10	ZLI-4581	M10	94	2.2	0.1006	4.1
	ZLI-4580	M11	95	2.0	0.1050	5.2
	89-374	M13	92	4.7	0.1132	1.2
	89-796	M18	91.2		0.153	6.2
	90-442	M21	87		0.1435	9.6
15	89/1018	M22	85	1.92	0.1480	
	89/1020	M23	84	1.82	0.1458	
	89/1034	M24	86	1.94	0.1531	
	89/1036	M25	96	2.24	0.1645	
	89/1037	M26	95	2.18	0.1648	
20	89-733	M27	80		0.1255	5.5
	90-81	M29	90	2.06	0.1403	11.1
	90-499	M30	82	1.93	0.1427	
	90-502	M31	84	2.01	0.1401	10.3
	90-515	M32	83	1.77	0.1405	12.3
25	90-602	M33	86	1.8	0.14	
	90-604	M34	81	2.0	0.137	
	90-605	M35	94	1.9	0.15	
	90-606	M36	80	1.8	0.14	
	90-607	M37	87	1.8	0.14	
30	90-608	M38	80	1.8	0.14	
	ZLI-4720-100	M39	91	2.3	0.1299	9.6
	90-609	M40	85	2.2	0.125	
	90/2008	M41	76	2.15	0.1115	
	90/370	M42	76	1.63	0.1345	
35	90/371	M43	70	1.44	0.1065	
	90/373	M44		2.12	0.1678	
	90/409	M45	68	1.42	0.1306	
	90/414	M46	74	1.44	0.1136	

		c.p.	$V_{10/0/20}$	Δn	Δe	
5	90/416	M47	63	1.66	0.1617	
	90/411	M48	72	1.89	0.1306	
	90/415	M49	78	2.07	0.1193	
	90/417	M50	80	1.86	0.1609	
	90/2014	M51	71	1.70	0.1401	10.5
	90/2015	M52	76	1.91	0.1152	8.6
	90/487	M53	87	1.90	0.1401	11.4

89-263 (M1)

D-50CF2	30	%
PCH-53	11	%
I32	16	%
I35	10	%
BCH-32	9	%
CBC-33	4	%
CBC-53	4	%
CBC-55	4	%
CBC-33F	4	%
CBC-53F	5	%
CBC-55F	3	%

89-220 (M2)

PYP-50CF3	18	%
PYP-70CF3	18	%
PCH-301	13	%
CCH-303	13	%
CH-35	4	%
CH-43	4	%
CH-45	4	%
CBC-33	4	%
CBC-53	5	%
CBC-55	4	%
CBC-33F	4	%
CBC-53F	5	%
CBC-55F	4	%

89-172 (M3)

CCP-30CF3	20	%
CCP-50CF3	20	%
PCH-301	15	%
PCH-302	10	%
CCH-303	10	%
CCH-501	9	%
CBC-33	3	%
CBC-53	4	%
CBC-33F	3	%
CBC-53F	3	%
CBC-55F	3	%

89-83 (M4)

PCH-3	14	%
PCH-5F	10	%
PCH-7F	10	%
PCH-50CF2	20	%
ECCP-3F	6	%
ECCP-5F	6	%
ECCP-33	5	%
CBC-33	5	%
CBC-53	5	%
CBC-55	4	%
CBC-33F	5	%
CBC-53F	5	%
CBC-55F	5	%

89-25 (M6)

PCH-5F	14	%
PCH-6F	13	%
PCH-7F	14	%
I32	16	%
I35	10	%
BCH-32	9	%
CBC-33	4	%
CBC-53	4	%
CBC-55	4	%
CBC-33F	4	%
CBC-53F	5	%
CBC-55F	3	%

89-15 (M7)

PCH-30CF2	20	%
PCH-50CF2	10	%
CCH-303	13	%
CCH-502	13	%
ECCP-31	4	%
ECCP-32	4	%
ECCP-33	4	%
ECCP-35	4	%
BCH-32	9	%
BCH-52	9	%
CBC-33F	4	%
CBC-53F	3	%
CBC-55F	3	%

ZLI-4582 (M9)

PCH-3	7	%
PCH-5F	12	%
PCH-6F	12	%
PCH-7F	10	%
ECCP-3F	7	%
ECCP-5F	7	%
PCH-53	8	%
ECCP-33	5	%
CBC-33	5	%
CBC-53	6	%
CBC-55	5	%
CBC-33F	5	%
CBC-53F	6	%
CBC-55F	5	%

ZLI-4581 (M10)

PCH-3	10	%
PCH-5F	18	%
PCH-6F	14	%
PCH-7F	10	%
ECCP-3F	9	%
ECCP-5F	7	%
ECCP-33		%
CBC-33	5	%
CBC-53	6	%
CBC-55	5	%
CBC-33F	5	%
CBC-53F	6	%
CBC-55F	5	%

ZLI-4580 (M11)

PCH-3	18	%
PCH-5F	12	%
PCH-6F	12	%
PCH-7F	10	%
ECCP-3F	7	%
ECCP-5F	7	%
ECCP-33	5	%
CBC-33	5	%
CBC-53	5	%
CBC-55	4	%
CBC-33F	5	%
CBC-53F	5	%
CBC-55F	5	%

89-374 (M13)

PCH-5F	15	%
PCH-7F	15	%
PCH-53	20	%
BCH-32	14	%
BCH-52	11	%
CBC-33	3	%
CBC-53	4	%
CBC-55	4	%
CBC-33F	5	%
CBC-53F	6	%
CBC-55F	3	%

89-796 (M18)

PCH-3	15	%
PCH-4	10	%
PCH-301	16	%
PCH-302	10	%
PTP-40F	23	%
CBC-33F	4	%
CBC-53F	5	%
CBC-55F	4	%
CBC-33	4	%
CBC-53	5	%
CBC-55	4	%

90-442 (M21)

PCH-2	4	%
PCH-3	17	%
PCH-4	12	%
PCH-5	11	%
CCP-30CF3	7	%
CCP-50CF3	6	%
ECCP-31	4	%
ECCP-32	4	%
ECCP-3F	6	%
ECCP-5F	6	%
CPTP-301	5	%
CPTP-302	5	%
PTP-40F	7	%
PTP-50F	6	%

89/1020 (M23)

PCH-3	22	%
PCH-4	17	%
K6	9	%
K9	3	%
PTP-70F	6	%
CP-3F	10	%
CP-5F	9	%
ECCP-3F	9	%
CPTP-301	5	%
CPTP-302	4	%

89/1018 (M22)

PCH-3	22	%
PCH-4	18	%
PTP-70F	6	%
PTP-102	5	%
PTP-201	7	%
CP-3F	10	%
CP-5F	8	%
ECCP-3F	4	%
BCH-32	10	%
BCH-5.F2	10	%

89/1034 (M24)

PCH-3	22	%
PCH-4	16	%
K6	2	%
PTP-40F	8	%
PTP-102	4	%
PTP-201	5	%
CP-3F	10	%
CP-5F	8	%
ECCP-3F	5	%
BCH-32	8	%
BCH-5.F2	10	%
CPTP-301	2	%

89/1036 (M25)

PCH-3	21	%
K6	6	%
PTP-40F	8	%
PTP-102	6	%
PTP-201	7	%
CP-3F	10	%
CP-5F	10	%
ECCP-3F	11	%
BCH-32	10	%
BCH-5.F2	11	%

89/1037 (M26)

PCH-3	15	%
K6	6	%
K9	6	%
PTP-40F	8	%
PTP-102	4	%
PTP-201	6	%
PCH-302	3	%
CP-3F	10	%
CP-5F	10	%
ECCP-3F	11	%
BCH-32	10	%
BCH-5.F2	11	%

89-733 (M27)

PCH-3	21	%
K6	6	%
PTP-40F	8	%
PTP-35	7	%
PTP-201	7	%
CP-3F	10	%
CP-5F	8	%
ECCP-3F	12	%
BCH-32	10	%
BCH-5.F2	11	%

9081 (M29)

PCH-2	7	%
PCH-3	18	%
PCH-4	14	%
PCH-5	15	%
PCH-7	7	%
BCH-32	10	%
CPTP-301	4	%
CPTP-302	3	%
CPTP-303	3	%
ECCP-3	7	%
ECCP-3F	6	%
ECCP-5F	6	%

90-499 (M30)

PCH-3	18	%
PCH-4	8	%
PCH-5	10	%
PCH-301	13	%
ME2N.F	3	%
ME3N.F	3	%
PTP-102	3	%
PTP-201	4	%
CPTP-301	4	%
CPTP-302	4	%
CPTP-303	4	%
ECCP-3F	6	%
ECCP-5F	6	%
ECCP-31	3	%
ECCP-32	2	%
CCP-30CF3	5	%
CCP-50FF3	4	%

90502 (M31)

PCH-3	18	%
PCH-4	8	%
PCH-5	10	%
PCH-301	11	%
ME2N.F	3	%
ME3N.F	3	%
PTP-102	4	%
PTP-201	3	%
CPTP-301	3	%
CPTP-302	4	%
CPTP-303	3	%
ECCP-3F	6	%
ECCP-5F	6	%
ECCP-31	5	%
ECCP-32	4	%
CCP-30CF3	5	%
CCP-50CF3	4	%

90-602 (M33)

PCH-2	5	%
PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-7	11	%
PCH-32	5	%
CFET-3F	12	%
CFET-5F	10	%
CBC-33	4	%
CBC-53	6	%

90-515 (M32)

PCH-3	18	%
PCH-4	8	%
PCH-5	10	%
PCH-301	8	%
ME2N.F	3	%
ME3N.F	3	%
ME5N.F	5	%
PTP-102	5	%
CPTP-301	3	%
CPTP-302	4	%
CPTP-303	3	%
ECCP-3F	6	%
ECPP-5F	6	%
ECCP-31	5	%
ECCP-32	4	%
CCP-30CF3	5	%
CCP-50CF3	4	%

90-604 (M34)

PCH-2	5	%
PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-32	5	%
FET-3F	14	%
FET-5F	11	%
CBC-33	6	%
CBC-53	6	%
CBC-55	6	%

90-605 (M35)

PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-7	11	%
CFET-3F	12	%
CFET-5F	10	%
FET-3F	5	%
FET-5F	5	%
CBC-33	4	%
CBC-53	6	%

90-606 (M36)

PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-7	11	%
PCH-32	5	%
CFET-3F	8	%
CFET-5F	6	%
FET-3F	7	%
FET-5F	7	%
CBC-33	4	%
CBC-53	5	%

90-607 (M37)

PCH-2	5	%
PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-7	11	%
PCH-32	5	%
CFET-3F	12	%
CFET-3F.F	10	%
CBC-33	4	%
CBC-53	6	%

90-608 (M38)

PCH-2	5	%
PCH-3	15	%
PCH-4	11	%
PCH-5	21	%
PCH-7	11	%
PCH-32	5	%
CPTP-30CF3	12	%
CPTP-50CF3	10	%
CBC-33	4	%
CBC-53	6	%

ZLI-4720-100 (M 39)

PCH-3	18	%
PCH-4	14	%
PCH-5	12	%
PCH-7	8	%
PTP-102	3	%
PTP-201	3	%
CPTP-302	3	%
ECCP-31	4	%
ECCP-32	5	%
ECCP-33	5	%
ECCP-35	4	%
ECCP-3	7	%
ECCP-3F	7	%
ECCP-5F	7	%

90609 (M 40)

PCH-3	18	%
PCH-4	14	%
PCH-5	12	%
PCH-7	8	%
PTP-20F	3	%
PTP-40F	3	%
CPTP-30CF3	3	%
ECCP-31	4	%
ECCP-32	5	%
ECCP-33	5	%
ECCP-35	4	%
ECCP-3	7	%
ECCP-3F	7	%
ECCP-5F	7	%

90/2008 (M 41)

PCH-3	10	%
PYP-3F	10	%
PYP-5F	9	%
PCH-5F	9	%
PCH-7F	9	%
ECCP-3F	13	%
ECCP-5F	12	%
CP-3F	9	%
CP-5F	9	%
CPTP-301	5	%
CPTP-303	5	%

90/370 (M 42)

PYP-3F	7	%
PCH-3	11	%
PCH-5	10	%
PCH-7	10	%
PTP-35	16	%
CPTP-303	4	%
CCP-20CF3	15	%
CCP-30CF3	21	%
CCP-50CF3	6	%

90/371 (M 43)

PYP-3F	7	%
PCH-3	11	%
PCH-5	10	%
PCH-7	10	%
PCH-301	16	%
CPTP-303	4	%
CCP-20CF3	15	%
CCP-30CF3	21	%
CCP-50CF3	6	%

90/409 (M 45)

PYP-3F	7	%
PCH-3	21	%
PCH-5	10	%
PCH-7	10	%
PCH-301	10	%
PTP-102	4	%
PTP-201	4	%
CPTP-303	6	%
CCP-20CF3	8	%
CCP-30CF3	8	%
CCP-40CF3	6	%
CCP-50CF3	6	%

90/373 (M 44)

PYP-3F	7	%
PCH-3	9	%
PCH-5	10	%
PCH-7	9	%
PTP-35	15	%
PTP-45	19	%
CPTP-303	4	%
BCH-32	14	%
BCH-52F	13	%

90/414 (M 46)

PYP-3F	7	%
PCH-3	11	%
PCH-5	10	%
PCH-7	10	%
PCH-301	13	%
CPTP-303	4	%
PTP-102	3	%
CCP-20CF3	10	%
CCP-30CF3	11	%
CCP-40CF3	10	%
CCP-50CF3	11	%

90/416 (M 47)

PYP-3F	10	%
K6	10	%
PCH-3	11	%
PCH-5	10	%
PCH-7	10	%
PCH-301	12	%
PTP-35	5	%
PTP-102	5	%
CPTP-302	5	%
CPTP-303	5	%
BCH-32	8	%
BCH-52F	9	%

90/415 (M 49)

PYP-3F	6	%
PCH-3	14	%
PCH-5	10	%
PCH-7	10	%
PCH-301	13	%
CPTP-303	4	%
PTP-102	4	%
CCP-30CF3	11	%
CCP-50CF3	11	%
ECCP-32	9	%
ECCP-33	8	%

90/411 (M 48)

PYP-3F	7	%
PCH-3	21	%
PCH-5	10	%
PCH-7	10	%
PCH-301	10	%
PTP-102	4	%
PTP-201	3	%
CPTP-303	6	%
CCP-30CF3	10	%
CCP-50CF3	10	%
ECCP-32	4	%
ECCP-33	5	%

90/417 (M 50)

PYP-3F	4	%
PCH-3	22	%
PCH-5	11	%
PCH-7	13	%
PCH-301	11	%
PTP-102	5	%
PTP-201	4	%
CPTP-301	4	%
CPTP-302	3	%
CPTP-303	5	%
BCH-32	10	%
BCH-52F	8	%

90/2014 (M51)

K6	7,0
PCH-3	28,0
PCH-5	13,0
PCH-301	11,0
CCP-20CF3	8,0
CCP-30CF3	8,0
CCP-40CF3	5,0
CCP-50CF3	6,0
PTP-102	3,0
CPTP-301	6,0

90/2015 (M52)

PCH-3	21,0
PCH-5	10,0
PCH-7F	15,0
CCP-20CF3	12,0
CCP-30CF3	13,0
CCP-40CF3	10,0
CCP-50CF3	8,0
PTP-102	7,0
CPTP-301	4,0

90/487 (M53)

PCH-3	18,0
PCH-4	14,0
PCH-5	11,0
ME2N.F	3,0
ME3N.F	4,0
D-302	5,0
D-402	5,0
PTP-102	4,0
CPTP-301	4,0
CPTP-302	4,0
CPTP-303	3,0
ECCP-3F	6,0
ECCP-5F	6,0
ECCP-31	6,0
ECCP-32	7,0

	PCH-53:	trans-1-p-propylphenyl-4-pentylcyclohexane
	I-32:	1-(trans-4-propylcyclohexyl)-2-(4'-ethyl-2'-fluorobiphenyl-4-yl)-ethane
5	I-35:	1-(trans-4-propylcyclohexyl)-2-(4'-pentyl-2'-fluorobiphenyl-4-yl)-ethane
	BCH-32:	4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
	BCH-52:	4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
10	CCH-303:	trans,trans-4-propoxy-4'-propylcyclohexyl-cyclohexane
	CCH-501:	trans,trans-4-methoxy-4'-pentylcyclohexyl-cyclohexane
15	CH-35:	trans-4-pentylcyclohexyl trans,trans-4-propylcyclohexylcyclohexanecarboxylate
	CH-43:	trans-4-propylcyclohexyl trans,trans-4-butylcyclohexylcyclohexanecarboxylate
	CH-45:	trans-4-pentylcyclohexyl trans,trans-4-butylcyclohexylcyclohexanecarboxylate
20	PCH-302:	trans-1-p-ethoxyphenyl-4-propylcyclohexane
	PCH:303:	trans-1-p-propoxyphenyl-4-propylcyclohexane
	PCH-304:	trans-1-p-butoxyphenyl-4-propylcyclohexane
	CCH-502:	trans,trans-4-ethoxy-4'-pentylcyclohexyl-cyclohexane
25	ECCP-32:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-ethylphenyl)-ethane
	ECCP-31:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-methylphenyl)-ethane
30	ECCP-35:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-pentylphenyl)-ethane
	PCH-501:	trans-1-p-methoxyphenyl-4-pentylcyclohexane
	PCH-502:	trans-1-p-ethoxyphenyl-4-pentylcyclohexane
	CP-33:	p-propylphenyl trans,trans-4-propylcyclohexylcyclohexanecarboxylate
35	CP-35:	p-pentylphenyl trans,trans-4-propylcyclohexylcyclohexanecarboxylate
	CP-43:	p-propylphenyl trans,trans-4-butylcyclohexylcyclohexanecarboxylate

	CP-45:	p-pentylphenyl trans,trans-4-butylcyclohexyl-cyclohexanecarboxylate
	PTP-40F:	4-butoxy-4'-fluorotolan
	PTP-50F:	4-pentoxy-4'-fluorotolan
5	PTP-70F:	4-heptoxy-4'-fluorotolan
	PCH-301:	trans-1-p-methoxyphenyl-4-propylcyclohexane
	CCH-301:	trans,trans-4-methoxy-4'-propylcyclohexyl-cyclohexane
	CBC-33F:	4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl
10	CBE-55F:	4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluoro-biphenyl
	CBC-53F:	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
15	CBC-33:	4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
	CBC-55:	4,4'-bis-(trans-4-pentylcyclohexyl)-biphenyl
	CBC-53:	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
	ECCP-33:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-propylphenyl)-ethane
20	CCH-51F:	trans,trans-4-fluoromethyl-4'-pentylcyclohexylcyclohexane
	CCH-31F:	trans,trans-4-fluoromethyl-4'-propylcyclohexylcyclohexane
25	PTP-102:	4-methyl-4'-ethoxy-tolan
	PTP-201:	4-methoxy-4'-ethyl-tolan
	CPTP-301:	4-(trans-4-propylcyclohexyl)-4'-methoxy-tolan
	CPTP-302:	4-(trans-4-propylcyclohexyl)-4'-ethoxy-tolan
	CPTP-303:	4-(trans-4-propylcyclohexyl)-4'-propoxy-tolan
30	PCH-5F:	trans-1-p-fluorophenyl-4-pentylcyclohexane
	PCH-6F:	trans-1-p-fluorophenyl-4-hexylcyclohexane
	PCH-7F:	trans-1-p-fluorophenyl-4-heptylcyclohexane
	EPCH-20CF ₃ :	1-(trans-4-ethylcyclohexyl)-2-(p-trifluoromethoxyphenyl)-ethane
35	EPCH-30CF ₃ :	1-(trans-4-propylcyclohexyl)-2-(p-trifluoromethoxyphenyl)-ethane
	EPCH-50CF ₃ :	1-(trans-4-pentylcyclohexyl)-2-(p-trifluoromethoxyphenyl)-ethane

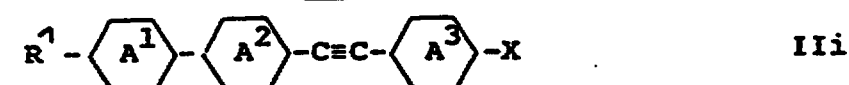
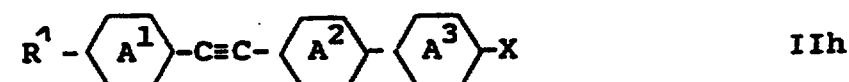
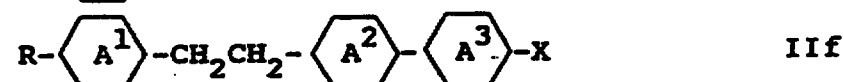
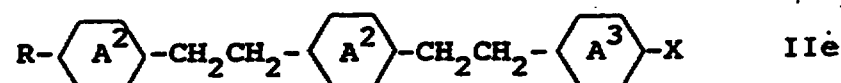
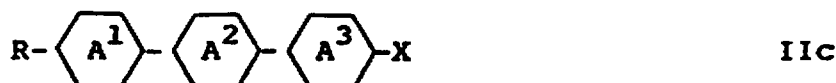
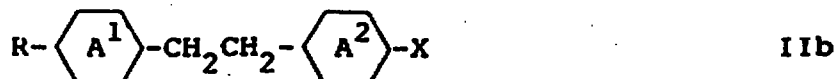
	EPCH-70CF ₃ :	1-(trans-4-heptylcyclohexyl)-2-(p-trifluoromethoxyphenyl)-ethane
	PCH-30CF ₃ :	trans-1-p-trifluoromethoxyphenyl-4-propylcyclohexane
5	PCH-50CF ₃ :	trans-1-p-trifluoromethoxyphenyl-4-pentylcyclohexane
	ECCP-30CF ₃ :	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane
	ECCP-50CF ₃ :	1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethoxyphenyl)-ethane
10	CCP-20CF ₃ :	p-[trans-4-(trans-4-ethylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene
	CCP-30CF ₃ :	p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene
15	CCP-40CF ₃ :	p-[trans-4-(trans-4-butylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene
	CCP-50CF ₃ :	p-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-trifluoromethoxybenzene
20	BCH-30CF ₃ :	4-trifluoromethoxy-4'-(trans-4-propylcyclohexyl)-biphenyl
	ECCP-3F.F:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(3,4-difluorophenyl)-ethane
	ECCP-5F.F:	1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(3,4-difluorophenyl)-ethane
25	CCP-3F.F:	4-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-1,2-difluorobenzene
	CCP-5F.F:	4-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-1,2-difluorobenzene
30	D-302FF:	2,3-difluoro-4-ethoxyphenyl trans-4-propylcyclohexylcarboxylate
	D-502FF:	2,3-difluoro-4-ethoxyphenyl trans-4-pentylcyclohexylcarboxylate
	CCP-3F:	4-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-fluorobenzene
35	ECCP-3F:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-fluorophenyl)-ethane
	ECCP-5F:	1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(p-fluorophenyl)-ethane

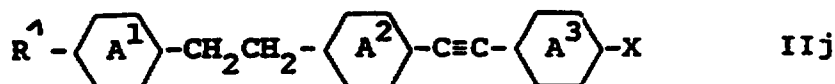
	CP-3F:	p-fluorophenyl trans-4-(trans-4-propylcyclohexyl)-cyclohexanecarboxylate
	CP-5F:	p-fluorophenyl trans-4-(trans-4-pentylcyclohexyl)-cyclohexanecarboxylate
5	PYP-5F:	2-p-fluorophenyl-5-pentylpyrimidine
	PYP-6F:	2-p-fluorophenyl-5-hexylpyrimidine
	PYP-7F:	2-p-fluorophenyl-5-heptylpyrimidine
	PYP-30CF ₃ :	2-p-trifluoromethoxyphenyl-5-propylpyrimidine
	PYP-50CF ₃ :	2-p-trifluoromethoxyphenyl-5-pentylpyrimidine
10	PYP-70CF ₃ :	2-p-trifluoromethoxyphenyl-5-heptylpyrimidine
	PCH-3:	p-trans-4-propylcyclohexyl-benzonitrile
	PCH-4:	p-trans-4-butylcyclohexyl-benzonitrile
	PCH-5:	p-trans-4-pentylcyclohexyl-benzonitrile
	ECCP-3:	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-cyanophenyl)-ethane
15	ECCP-3CF ₃ :	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethylphenyl)-ethane
	ECCP-5CF ₃ :	1-[trans-4-(trans-4-pentylcyclohexyl)-cyclohexyl]-2-(p-trifluoromethylphenyl)-ethane
20	PYP-5N.F:	2-(3-fluoro-4-cyanophenyl)-5-pentylpyrimidine
	PYP-7N.F:	2-(3-fluoro-4-cyanophenyl)-5-heptylpyrimidine
	PCH-30CF ₂ :	trans-1-p-difluoromethoxyphenyl-4-propylcyclohexane
	PCH-50CF ₂ :	trans-1-p-difluoromethoxyphenyl-4-pentylcyclohexane
25	PCH-3-OCF ₂ :	trans-1-p-difluoromethoxyphenyl-4-propylcyclohexane
	BCH-5.F2:	4-(trans-4-pentylcyclohexyl)-2'-fluoro-4'-ethylbiphenyl
30	K6:	4-ethyl-4'-cyanobiphenyl
	K9:	4-propyl-4'-cyanobiphenyl
	PTP-35:	4-propyl-4'-pentyltolane
	ME2N.F:	3-fluoro-4-cyanophenyl 4-ethylbenzoate
	ME3N.F:	3-fluoro-4-cyanophenyl 4-propylbenzoate
35	ME5N.F:	3-fluoro-4-cyanophenyl 4-pentylbenzoate
	PCH-2:	p-trans-4-ethylcyclohexylbenzonitrile
	PCH-7:	p-trans-4-heptylcyclohexylbenzonitrile
	PCH-32:	trans-1-p-ethylphenyl-4-propylcyclohexane

	CFET-3F:	1-(4-(trans-4-propylcyclohexyl)-2-fluoro-4'-yl-biphenyl)-2-(4-fluorophenyl)-ethane
	CFET-5F:	1-(4-(trans-4-pentylcyclohexyl)-2-fluoro-4'-yl-biphenyl)-2-(4-fluorophenyl)-ethane
5	FET-3F:	1-(2-fluoro-4-propyl-4'-yl-biphenyl)-2-(4-fluorophenyl)-ethane
	FET-5F:	1-(2-fluoro-4-pentyl-4'-yl-biphenyl)-2-(4-fluorophenyl)-ethane
10	CPTP-30CF3:	4-(trans-4-propylcyclohexyl)-4'-trifluoromethoxy-ethane
	CPTP-50CF3:	4-(trans-4-pentylcyclohexyl)-4'-trifluoromethoxy-ethane
	PTP-20F:	4-ethoxy-4'-fluorotolane
	PYP-3F:	2-(4-fluorophenyl)-5-propylpyrimidine
15	PTP35:	4-propyl-4'-pentyltolane
	PTP45:	4-butyl-4'-pentyltolane
	BCH-52F:	4-(trans-4-pentylcyclohexyl)-2-fluoro-4'-ethylbiphenyl
20	CP-302FF:	2,3-difluoro-4-ethoxyphenyl trans-4-(trans-4-propylcyclohexyl)-cyclohexanecarboxylate
	PCH-301:	trans-1-p-methoxyphenyl-4-propylcyclohexane
	PCH-401:	trans-1-p-methoxyphenyl-4-butylcyclohexane
	D-302:	4-ethoxyphenyl trans-4-propylcyclohexylcarboxylate
25	D-402:	4-ethoxyphenyl trans-4-butylcyclohexylcarboxylate

Patent claims

1. Supertwist liquid crystal display with
 - two plane-parallel carrier plates which, with a frame, form a cell,
 - 5 - a nematic liquid crystal mixture, located in the cell, having a positive dielectric anisotropy,
 - electrode layers with superposed orientation layers on the insides of the carrier plates,
 - a tilt angle of about 1 degree to 30 degrees between the longitudinal axis of the molecules at the surface of the carrier plates and the carrier plates, and
 - 10 - a twist angle of the liquid crystal mixture in the cell from orientation layer to orientation layer of an amount between 100 and 600°, characterized in that the nematic liquid crystal mixture
 - 15 a) is based on component A containing one or more compounds selected from group A comprising compounds of the formulae IIa-IIc and IIe-IIk:



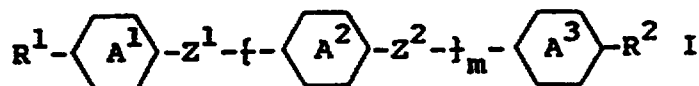


in which R is n-alkyl or n-alkenyl having up to 9 C atoms,

X is F, Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₂H or -OC₂F₅, and

the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene, or one of the rings A¹, A² and A³ can also be 1,4-cyclohexenylene, 2,3-difluoro-1,4-phenylene, pyridine-2,5-diyl or pyrimidine-2,5-diyl,

b) contains 0-40% by weight of a liquid-crystalline component B, consisting of one or more compounds having a dielectric anisotropy from -1.5 to +1.5, of the general formula I



in which R¹ and R² each independently of one another are n-alkyl, n-alkoxy, n-oxaalkyl, ω-fluoroalkyl or n-alkenyl having up to 9 C atoms, the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, trans-1,4-cyclohexylene or 1,4-cyclohexenylene,

Z¹ and Z² each independently of one another are -CH₂CH₂-, -C≡C- or a single bond, and

m is 0, 1 or 2,

c) contains 0-20% by weight of a liquid-crystalline component C consisting of one or more compounds having a dielectric anisotropy below -1.5, and

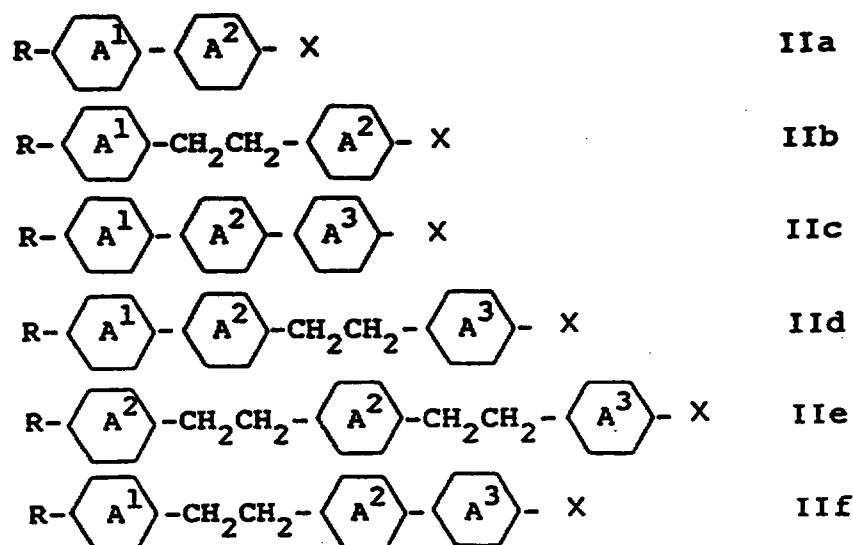
d) contains an optically active component D in such a quantity that the ratio of cell thickness (spacing

of the plane-parallel carrier plates) to the natural pitch of the chiral nematic liquid crystal mixture is about 0.2 to 1.3, and

in that the nematic liquid crystal mixture has a nematic phase range of at least 60°C, a viscosity of not more than 35 mPa.s and a dielectric anisotropy of at least +1, the dielectric anisotropies of the compounds and the parameters relating to the nematic liquid crystal mixture referring to a temperature of 20°C.

2. Display according to Claim 1, characterized in that component A additionally contains one or more cyano compounds, the proportion of the cyano compounds in component A amounting to 0 to 50% by weight.

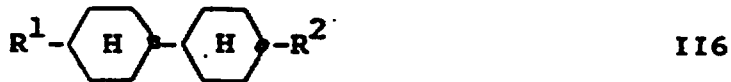
3. Display according to Claim 2, characterized in that the cyano compounds are selected from the compounds of the formulae IIa-IIf



in which X is cyano and the meaning of R, A¹, A² and A³ is given in Claim 1.

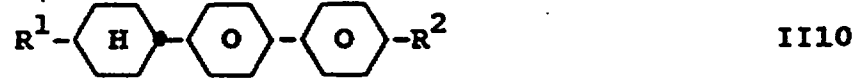
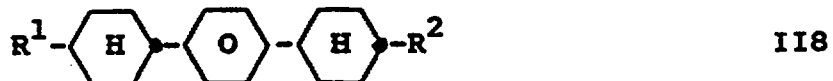
4. Display according to Claim 2 or 3, characterized in that component A contains one or more compounds of the formulae IIa-IIc and IIe-IIIf, in which X is -F, -Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₃H or -OC₂F₅, and R, A¹, A² and A³ have the meanings given in Claim 1.

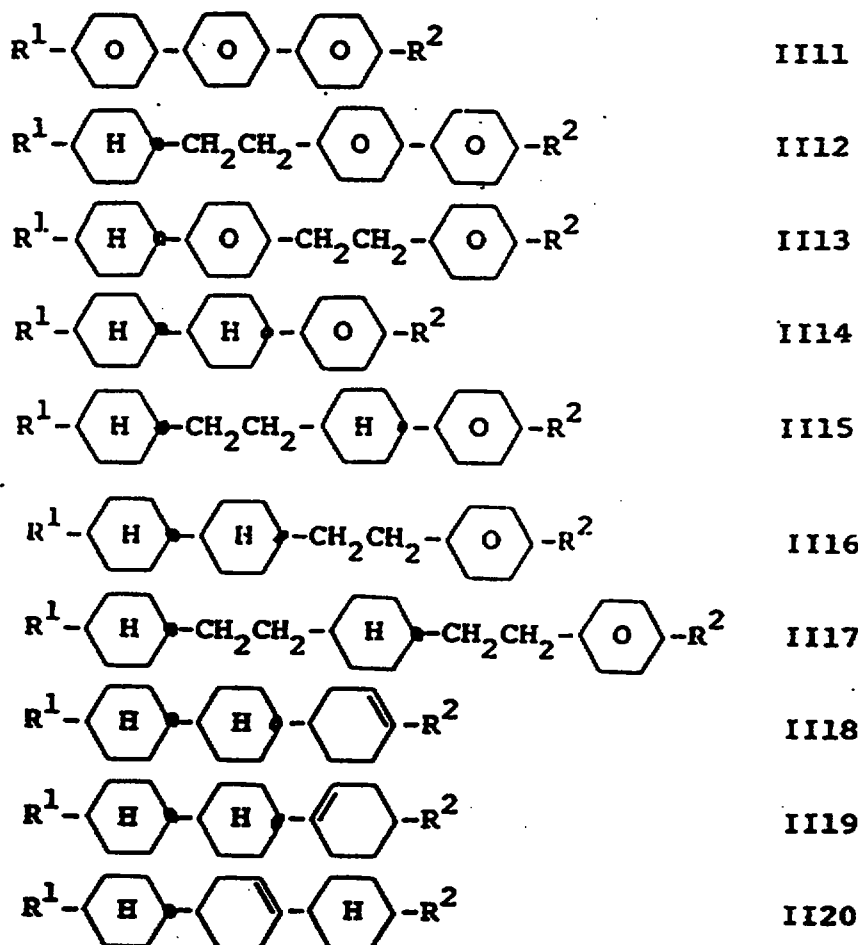
5. Display according to Claim 4, characterized in that component A contains no compounds of the formulae IIa to IIf, in which X is cyano.
6. Display according to at least one of Claims 1 to 5, characterized in that X is F, Cl, CF₃, -OCF₃, -OCHF₂ or -CHF₂.
7. Display according to at least one of Claims 1 to 6, characterized in that component B contains one or more compounds selected from the group comprising II1 to II7:



10 in which R¹ and R² have the meanings given in Claim 1.

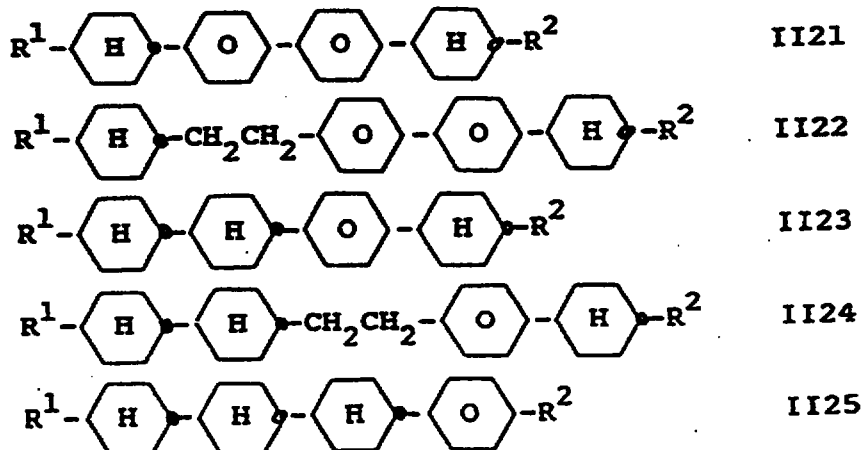
8. Display according to Claim 7, characterized in that component B additionally contains one or more compounds selected from the group comprising II8 to II20:





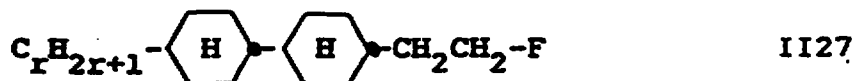
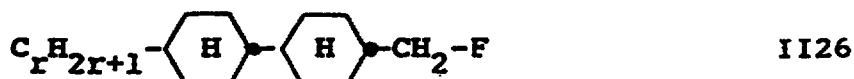
in which R¹ and R² have the meanings given in Claim 1 and the 1,4-phenylene groups in II18 to II17 each independently of one another can also be mono- or poly-substituted by fluorine.

- 5 9. Display according to Claim 7 or 8, characterized in that component B additionally contains one or more compounds selected from the group comprising II21 to II25:



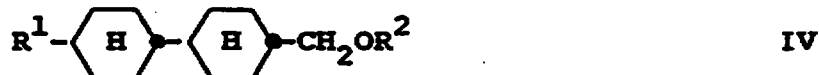
in which R¹ and R² have the meanings given in Claim 1 and the 1,4-phenylene groups in II21 to II25 each independently of one another can also be mono- or poly-substituted by fluorine.

- 5 10. Display according to at least one of Claims 1 to 9, characterized in that component B contains one or more compounds selected from the group comprising II26 and II27:



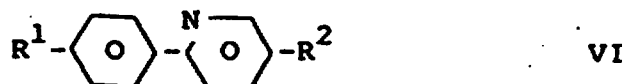
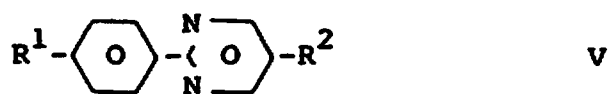
- 10 in which C_rH_{2r+1} is a straight-chain alkyl group having up to 7 C atoms.

11. Display according to at least one of Claims 1 to 10, characterized in that the liquid crystal mixture additionally contains, apart from components A, B and C, one or more compounds selected from the group comprising
15 III and IV:



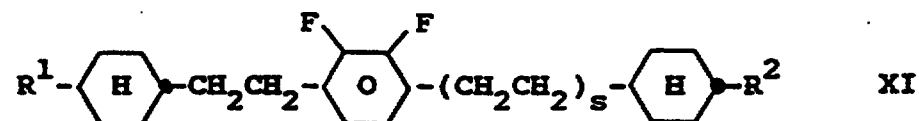
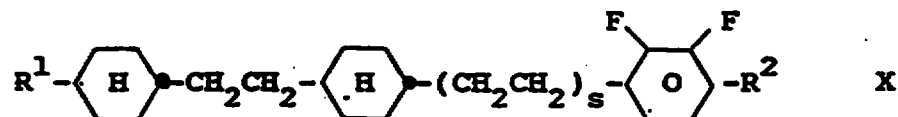
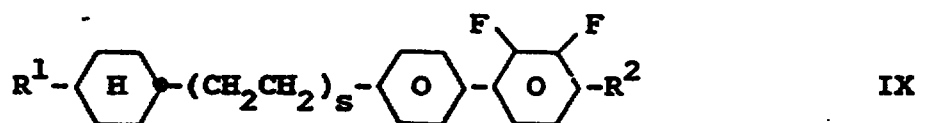
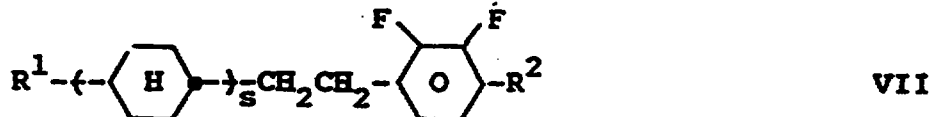
in which R¹ and R² have the meanings given in Claim 1.

12. Display according to at least one of Claims 1-11, characterized in that the liquid crystal mixture additionally contains, apart from components A, B and C, one
20 or more compounds selected from the group comprising V and VI:



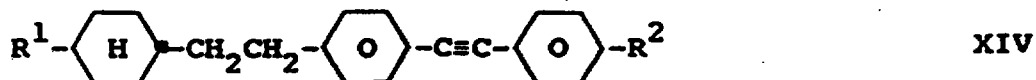
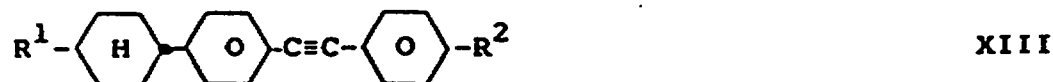
in which R¹ and R² have the meanings given in Claim 1.

13. Display according to at least one of Claims 1-12, characterized in that component C contains one or more compounds selected from the group comprising VII to XI:



5 in which R¹ and R² have the meanings given in Claim 1 and S [sic] is 0 or 1.

14. Display according to at least one of Claims 1-13, characterized in that component B contains one or more compounds selected from the group comprising XII to XIV



10 in which R¹ and R² have the meanings given in Claim 1.

15. Liquid crystal mixture of the composition defined in any one of Claims 1-14, characterized in that these has a high dielectric anisotropy of $\Delta\epsilon > 5$ and a high

content of cyano compounds of more than 20% by weight and less than 50% by weight.

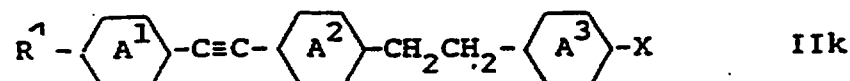
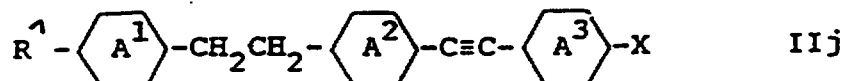
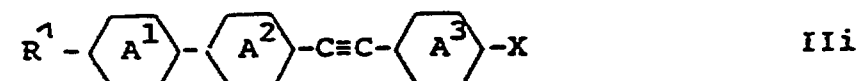
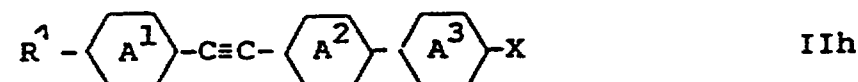
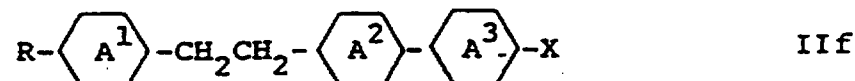
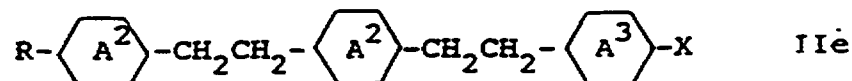
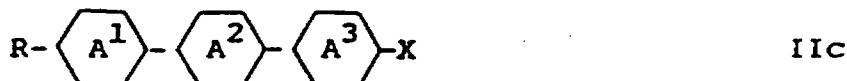
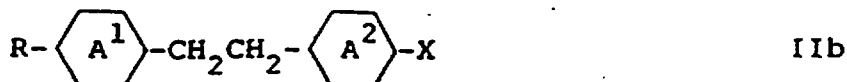


[As printed]

Claims

1. Supertwist liquid crystal display with

- two plane-parallel carrier plates which, with a frame, form a cell,
- a nematic liquid crystal mixture, located in the cell, having a positive dielectric anisotropy,
- electrode layers with superposed orientation layers on the insides of the carrier plates,
- a tilt angle of about 1 degree to 30 degrees between the longitudinal axis of the molecules at the surface of the carrier plates and the carrier plates, and
- a twist angle of the liquid crystal mixture in the cell from orientation layer to orientation layer of an amount between 100 and 600°, characterized in that the nematic liquid crystal mixture
 - a) is based on component A containing one or more compounds selected from group A comprising compounds of the formulae IIa-IIc and IIe-IIk:

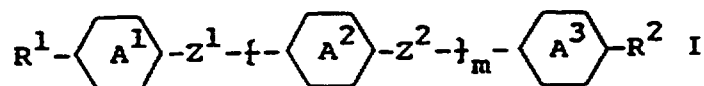


in which R is n-alkyl or n-alkenyl having up to 9 C atoms,

X is F, Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₂H or -OC₂F₅, and

the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene, or one of the rings A¹, A² and A³ can also be 1,4-cyclohexenylene, 2,3-difluoro-1,4-phenylene, pyridine-2,5-diyl or pyrimidine-2,5-diyl,

b) contains 0-40% by weight of a liquid-crystalline component B, consisting of one or more compounds having a dielectric anisotropy from -1.5 to +1.5, of the general formula I



in which R¹ and R² each independently of one another are n-alkyl, n-alkoxy, n-oxaalkyl, ω-fluoroalkyl or n-alkenyl having up to 9 C atoms, the rings A¹, A² and A³ each independently of one another are 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, trans-1,4-cyclohexylene or 1,4-cyclohexenylene,

Z¹ and Z² each independently of one another are -CH₂CH₂-, -C≡C- or a single bond, and m is 0, 1 or 2,

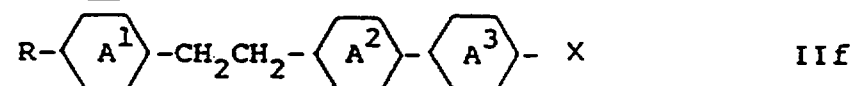
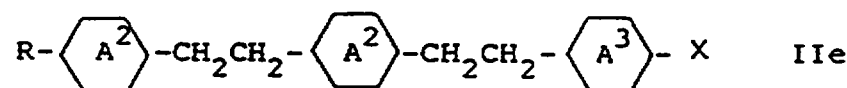
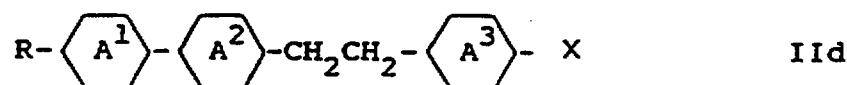
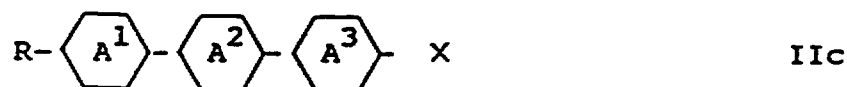
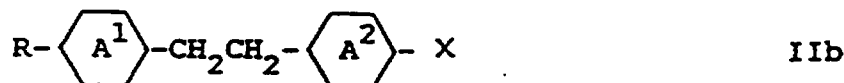
c) contains 0-20% by weight of a liquid-crystalline component C consisting of one or more compounds having a dielectric anisotropy below -1.5, and



d) contains an optically active component D in such a quantity that the ratio of cell thickness (spacing of the plane-parallel carrier plates) to the natural pitch of the chiral nematic liquid crystal mixture is about 0.2 to 1.3, and

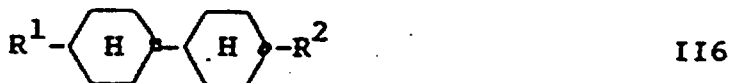
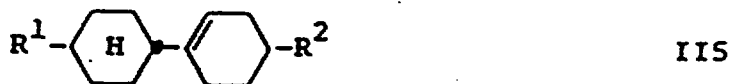
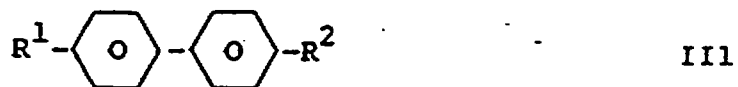
in that the nematic liquid crystal mixture has a nematic phase range of at least 60°C, a viscosity of not more than 35 mPa.s and a dielectric anisotropy of at least +1, the dielectric anisotropies of the compounds and the parameters relating to the nematic liquid crystal mixture referring to a temperature of 20°C.

2. Display according to Claim 1, characterized in that component A additionally contains one or more cyano compounds, the proportion of the cyano compounds in component A amounting to 0 to 50% by weight.
3. Display according to Claim 2, characterized in that the cyano compounds are selected from the compounds of the formulae IIa-IIf



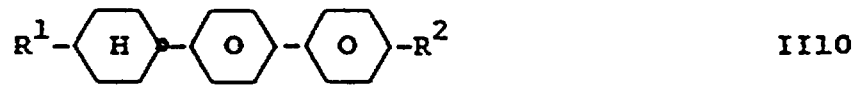
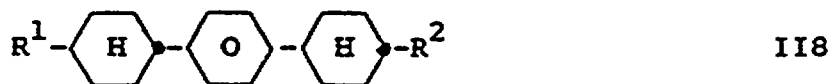
in which X is cyano and the meaning of R, A¹, A² and A³ is given in Claim 1.

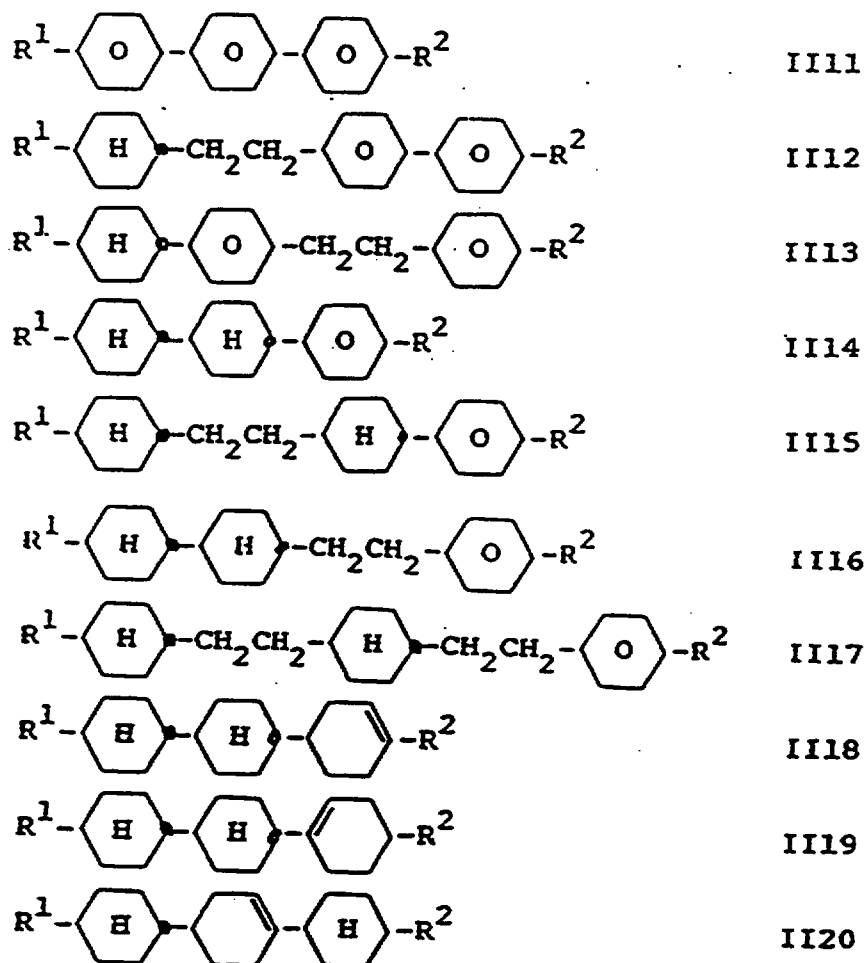
4. Display according to Claim 2 or 3, characterized in that component A contains one or more compounds of the formulae IIa-IIc and IIe-IIf, in which X is -F, -Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₂H or -OC₂F₅, and R, A¹, A² and A³ have the meanings given in Claim 1.
5. Display according to Claim 4, characterized in that component A contains no compounds of the formulae IIa to II f, in which X is cyano.
6. Display according to at least one of Claims 1 to 5, characterized in that X is F, Cl, CF₃, -OCF₃, -OCHF₂ or -CHF₂.
7. Display according to at least one of Claims 1 to 6, characterized in that component B contains one or more compounds selected from the group comprising II1 to II7:



in which R¹ and R² have the meanings given in Claim 1.

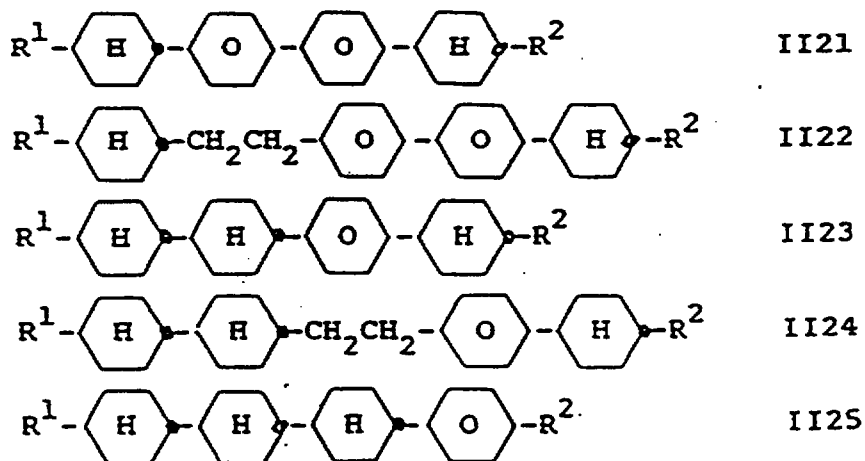
8. Display according to Claim 7, characterized in that component B additionally contains one or more compounds selected from the group comprising II8 to II20:





in which R¹ and R² have the meanings given in Claim 1 and the 1,4-phenylene groups in II8 to II17 each independently of one another can also be mono- or poly-substituted by fluorine.

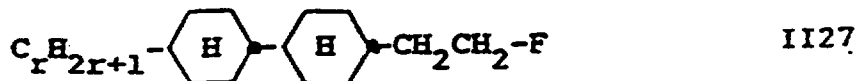
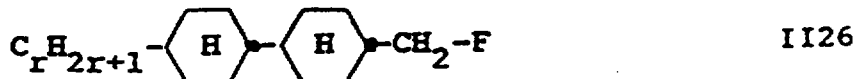
9. Display according to Claim 7 or 8, characterized in that component B additionally contains one or more compounds selected from the group comprising II21 to II25:



in which R¹ and R² have the meanings given in Claim 1 and the 1,4-phenylene groups in II21 to II25 each independently of one another can also be mono- or poly-substituted by fluorine.

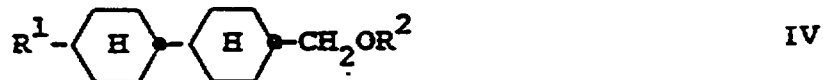


10. Display according to at least one of Claims 1 to 9, characterized in that component B contains one or more compounds selected from the group comprising II26 and II27:



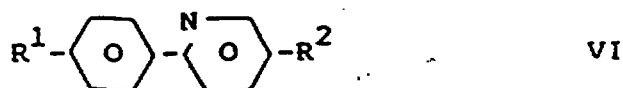
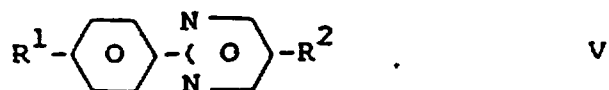
in which $\text{C}_r\text{H}_{2r+1}$ is a straight-chain alkyl group having up to 7 C atoms.

11. Display according to at least one of Claims 1 to 10, characterized in that the liquid crystal mixture additionally contains, apart from components A, B and C, one or more compounds selected from the group comprising III and IV:



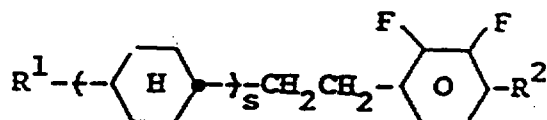
in which R^1 and R^2 have the meanings given in Claim 1.

12. Display according to at least one of Claims 1-11, characterized in that the liquid crystal mixture additionally contains, apart from components A, B and C, one or more compounds selected from the group comprising V and VI:

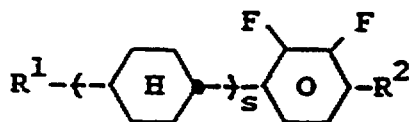


in which R^1 and R^2 have the meanings given in Claim 1.

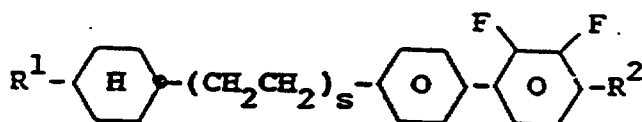
13. Display according to at least one of Claims 1-12, characterized in that component C contains one or more compounds selected from the group comprising VII to XI:



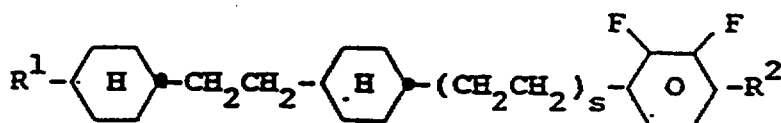
VII



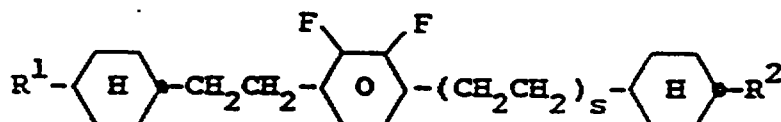
VIII



IX



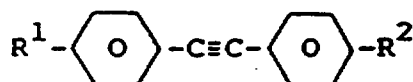
X



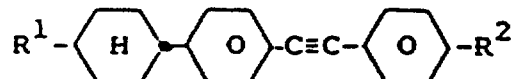
XI

in which R¹ and R² have the meanings given in Claim 1 and S [sic] is 0 or 1.

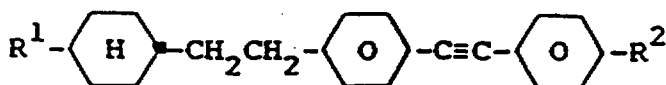
14. Display according to at least one of Claims 1-13, characterized in that component B contains one or more compounds selected from the group comprising XII to XIV



XII



XIII



XIV

in which R¹ and R² have the meanings given in Claim 1.

15. Liquid crystal mixture of the composition defined in any one of Claims 1-14, characterized in that these has a high dielectric anisotropy of $\Delta\epsilon > 5$ and a high content of cyano compounds of more than 20% by weight and less than 50% by weight.

[As printed]

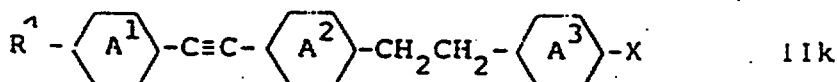
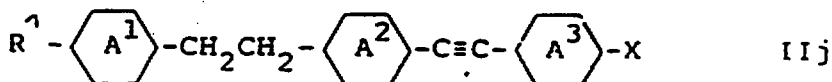
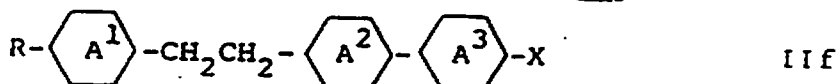
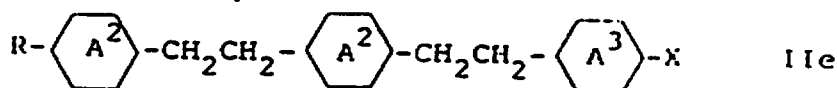
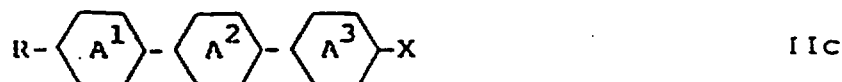
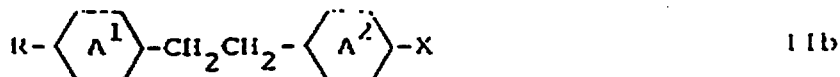
Revendications

1. Affichage à cristaux liquides supertorsadé avec

- deux plaques support à plans parallèles qui forment avec un bord une cellule,
- un mélange à cristaux liquides nématique à anisotropie diélectrique positive se trouvant dans la cellule,
- des couches d'électrodes sur lesquelles se trouvent des couches d'orientation sur les côtés intérieurs des plaques support,
- un angle de mise en place entre l'axe longitudinal des molécules à la surface de la plaque support et les plaques support d'environ 1° à 30°.



- un angle de torsade du mélange à cristaux liquides dans la cellule de couche d'orientation à couche d'orientation compris entre 100 et 600°, caractérisé en ce que le mélange à cristaux liquides nématique
a) est à base de composant A, contenant un ou plusieurs choisis dans le groupe A, constitué de composés de formules IIa-IIc et IIe-IIk,

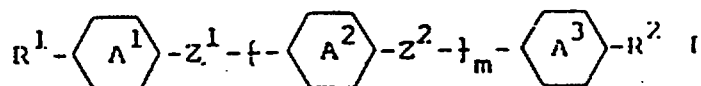


où R représente un n-alkyle ou un n-alcényle ayant jusqu'à 9 atomes de carbone,

X représente F, Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₂H ou -OC₂F₅, et

les noyaux, A¹, A² et A³ représentent chacun indépendamment l'un de l'autre un 1,4-phénylène, 2- ou 3-fluoro-1,4-phénylène ou un trans-1,4-cyclohexylène, ou encore l'un des noyaux A¹, A² et A³ représente un 1,4-cyclohexylène, 2,3-difluoro-1,4-phénylène, pyridine-2,5-diyle ou pyrimidine-2,5-diyle,

b) contient de 0 à 40% en poids d'un composant B à cristaux liquides constitué d'un ou plusieurs composés ayant une anisotropie diélectrique de -1,5 à +1,5 de formule générale I



où R¹ et R² représentent chacun indépendamment l'un de l'autre un N-alkyle, n-alcoxy, n-oxaalkyle, ω-fluoroalkyle ou n-alcényle ayant jusqu'à 9 atomes de carbone, les noyaux A¹, A² et A³ représentent chacun indépendamment l'un de l'autre un 1,4-phénylène, 2- ou 3-fluoro-1,4-phénylène, trans-1,4-cyclohexylène ou 1,4-cyclohexénylène,

Z¹ et Z² représentent chacun indépendamment l'un de l'autre -CH₂CH₂-, -C≡C- ou une liaison



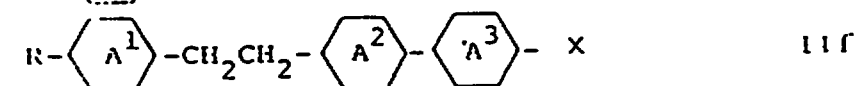
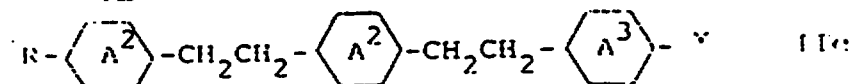
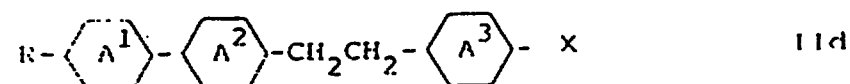
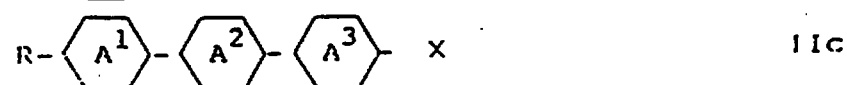
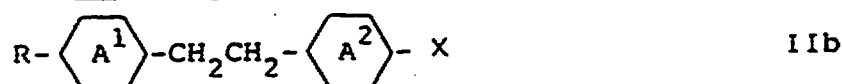
simple, et m vaut 0, 1 ou 2,

c) contient de 0 à 20% en poids d'un composant C à cristaux liquides constitué d'un ou plusieurs composés ayant une anisotropie diélectrique inférieure à -1,5 et

d) contient un composant D optiquement actif en une quantité telle que le rapport entre la couche d'épaisseur (intervalle entre les plaques support à plans parallèles) et le pas naturel du mélange à cristaux liquides nématique chiral s'élève à environ 0,2 à 1,3, et

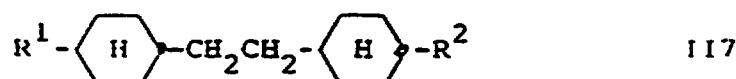
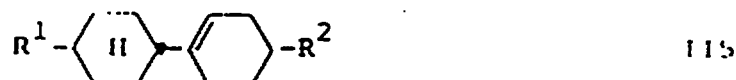
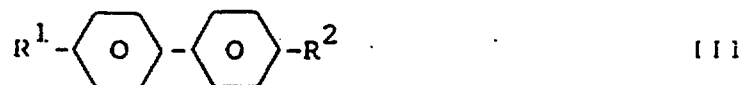
en ce que le mélange à cristaux liquides nématique présente un domaine de phase nématique d'au moins 60°C, une viscosité ne dépassant pas 35 mPa.s et une anisotropie diélectrique d'au moins +1, les anisotropies diélectriques des composés et les paramètres se rapportant au mélange à cristaux liquides nématiques se référant à une température de 20°C.

2. Affichage selon la revendication 1, caractérisé en ce que le composant A contient en outre 1 ou plusieurs composés cyano, la proportion des composés cyano dans le composant A s'élevant de 0 à 50% en poids.
3. Affichage selon la revendication 2, caractérisé en ce que les composés cyano sont choisis parmi les composés de formule IIa-IIf



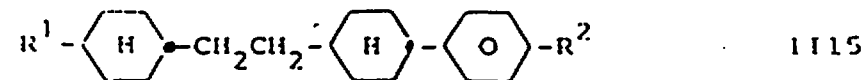
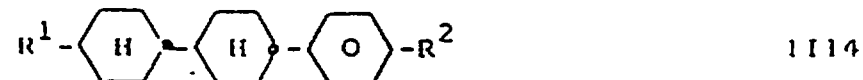
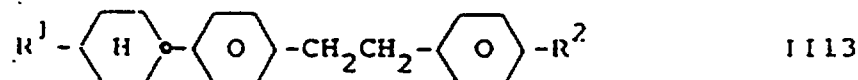
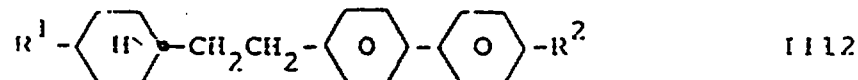
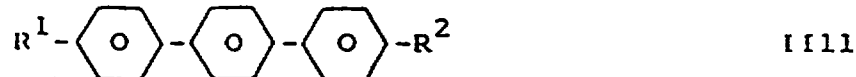
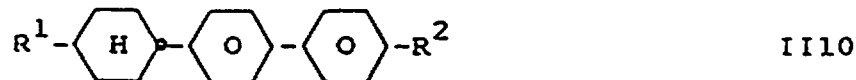
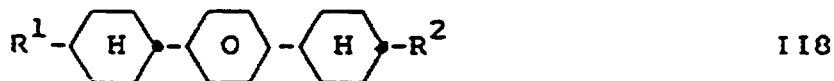
où X est un cyano et la signification de R, A¹, A² et A³ est donnée dans la revendication 1.

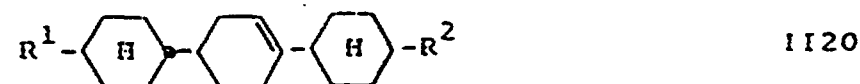
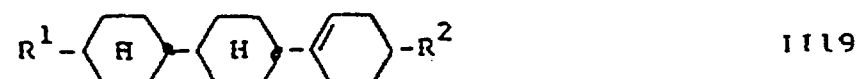
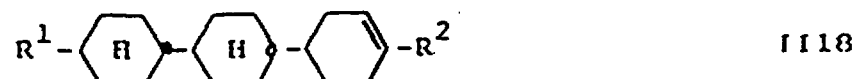
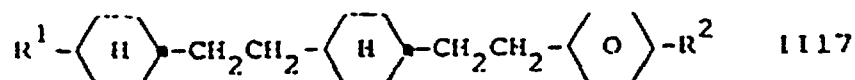
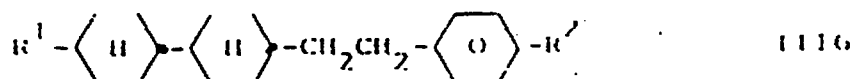
4. Affichage selon la revendication 2 ou la revendication 3, caractérisé en ce que le composant A contient un ou plusieurs composés de formules IIa-IIc et IIe-IIf, où X représente -F, -Cl, -CF₃, -CHF₂, -OCF₃, -OCHF₂, -OCF₂CF₂H ou -OC₂F₅ et R, A¹, A², et A³ ont la signification donnée dans la revendication 1.
5. Affichage selon la revendication 4, caractérisé en ce que le composant A ne contient pas de composés de formules IIa à II f, où X représente un cyano.
6. Affichage selon au moins l'une des revendications 1 à 5, caractérisé en ce que X représente F, Cl, CF₃, -OCF₃, OCHF₂ ou -CHF₂.
7. Affichage selon au moins l'une des revendications 1 à 6, caractérisé en ce que le composant B contient un ou plusieurs composés choisis dans le groupe constitué par II1 à II7 :



où R¹ et R² ont la signification donnée dans la revendication 1.

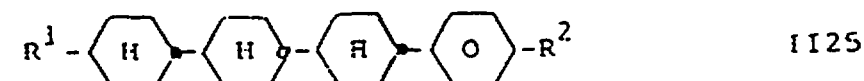
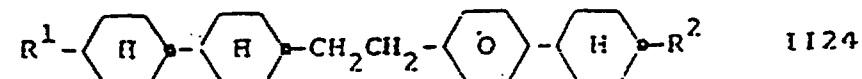
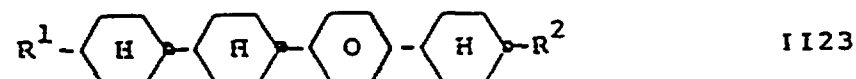
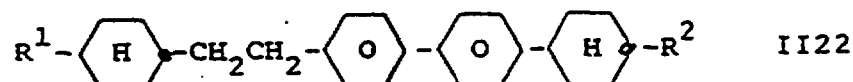
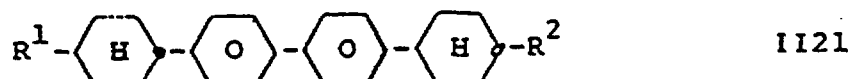
8. Affichage selon la revendication 7, caractérisé en ce que le composant B contient en outre un ou plusieurs composés choisis dans le groupe constitué par II8 à II20 :





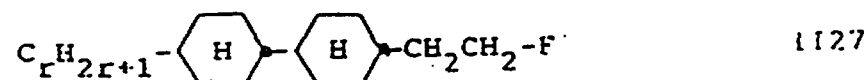
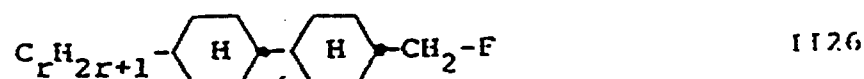
où R^1 et R^2 ont la signification donnée dans la revendication 1 et les groupes 1,4-phénylène dans 1118 à 1117 peuvent être également chacun indépendamment l'un de l'autre mono- ou poly-substitués par un fluor.

9. Affichage selon la revendication 7 ou 8, caractérisé en ce que le composant B contient en outre un ou plusieurs composés choisis dans le groupe constitué par 1121 à 1125 :



où R^1 et R^2 ont la signification donnée dans la revendication 1 et les groupes 1,4-phénylène dans 1121 à 1125 peuvent également être à chaque fois indépendamment l'un de l'autre mono- ou poly-substitués par un fluor.

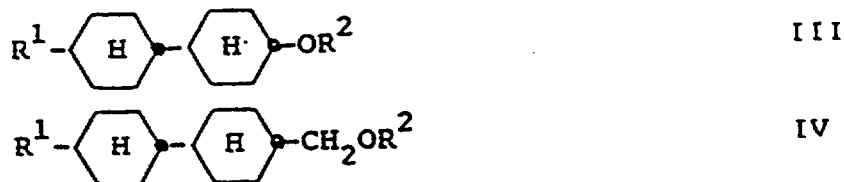
10. Affichage selon au moins l'une des revendications 1 à 9, caractérisé en ce que le composant B contient un ou plusieurs composés choisis dans le groupe constitué par 1126 et 1127 :



où C_rH_{2r+1} représente un groupe alkyle à chaîne droite comportant jusqu'à 7 atomes de carbone.

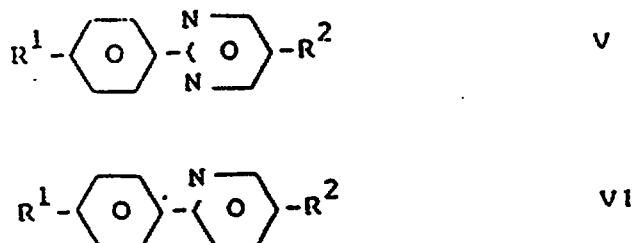


11. Affichage selon au moins l'une des revendications 1 à 10, caractérisé en ce que le mélange à cristaux liquides contient en outre, outre les composants A, B et C, un ou plusieurs composés choisis dans le groupe constitué par III et IV :



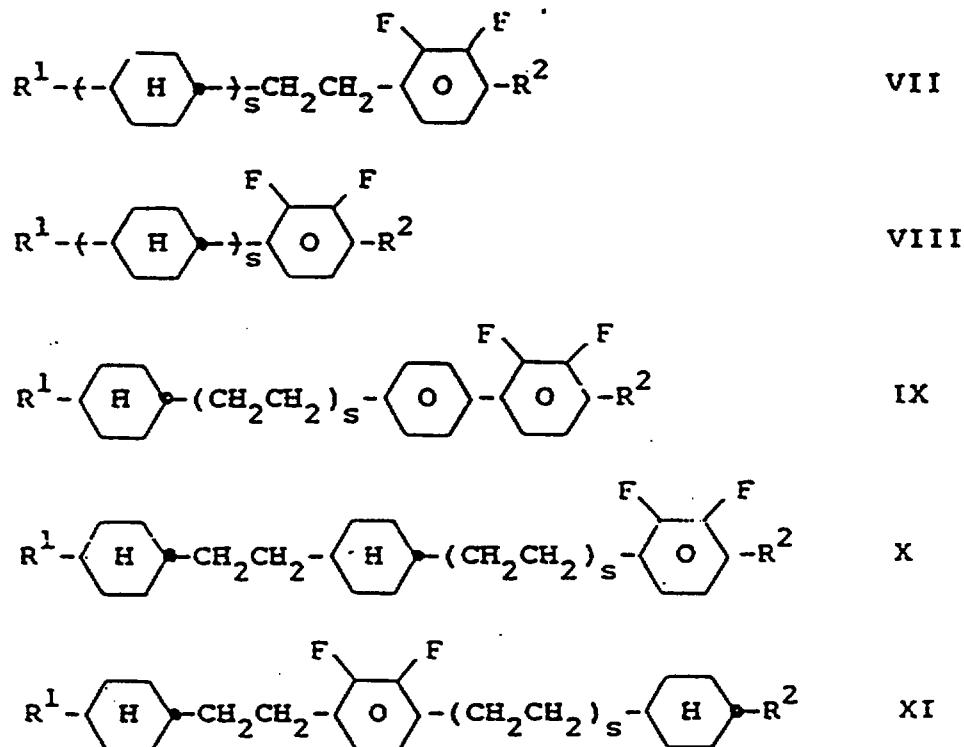
où R¹ et R² ont la signification donnée dans la revendication 1.

12. Affichage selon au moins l'une des revendications 1-11, caractérisé en ce que le mélange à cristaux liquides contient en outre, outre les composants A, B et C, un ou plusieurs composés, choisis dans le groupe constitué par V et VI :



où R¹ et R² ont la signification donnée dans la revendication 1.

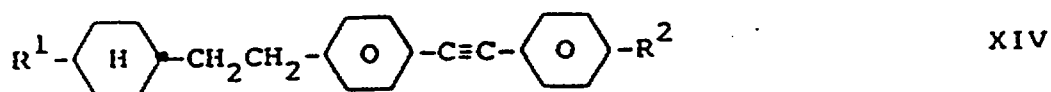
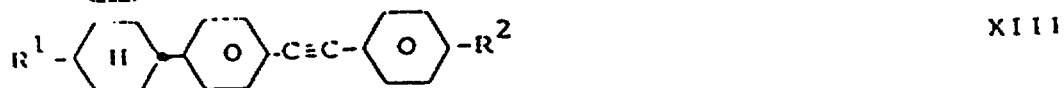
13. Affichage selon au moins l'une des revendications 1-12 caractérisé en ce que le composant C contient un ou plusieurs composés choisis dans le groupe constitué par VII à XI :





où R¹ et R² ont la signification donnée dans la revendication 1 et S vaut 0 ou 1.

14. Affichage selon au moins l'une des revendications 1-13, caractérisé en ce que le composant B contient un ou plusieurs composés choisis dans le groupe constitué par XII à XIV :



où R¹ et R² ont la signification donnée dans la revendication 1.

15. Mélange à cristaux liquides de composition définie dans l'une des revendications 1-14, caractérisé en ce qu'il présente une anisotropie diélectrique élevée $\Delta\epsilon > 5$ et une proportion élevée de composés cyano supérieure à 20% en poids et inférieure à 50 % en poids.