

Description

The invention relates to an electrooptical liquid crystal system

- 5 - which contains a dielectrically positive liquid crystal mixture and a further optically transparent medium between 2 electrodes which are optionally applied to substrate sheets, where the liquid crystal mixture is embedded in the optically transparent medium in the form of compartments which are separated to a greater or lesser extent from one another or forms a more or less coherent, continuous phase in the optically transparent medium,
- 10 - whose liquid crystal molecules in the switched-off state have an irregular orientation,
- 15 - in which one of the refractive indices of the liquid crystal mixture essentially agrees with the refractive index of the matrix n_m and/or in which the quotient of the mass of the liquid crystal mixture and of the mass of the optically transparent medium is 1.5 or more, and
- 20 - which, independently of the polarization of the incident light, has a reduced transmission in one of the two switch states compared to the other state, and liquid crystal mixtures used in this system.

25 Depending on the mass content of the liquid crystal mixture in the system, this can be embedded in the optically transparent medium in liquid crystal microdroplets which are separated to a greater or lesser extent from one another or else form a more or less coherent, continuous phase in which the optically transparent medium is present, for example, in the form of particles. A continuous phase is also obtained, for example, if the optically transparent medium forms a sponge-like, 3-dimensional network whose pores, in which the liquid crystal is located, merge into each other to a greater or lesser extent. The expression liquid crystal microdroplets here indicates small liquid crystal compartments separated from one another which, however, in no way have to have a spherical shape, but can be

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irregularly shaped and/or deformed.

If the optically transparent medium contains liquid crystal microdroplets, it is described in the following as a matrix; on the other hand, if a more or less continuous phase of the liquid crystal is present, the medium is described by the expression network.

NCAP and PDLC films (NCAP = nematic curvilinear aligned phases, PDLC = polymer dispersed liquid crystal) are examples of electrooptical liquid crystal systems in which the liquid crystal is embedded in the matrix in the form of microdrops [sic]. NCAP films are usually obtained by intimately mixing the encapsulated polymeric material, such as, for example, polyvinyl alcohol, the liquid crystal mixture and a carrier material, such as, for example, water, in a colloid mill. The carrier material is then removed, for example by drying. An appropriate process is described in US 4,435,047. In contrast, the liquid crystal mixture is first homogeneously mixed with monomers or oligomers of the matrix-forming material in the preparation of PDLC films described, for example, in US 4,688,900, Mol. Cryst. Liq. Cryst. Nonlin. Optic, 157, (1988), 427-441, WO 89/06264 and EP 0,272,585. The mixture is then polymerized and the phase separation is induced (so-called PIPS technology; polymerization-induced phase separation). In addition, differentiation must further be made between TIPS (temperature-induced phase separation) and SIPS (solvent-induced phase separation) (Mol. Cryst. Liq. Cryst. Inc. Nonlin. Opt. 157 (1988) 427).

The PN system (PN = Polymer Network) described in EP 0,313,053 and EP 0,359,146 has a sponge-like network structure of the optically transparent medium. The content of the liquid crystal mixture in the material of the light-modulating layer is in general greater than 60% in systems of this type and is, in particular, between 70 and 90%. In order to prepare the PN systems, a mixture of the liquid crystal, monomers or oligomers of the material forming the 3-dimensional network and a polymerization initiator, in particular a photoinitiator, is customarily brought between 2 substrate plates provided with

electrodes and then polymerized, for example by light irradiation.

5 The liquid crystal in general has a positive dielectric anisotropy $\Delta\epsilon$ and a relatively high optical anisotropy. In microdroplets matrix systems, one of the refractive indices of the liquid crystal, customarily the ordinary refractive index n_o , is selected in such a way that it more or less coincides with the refractive index n_m of the polymeric matrix. In the case of network
10 systems, an adjustment of the refractive indices owing to the customarily very much higher liquid crystal content in the light-modulating layer is not absolutely necessary, but can be carried out to increase the light transmission and the contrast. An electrically switchable
15 light scattering effect is observed in these electro-optical liquid crystal systems.

 If no voltage is applied to the electrodes, between which the matrix or the network is customarily arranged like a sandwich, light incident on the statis-
20 tically aligned liquid crystal molecules is strongly scattered and the system is non-transparent. On applying a voltage, the liquid crystal molecules are aligned parallel to the field and perpendicular to the E vector of the transmitted light.

25 In the case of microdroplets matrix systems, perpendicularly incident light sees an optically isotropic medium when voltage is applied owing to the adjustment of n_o and n_m and the system appears transparent. An adjustment is necessary in order to avoid
30 a scattering of the light at the matrix/liquid crystal droplets phase boundary. EP 0,272,585 describes another embodiment in which the refractive index n_x , which the liquid crystal exhibits at completely statistical orientation, is adjusted to the refractive index of the
35 matrix n_m . In this case, the system is transparent in the field-free state, and it is converted into the opaque state by applying a voltage.

 In the case of network systems, an adjustment of the refractive indices is not absolutely necessary, as

owing to the high liquid crystal content in the material of the light-modulating layer, the scattering at the network/liquid crystal phase boundary is obviously less strong. In the switched-on state, the system appears transparent even without adjustment of the refractive indices. In the case of network systems, the use of liquid crystals having high optical anisotropy is preferred to achieve a transmission which is as low as possible in the non-connected state.

In WO 89/09807, the use of an optically anisotropic, for example liquid crystalline polymeric matrix material has been proposed in order to avoid the frequently observed clouding ("haze", in particular "off-axis haze") in the transparent state of the system. In systems of this type, the refractive indices of liquid crystal and optically anisotropic matrix can be adapted to each other so that the transparent state is obtained either with the voltage applied or switched off.

Electrooptical liquid crystal systems according to the preamble of Claim 1 have been especially proposed for large-surface-area indicating systems, for architectural applications (windows, room dividers, sunroofs etc.) and for motor vehicles (windows, sunroofs etc.), these systems also being suitable for temperature regulation by virtue of controlled screening of the solar radiation. They can be switched on by applying a direct or alternating voltage.

As these systems are, in particular, also intended for "outdoor" applications, liquid crystal mixtures are required which are characterized by a high clear point, high $\Delta\epsilon$, a broad nematic range, a favourable temperature dependence of the electrooptical parameters [sic] and a high stability to UV and temperature.

Examples of other applications are:

- GH-indicating systems, the spectrum extending from simple segment displays to displays, to which it is possible to apply any desired electrode pattern using conventional printing techniques. Applications: motor vehicle, large displays,

advertizing boards, clocks

- displays having a high information content controlled by active or passive matrix
- projection systems
- 5 - switches.

Here too, liquid crystal mixtures having, in particular, high A_e , high electrical resistance, favourable values of the electrooptical parameters and their temperature dependence, advantageous values of viscosity and a high stability to UV and temperature are required.

10 In microdroplets matrix systems, until now LC mixtures were customarily employed which consist of alkyl- or alkoxy cyanobiphenyls and -terphenyls. Thus, for example, US 4,688,900, EP 0,205,261 and EP 0,272,585
15 describe the use of liquid crystal mixture E8 (prepared by BDH, Poole, Great Britain). This liquid crystal mixture is distinguished by a high value for the optical anisotropy A_n of 0.247 and a relatively high value for the flow viscosity η (20°C) of 54 mm²/s, but at the same
20 time has a relatively low clear point of only 72°C. If polynuclear polyphenyl compounds are added to the mixture to increase the clear point, a higher value for the flow viscosity η and an unchanged high or higher value for the optical anisotropy A_n results. High A_n values admittedly
25 provide on the one hand for a strong light scattering in the opaque state, but on the other hand they can cause a clouding of the system in the switched-on state ("haze", in particular "off-axis haze") and thus an impairment of the electrooptical properties. Indeed, in systems which
30 are controlled by a relatively low frequency alternating voltage, a high flow viscosity η is desired in order to obtain a flicker-free display; however, on the other hand in matrix displays having a high information content liquid crystal mixtures having a relatively low viscosity
35 are required for the realization of rapid switching times.

The liquid crystal mixture E7 (prepared by BDH, Poole, Great Britain) used in US 4,671,618, which also consists of alkyl- and alkoxy cyanobiphenyls and

-terphenyls, admittedly has a relatively low flow viscosity with $\eta = 39 \text{ mm}^2/\text{s}$ and a somewhat smaller optical anisotropy A_n than E8 with $A_n = 0.225$, but at the same time the clear point $T_c = 60.5^\circ\text{C}$ is considerably lower. The dielectric anisotropy of the mixture E7 A_e is 13.8 and is thus somewhat smaller than that of E8 with $A_e = 15.6$. In order to obtain threshold voltages which are as small as possible, still higher values for A_e are advantageous.

10 In EP 0,313,053, liquid crystal mixtures for network systems are proposed which are based on 2-(4-cyanophenyl)pyridines. Liquid crystal mixtures of this type indeed have relatively high values for the dielectric anisotropy A_e and thus relatively small
15 threshold voltages and high to very high values for the optical anisotropy A_n . At the same time, however, these liquid crystals are characterized by a relatively high viscosity η , a relatively low clear point T_c and a working temperature range which is insufficient for many
20 applications. Moreover, cyanophenylpyridine compounds have, inter alia, a lower stability to UV and temperature than cyano-oligophenyl compounds.

The PN systems described in EP 0,359,146 are based on liquid crystal mixtures which have a high
25 birefringence A_n of between 0.18 and 0.3 and a high dielectric anisotropy A_e of between 15 and 30.

The liquid crystals used hitherto only inadequately fulfil the requirements for a broad nematic range, a high clear point, a very high thermal and UV
30 stability, an absence of smectic phases down to low temperatures, an optical anisotropy A_n and flow viscosity η which are optimizable with respect to the respective application and a high A_e .

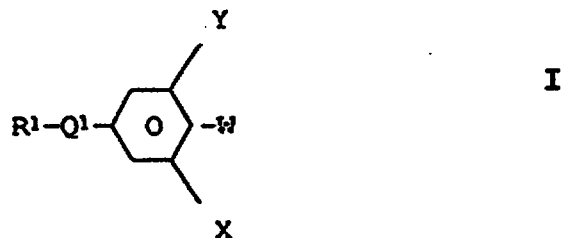
In addition, the previous liquid crystals frequently have too low a miscibility with the monomers
35 and/or oligomers of the polymer used for the formation of the matrix or of the network, which considerably impairs the preparation of PN systems and, in the case of microdroplets matrix systems considerably restricts, in

particular, the use of PIPS technology. Moreover, the liquid crystals are frequently characterized by too high a solubility in the matrix- or network-forming polymer. A further disadvantage of the previous liquid crystals is frequently that the liquid crystal exhibits unfavourable values of the the electrooptical parameters such as, for example, the slope of the electrooptical curve and/or the temperature dependence of the electrooptical parameters such as, for example, the threshold voltage, for the respective application.

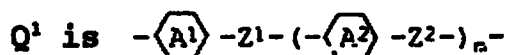
A great need thus still exists for electrooptical liquid crystal systems which are better suited to the appropriate requirements and do not have the disadvantages described or only have them to a relatively small extent.

The invention was thus based on the aim of making available electrooptical liquid crystal systems and liquid crystals which do not have the disadvantages mentioned of conventional systems or only have them to a relatively small extent. Other aims of the present invention are immediately evident to the person skilled in the art from the following detailed description.

It has been found that the aims on which the invention is based can be achieved if liquid crystal mixtures are used for the systems, which mixtures contain one or more compounds of the formula I



in which



30 $-\langle\text{A}^1\rangle\text{-}$ and $-\langle\text{A}^2\rangle\text{-}$ are independently of one another trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene and one of A¹ and, if present, A², is also pyridine-2,5-diyl, pyrimidine-2,5-diyl,

1,3-dioxane-2,5-diyl, tetrahydropyran-2,5-diyl
or naphthalene-2,6-diyl,

5 Z^1 and Z^2 are independently of one another a single bond,
-CH₂CH₂-, -COO-, -OCO-, -C=C-, -CH₂O- or any
desired combinations of these bridge groups,

Y and X are independently of one another H or F, and
one of X and Y is also Cl,

W is -Cl, -F, -CF₃, -OCF₃, -OCHF₃, or -NCS,

10 R^1 is alkyl having 1-12 C atoms, in which one or
2 non-adjacent CH₂ groups can also be replaced
by -O- or -HC=CH-, and

m is 0, 1 or 2,

with the provisos that

15 (i) the mass content of compounds of the formula I in
the liquid crystal mixture is at least 50%,
and/or

(ii) the liquid crystal mixture contains no compound
of the formula I where W is F or NCS, and/or

20 (iii) the liquid crystal mixture has no compound con-
taining a nitrogen-containing heterocycle.

The invention thus relates to an electrooptical
liquid crystal system

25 - which contains a dielectrically positive liquid
crystal mixture and a further optically transparent
medium between 2 electrodes which are optionally
applied to substrate sheets, where the liquid crys-
tal mixture is embedded in the optically transparent
medium in the form of compartments which are separ-
ated to a greater or lesser extent from one another
30 or forms a more or less coherent, continuous phase
in the optically transparent medium,

- whose liquid crystal molecules in the switched-off
state have an irregular orientation,

35 - in which one of the refractive indices of the liquid
crystal mixture essentially agrees with the refrac-
tive index of the optically isotropic transparent n_a
medium or in which the refractive indices of the
liquid crystal mixture essentially agree with the
refractive indices of the optically anisotropic

transparent medium and/or in which the quotient of the mass of the liquid crystal mixture and of the mass of the optically transparent medium is 1.5 or more,

- 5 - which, independently of the polarization of the incident light, has a reduced transmission in one of the two switch states compared to the other state, and
- whose liquid crystal contains one or more compounds
10 of the formula I.

The construction of the electrooptical liquid crystal systems according to the invention corresponds to the customary mode of construction for systems of this type. The term customary mode of construction is in this
15 case broadly interpreted and includes all adaptations and modifications.

Thus, for example, in the case of PDLC or NCAP films, the matrix formed by the transparent medium in which the liquid crystal mixture is microdispersed or
20 microencapsulated is arranged between conducting electrodes like a sandwich.

The electrodes are applied, inter alia, to substrate sheets of, for example, glass, plastic or the like; if desired, however, the matrix can also be
25 provided directly with electrodes so that the use of substrates can be avoided.

In the case of network systems, the liquid crystal is located in the pores of the sponge-like, 3-dimensional network or the optically transparent medium
30 is located in the form of small, for example spherical, particles in the liquid crystal. The network is customarily arranged between substrates provided with electrodes in order to prevent escape of the liquid crystal.

35 Both network systems and microdroplets matrix systems can be operated reflectively or transmissively so that at least one electrode and, if present, the associated substrate are transparent. Both systems customarily contain no polarizers, as a result of which

a distinctly higher light transmission results. Furthermore, no orientation layers are necessary, which is a considerable technological simplification in the production of these systems compared with conventional liquid crystal systems such as, for example, TN or STN cells.

The matrix or the 3-dimensional network are based, in particular, on isotropic thermoplastics, thermoset plastics and elastomers. Depending on the intended application, the systems obtained can be flexible, elastic or rigid.

A system based on a thermoplastic polymer can easily be deformed by the action of a mechanical stress at temperatures which are greater than the glass temperature of the matrix. This can be used, for example, in microdroplets matrix systems in order to freeze a specifically deformed shape of the droplets by cooling the matrix to temperatures below the glass temperature. Furthermore, for example, the matrix can be mechanically stretched at temperatures above the glass temperature or orientated by the action of electrical or magnetic fields, this orientation, which is maintained at temperatures below the glass temperature, causing optically anisotropic properties of the matrix.

While flexible and/or elastic systems are preferably based on thermoplastics and/or elastomers, thermoset polymers are preferably used for the production of rigid systems. These can be deformed mechanically, for example, during hardening, the shape and arrangement of the microdroplets, for example, being fixed in the hardened matrix.

In the literature, there are various details about materials particularly suitable for the production of the matrix or of the network. Thus, for example, in US 4,435,047 or in Liquid Crystals, 3, (1988) 1543, water-soluble polymers are proposed, such as, for example, polyvinyl alcohol PVA or latex-like emulsions. In US 4,671,618, US 4,673,255, US 4,688,900, WO 85/04262 and in Mol. Cryst. Liq. Cryst. Inc. Nonlin. Opt. 157 (1988) 427, on the other hand synthetic resins such as,

for example, epoxy resins and polyurethanes which, for example, are thermally cured, are mentioned as suitable matrix materials. EP 0,272,585 describes matrix or network materials based on photocurable vinyl compounds and WO 89/06264 proposes copolymerized [sic] of multi-functional acrylates containing multifunctional mercaptans. Other details about polymers which are suitable, in particular, for matrix systems are found, for example, in EP 0,165,063, EP 0,345,029, EP 0,357,234 or EP 0,205,261.

For the production of network systems, a number of 3-dimensional crosslinkable monomers such as, for example, di- and triacrylates are mentioned in EP 0,313,053.

In addition, however, other transparent materials such as, for example, inorganic oxide glass monoliths (US 4,814,211), other inorganic materials (see, for example, Japanese Laid-Open Specification 303325/1988) or, alternatively, other materials can also be used for matrix and network systems.

The materials mentioned are intended to illustrate the invention only by way of example, but should in no case limit it. In principle, all transparent materials can be used which permit the production of the matrix or network structures described according to the preamble of Claim 1.

Preferred embodiment [sic] of the electrooptical liquid crystal systems according to the invention are NCAP films, PDLC films and microdroplets matrix systems produced by modified processes. Processes for the production of these films are described, for example, in US 4,688,900, US 4,673,255, US 4,671,618, WO 85/04262, US 4,435,047, EP 0,272,595, Mol. Cryst. Liq. Cryst. Inc. Nonlin. Opt. 157 (1988) 427, Liquid Crystals, 3 (1988) 1543, EP 0,165,063, EP 0,345,029, EP 0,357,234 and EP 0,205,261.

A further preferred embodiment of the electro-optical systems according to the invention are the network systems whose production is described in EP 0,313,053. Included in the network systems here are

also arrangements in which the transparent medium is dispersed in the form of individual, for example spherical, particles in the liquid crystal, such as is described, for example, in GB 1,442,360.

5 However, in addition also those embodiments of the invention are included in which the transparent medium has a structure which lies between the network structure on the one side and the microdroplets matrix configuration on the other side.

10 In addition, other embodiments of the invention not explicitly mentioned here are also included.

 The thickness d of the electrooptical systems d is customarily chosen to be small in order to achieve a threshold voltage V_{th} which is as low as possible. Thus, 15 for example, layer thicknesses of 0.8 and 1.6 mm are reported in US 4,435,047, while values for the layer thickness between 10 μm and 300 μm are given in US 4,688,900 and between 5 μm and 30 μm in EP 0,313,053. The electrooptical systems according to the invention 20 only have layer thicknesses d which are distinctly greater than a few mm in exceptional cases; layer thicknesses $d \leq 2$ mm are preferred.

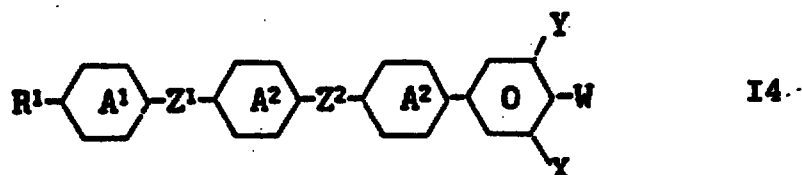
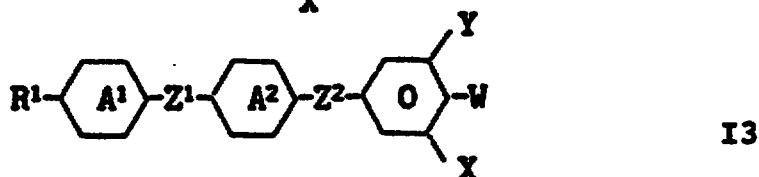
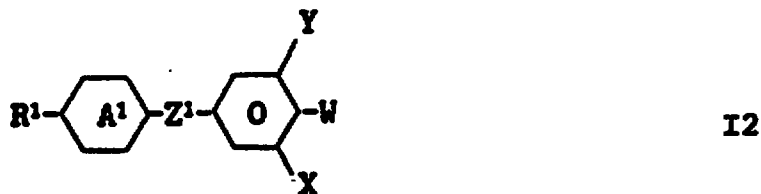
 The threshold voltage is also influenced by the size of the microdroplets or the mesh width of the 25 network. Generally, relatively small microdroplets cause a relatively high threshold voltage V_{th} , but relatively short switch times t_{on} or t_{off} (US 4,673,255). Experimental methods for influencing the average droplet size are described, for example, in US 4,673,255 and in J.L. West, 30 Mol. Cryst. Liq. Cryst. Inc. Nonlin. Opt., 157 (1988) 427. In US 4,673,255, average drop diameters between 0.1 μm and 8 μm are given, while, for example, a matrix which is based on a glass monolith has pores having a diameter between 15 and 2,000 Å. For the mesh width of 35 the network of the PN systems, a preferred range between 0.5 and 2 μm is given in EP 0,313,053.

 An essential difference between the electrooptical liquid crystal systems according to the invention and those customary hitherto exists, however,

in the liquid crystal mixture used.

The liquid crystal mixtures according to the invention contain at least one compound of the formula I.

The compounds of the formula I include 2-, 3- and 4-ring dielectrically positive or dielectrically neutral compounds of the sub-formulae I2, I3 and I4:



In the compounds of the formula [sic] I2-I4, X and Y independently of one another are H, F or Cl, but in particular H or F. Preferably, the compounds of the formulae I3 and I4 contain not more than 2 and, in particular, not more than 1 heterocycle. In the compounds of the formulae I3 and I4, one of the bridges Z¹ and Z² is preferably a single bond.

In the compounds of the formula I and the sub-formulae of the compounds I2-I4, R¹ and R², if present, are independently of one another alkyl having 1-12 C atoms, in which one or 2 non-adjacent CH₂ groups can also be replaced by -O- or -CH=CH-.

If R¹ and/or, if present, R² is an alkyl radical and/or an alkoxy radical, this can be straight-chain or branched. Preferably it is straight-chain, has 1, 2, 3, 4, 5, 6 or 7 C atoms and is therefore preferably methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy or heptoxy, or further methyl [sic], octyl, nonyl, decyl, undecyl, dodecyl, octoxy, nonoxy, decoxy, undecoxy or dodecoxy.

Oxaalkyl is preferably straight-chain 2-oxapropyl

(= methoxymethyl, 2- (= ethoxymethyl) or 3-oxabutyl
(= 2-methoxyethyl), 2-, 3- or 4-oxapentyl, 2-, 3-, 4- or
5-oxahexyl, 2-, 3-, 4-, 5- or 6-oxaheptyl, 2-, 3-, 4-,
5-, 6- or 7-oxaoctyl, 2-, 3-, 4-, 5-, 6-, 7- or
5 8-oxanonyl, 2-, 3-, 4-, 5-, 6-, 7-, 8- or 9-oxadecyl.

If R^1 and/or, if present, R^2 are an alkyl radical
in which a CH_2 group is replaced by $-CH=CH-$, this can be
straight-chain or branched. Preferably it is straight-
chain and has 2 to 10 C atoms. It is therefore particu-
10 larly vinyl, prop-1- or prop-2-enyl, but-1-, 2- or but-3-
enyl, pent-1-, 2-, 3- or pent-4-enyl, hex-1-, 2-, 3-, 4-
or hex-5-enyl, hept-1-, 2-, 3-, 4-, 5- or hept-6-enyl,
oct-1-, 2-, 3-, 4-, 5-, 6- or oct-7-enyl, non-1-, 2-, 3-,
4-, 5-, 6-, 7- or non-8-enyl, dec-1-, 2-, 3-, 4-, 5-, 6-,
15 7-, 8- or dec-9-enyl.

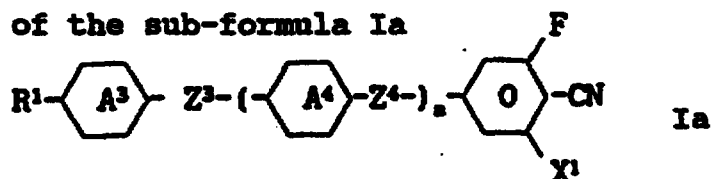
In the compounds of the formula I, the radicals
 R^1 and/or, if present, R^2 can be straight-chain or
branched; however, they are preferably straight-chain.
Compounds of the formula I having branched alkyl or
20 alkoxy radicals can occasionally be of importance owing
to a better solubility in the customary liquid crystal-
line base materials, but in particular as chiral dopants
if they are optically active. Electrooptical systems
according to the preamble of Claim 1, whose liquid
25 crystal contains one or more chiral components, are
described in DE 3,911,255.1.

Branched groups of this type as a rule contain
not more than one chain branching. Preferred branched
radicals are isopropyl, 2-butyl (= 1-methylpropyl),
30 isobutyl (= 2-methylpropyl), 2-methylbutyl, isopentyl
(= 3-methylbutyl), 2-methylpentyl, 3-methylpentyl,
2-ethylhexyl, 2-propylpentyl, 2-octyl, isopropoxy,
2-methylpropoxy, 2-methylbutoxy, 3-methylbutoxy,
2-methylpentoxy, 3-methylpentoxy, 2-ethylhexoxy,
35 2-methylhexoxy, 2-octyloxy, 2-oxa-3-methylbutyl,
3-oxa-4-methylpentyl, 4-methylhexyl, 2-nonyl,
6-methyloctoxy, 2-methyl-3-oxapentyl and 2-methyl-3-oxa-
hexyl.

The compounds of the formula I are prepared by

methods known per se, such as are described in the literature (for example in the standard works such as Houben-Weyl, Methoden der Organischen Chemie (Methods of Organic Chemistry), Georg-Thieme-Verlag, Stuttgart Vol. IX, p. 867 et seq.), in particular under reaction conditions which are known and suitable for the reactions mentioned. In this connection, use can also be made of variants known per se which are not mentioned here in more detail.

Particularly preferred is a small group of compounds of the sub-formula Ia



in which

and independently of one another are 1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene and

X¹ is H or F

and the following combinations Nos. 1-5 apply to n, Z² and Z⁴:

No.	n	Z ² [sic]	Z ⁴ [sic]
1	0	single bond	-
2	0	-CH ₂ CH ₂ -	-
25 3	1	-CH ₂ CH ₂ -	single bond
4	1	single bond	-CH ₂ CH ₂ -
5	1	single bond	single bond

For the sake of simplicity, in the following Cyc is trans-1,4-cyclohexylene, Phe is 1,4-phenylene, Phe.2F is 2-fluoro-1,4-phenylene, Phe.3F is 3-fluoro-1,4-phenylene, Phe.F2 is 2,3-difluoro-1,4-phenylene, Phe.3F5F is 3,5-difluoro-1,4-phenylene, Phe.F is 2- or 3-difluoro-1,4-phenylene, Pyr is pyrimidine-2,5-diyl, Pyd is pyridine-2,5-diyl, Dio is 1,3-dioxane-2,5-diyl and Thp is tetrahydropuran-2,5-diyl [sic]. The acronyms Pyr, Pyd, Dio and Thp in each case include the two possible

positional isomers; the meaning of the acronyms Phe.2Cl, Phe.3Cl, Phe.3Cl5Cl and Phe.Cl is evident from that of the appropriate fluorinated 1,4-phenylene groups.

5 The compounds of the sub-formula Ia include 2-ring compounds, of which those of the sub-formulae Ia2-1 - Ia2-6 are preferred:

R ¹ -Phe-Phe.3F-CN	Ia2-1
R ¹ -Phe-Phe.3F5F-CN	Ia2-2
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F-CN	Ia2-3
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F5F-CN	Ia2-4
R ¹ -Cyc-Phe.3F-CN	Ia2-5
R ¹ -Cyc-Phe.3F5F-CN	Ia2-6

10 In the compounds of the sub-formulae Ia2-1 - Ia2-6, R¹ has the meaning given for the compounds of the formulae [sic] I. R¹ is preferably alkyl, alkenyl or alkoxy having 1-10, but in particular having 1-8 C atoms. n-Alkoxyalkyl compounds and, in particular, n-methoxy-alkyl, n-alkoxyethyl and n-alkoxymethyl compounds are additionally preferred. Liquid crystal media which contain compounds of the formulae Ia2-2, Ia2-4 and Ia2-6
15 have particularly advantageous values for the dielectric anisotropy. In the compounds of the sub-formulae Ia2-1 and Ia2-2, Phe may also in each case independently of one another be laterally fluorinated.

20 The compounds of the sub-formula Ia include 3-ring compounds, of which those of the sub-formulae Ia3-1 - Ia3-16 [sic] are preferred:

R ¹ -Cyc-Phe-CH ₂ CH ₂ -Phe.3F-CN	Ia3-1
R ¹ -Cyc-Phe-CH ₂ CH ₂ -Phe.3F5F-CN	Ia3-2
R ¹ -Cyc-Cyc-CH ₂ CH ₂ -Phe.3F-CN	Ia3-3
R ¹ -Cyc-Cyc-CH ₂ CH ₂ -Phe.3F5F-CN	Ia3-4

R^1 -Cyc-CH ₂ CH ₂ -Phe-Phe.3F-CN	Ia3-5
R^1 -Cyc-CH ₂ CH ₂ -Phe-Phe.3F5F-CN	Ia3-6
R^1 -Cyc-CH ₂ CH ₂ -Cyc-Phe.3F-CN	Ia3-7
R^1 -Cyc-CH ₂ CH ₂ -Cyc-Phe.3F5F-CN	Ia3-8
R^1 -Phe-Phe-Phe.3F-CN	Ia3-9
R^1 -Phe-Phe-Phe.3F5F-CN	Ia3-10
R^1 -Cyc-Phe-Phe.3F-CN	Ia3-11
R^1 -Cyc-Phe-Phe.3F5F-CN	Ia3-12
R^1 -Cyc-Cyc-Phe.3F-CN	Ia3-13
R^1 -Cyc-Cyc-Phe.3F5F-CN	Ia3-14
R^1 -Phe-CH ₂ CH ₂ -Phe-Phe.3F-CN	Ia3-15
R^1 -Phe-CH ₂ CH ₂ -Phe.3F5F-CN	Ia3-16
R^1 -Phe-Phe-CH ₂ CH ₂ -Phe.3F-CN	Ia3-17
R^1 -Phe-Phe-CH ₂ CH ₂ -Phe.3F5F-CN	Ia3-18

In the compounds of the sub-formulae Ia3-1 - Ia3-18, R¹ has the meaning given for the compounds of the formula I, but preferably R¹ is n-alkyl, n-alkenyl or n-alkoxy having 1-10 C atoms, and in addition also
5 n-alkoxymethyl or n-alkoxymethyl having 1-18 C atoms.

Very particularly preferred compounds of the formulae Ia3-1 - Ia3-18 are those in which R¹ is methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy,
10 methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl,

pentoxymethyl, methoxyethyl, ethoxyethyl, propoxyethyl, butoxyethyl or pentoxyethyl.

In the compounds of the formulae Ia3-1 - Ia3-18, Phe groups may in each case independently of one another be laterally fluorinated, in particular monofluorinated.

The compounds of the formula Ia and, in particular, of the formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-18 are for the largest part known and are preferably prepared by the methods described in DE 3,209,178, JP 62-103,057, DE 3,929,418, JP 63-216,858, DE 3,401,320, EP 0,119,756, DE 3,632,411, EP 0,205,998 and, in particular, by those in DE 3,929,418.

Liquid crystal mixtures which contain compounds of the formula Ia and, in particular, of the formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-18 are particularly suitable for use in electrooptical systems according to the invention and are distinguished by advantageous values for the birefringence Δn and the flow viscosity η , a high stability, low miscibility with the polymer used for the matix [sic] and, in particular, by a broad mesogenic range, a relatively high clear point and advantageous values for the dielectric anisotropy, the threshold voltage and the temperature dependence of the electrooptical parameters.

The liquid crystals used in the electrooptical liquid crystal systems according to the invention preferably contain 1-40%, in particular 5-30%, of compounds of the sub-formula Ia and, in particular, of the sub-formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-18. The liquid crystals preferably contain 1-5, but in particular 1-3, compounds of the sub-formula Ia and in particular of the sub-formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-18.

Liquid crystal mixtures are particularly preferred which, in addition to compounds of the sub-formula Ia, are based on compounds of the formulae II-IV.

T-W¹-Phe-CN

II

R-W¹-Cyc-CN

III

T-V-Phe-CN

IV

in which

- R in each case independently of one another is an alkyl group having 1-15 C atoms, in which one or two non-adjacent CH₂ groups can also be replaced by $\ddot{O}$ -, -CO- and/or -CH=CH,
- 5 W¹ is Phe.(F)-Y¹ or Cyc-Y¹,
- Y¹ is a single bond, -COO- or -OCO-
- V is pyridine-1,5-diyl or pyrimidine-2,5-diyl,
- T is R, R-Phe.(F)-Y¹ or R-Cyc-Y¹ and
- 10 Phe.(F) is 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene.

In the compounds of the formulae II-IV, the terminal group Phe-CN can also be mono- or difluorinated in 3- and/or 5-position by F, in particular if Y¹ is -COO- or -OCO-.

15

The compounds of the formulae II-IV are either known and/or are prepared by methods known per se, as are described in the literature (e.g. in the standard works such as Houben-Weyl, Methoden der Organischen Chemie

20 [Methods of Organic Chemistry], Georg-Thieme-Verlag, Stuttgart Vol. IX, p. 867 ff.), namely under reaction conditions which are known and suitable for the reactions mentioned. Use can also be made in this case of variants which are known per se but not mentioned in greater

25 detail here.

The content of the component mixture consisting of one or more compounds selected from the group of compounds of the sub-formulae [sic] Ia and in particular of the sub-formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-16

30 [sic], and one or more compounds selected from the group of compounds of the formulae II-IV in the liquid crystal mixtures used in the electrooptical liquid crystal systems according to the invention is preferably 15%100%, but in particular 25%-100%. The component mixtures, in

35 addition to one or more compounds of the sub-formula Ia and in particular of the sub-formulae Ia2-1 - Ia2-6 and Ia3-1 - Ia3-16 [sic], particularly preferably contain one or more compounds which are selected from the following smaller group of compounds III1-II25 [sic], III1-III3 and

IV1-IV8;

R-Cyc-Phe-CN	II1
R-Cyc-COO-Phe-CN	II2
R-Cyc-COO-Phe.3F-CN	II3
R-Cyc-COO-Phe.3F5F-CN	II4
R-Phe-Phe-CN	II5
R-Phe-COO-Phe-CN	II6
R-Phe-COO-Phe.3F-CN	II7
R-Phe-COO-Phe.3F5F-CN	II8
R-Cyc-Phe-Phe-CN	II9
R-Cyc-COO-Phe-Phe-CN	II10
R-Cyc-Phe-COO-Phe-CN	II11
R-Cyc-COO-Phe-Phe.3F-CN	II12
R-Cyc-COO-Phe-Phe.3F5F-CN	II13
R-Cyc-Phe-COO-Phe.3F-CN	II14
R-Cyc-Phe-COO-Phe.3F5F-CN	II15
R-Phe-Phe-Phe-CN	II16
R-Phe-Phe.3F-Phe-CN	II17
R-Phe-Phe.2F-Phe-CN	II18
R-Phe-COO-Phe-Phe-CN	II19
R-Phe-COO-Phe-Phe.3F-CN	II20
R-Phe-COO-Phe-Phe.3F5F-CN	II21
R-Phe-Phe-COO-Phe-CN	II22
R-Phe-Phe-COO-Phe.3F-CN	II23
R-Phe-Phe-COO-Phe.3F5F-CN	II24

R-Cyc-Cyc-CN	III1
R-Cyc-COO-Cyc-CN	III2
R-Cyc-OCO-Cyc-CN	III3
R-Pyd-Phe-CN	IV1
R-Pyr-Phe-CN	IV2
R-Pyd-Phe-Phe-CN	IV3
R-Pyr-Phe-Phe-CN	IV4
R-Phe-Pyd-Phe-CN	IV5
R-Phe-Pyr-Phe-CN	IV6
R-Cyc-Pyr-Phe-CN	IV7
R-Cyc-Pyd-Phe-CN	IV8

Component mixtures are very particularly preferred which, in addition to at least one compound selected from the compounds of the sub-formulae [sic] Ia and in particular of the sub-formulae Ia2-1 - Ia2-6 and 5 Ia3-1 -Ia3-16 [sic], contain one or more compounds selected from the compounds of the sub-formulae III1-II24, and at least one compound selected from the compounds of the sub-formulae IV1-IV8.

Liquid crystal mixtures which are based on the 10 following component mixtures T(Ia) 1-4, which contain at least one compound each from the compound classes of the formulae shown in each case, are preferred. The preferred mass content of these compounds in the component mixtures is additionally given in the table. The component mix- 15 tures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these

compounds in the component mixture is 100%. The mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

5	Mixture	Formula	Mass content in the component mixture [%]
	T (Ia) 1	Ia	5-75
		II	6-65
	T (Ia) 2	Ia	5-55
		II	5-65
		III	5-29
	T (Ia) 3	Ia	5-75
		IV	5-63
10	T (Ia) 4	Ia	5-55
		II	5-49
		IV	5-50, in particular 5-31

Systems according to the invention are also particularly preferred whose liquid crystal mixture is based on the compound classes

R-Cyc-Phe-CN	III
R-Phe-Phe-CN	II5
R-Cyc-Phe-Phe-CN	II9
R-Phe-Phe-Phe-CN	II16

characterized in that, to increase the dielectric anisotropy, the liquid crystal mixture contains 5-60% of one or more compounds of the following formulae

R-Phe.2F-Phe-CN	II25
R-Phe.3F-Phe-CN	II25a

R ¹ -Phe-Phe.3F-CN	Ia2-1
R ¹ -Phe-Phe-Phe.3F-CN	Ia3-9
R-Phe-Phe.2F-Phe-CN	II18
R-Phe-Phe.3F-Phe-CN	II17
R-Cyc-Phe.2F-Phe-CN	II26
R-Cyc-Phe.3F-Phe-CN	II27
R-Phe.F-Phe.F-Phe-CN	II28

where the meaning of R¹ and R is given above and R is, in particular, an alkyl group having 2-7 C atoms. Mixtures of this type are preferred and are a subject of this invention.

5 In the following, the component of this liquid crystal mixture based on the compounds II1, II5, II9 and II16 may be designated as component (i) thereof, while the component based on the compounds II25, Ia2-1, Ia3-9, II17, II18, II26, II27, II28 and II25a may be designated
10 component (ii). These liquid crystal mixtures may consist exclusively of the components (i) and (ii), but it is also possible that the liquid crystal mixture contains other components (iii) and (iv), the component (iii)
15 containing other nematic or nematogenic substances which are selected such that the birefringence Δn and/or the ordinary refractive index n_o and/or other refractive indices and/or the viscosity and/or the dielectric anisotropy and/or other parameters of the liquid crystal are specifically optimized with respect to the respective
20 application; a list of nematic or nematogenic substances which can preferably also be used for the component (iii) is given further below. The component (iv) contains, for example, chiral dopants for inducing a cholesteric phase and/or pleochroitic dyes and/or other additives for
25 modifying other properties of the liquid crystal mixture such as, for example, the conductivity; in this connection the compounds of the component (iv) can be both mesogenic and non-mesogenic.

30 The mass content of the component (i) in the liquid crystal is preferably 10-80%, in particular 15-70%

and very particularly 15-65%. If the liquid crystal mixture is intended to have a high birefringence $An > 0.24$, the component (i) preferably contains 4-alkyl- and/or 4-alkoxy-4'-cyanobiphenyls [sic] and/or 4-alkyl- and/or 4-alkoxy-4"-cyanotherphenyls [sic] and/or 4-(trans-4-alkyl- or trans-4-alkoxycyclohexyl)-4'-cyano-biphenyls. On the other hand, if it is intended for the liquid crystal mixture to have a birefringence $0.13 \leq An \leq 0.22$, the component (i) preferably contains 4-(trans-4-alkyl- or trans-4-alkoxycyclohexyl)benzonitriles, in particular in addition to one or more of the high- An compounds of the component (i) just mentioned.

In the laterally fluorinated biphenyls of the formulae II25, II25a and Ia2-1, which are preferred, R^1 is preferably methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy and heptoxy.

Furthermore, the component (ii) preferably contains 3-ring, laterally monofluorinated compounds of the formulae Ia3-9, II17, II18, II26 and II27. In these compounds, R^1 is preferably alkyl, alkoxy or alkoxyalkyl having 1-7 C atoms, in particular having 2-7 C atoms and very particularly having 2-5 C atoms.

If it is intended to obtain liquid crystal mixtures having a high clear point, the component (i) preferably contains 3-ring compounds of the formulae II9 and II16 and/or the component (ii) preferably contains 3-ring compounds of the formulae Ia3-9, II17, II18, II26, II27 and II28. Liquid crystal mixtures are particularly preferred which contain at least one compound of the formulae II9 and II16 and at least one compound of the formulae Ia3-9, II17, II18 and II26-28, as these mixtures in general have a relatively high or high value for $\Delta\epsilon$ and at the same time a high clear point.

The liquid crystal mixtures containing a component (i) and (ii) preferably have a clear point $T_c > 75^\circ\text{C}$, in particular $T_c > 80^\circ\text{C}$ and very particularly $T_c > 85^\circ\text{C}$.

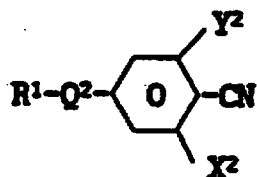
The laterally fluorinated compounds of the

formulae II25, II25a, Ia2-1, Ia3-9, II18, II17 and II26-II28 customarily have a very good solubility in the component (i) and in modified mixtures. The solubility of the laterally fluorinated terphenyls of the formulae Ia3-9, II18, II17 and II26-II28 in liquid crystal mixtures is in general substantially better than that of the non-fluorinated terphenyl of the formula II16.

Liquid crystal mixtures which contain one or more laterally fluorinated compounds of the formulae II25, II25a, Ia2-1, Ia3-9, II18, II17 and II26-II28 and in particular of the formulae Ia2-1, Ia3-9, II18, II17, II25, II25a and II26-27 are characterized by a better UV and temperature stability than the mixtures E7 and E8 known from the prior art or, alternatively, comparable mixtures.

The liquid crystal mixtures containing a component (i) and (ii) and, if desired, also other components (iii) and (iv) and the electrooptical systems containing these have advantageous properties. The mixtures in particular have a high or relatively high birefringence and at the same time a high or relatively high dielectric anisotropy and/or a high clear point. The compounds of the formulae II1, II5, II9, II16, II25, II25a, Ia2-1, Ia3-9, II18, II17, II26, II27 and II28 are sufficiently stable to thermal and radiation energy for most applications and they are very stable to chemicals. The liquid crystal mixtures containing these compounds are highly nematic, in particular even at low temperatures, and have advantageous values for η . The electrooptical systems operated using these mixtures have favourable values for the electrooptical parameters and their temperature dependence, a high contrast and a low angular dependence of the contrast and also a good preparation capability.

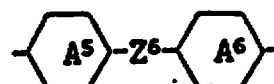
Electrooptical liquid crystal systems according to the invention are further preferred whose liquid crystal mixtures contain one or more compounds selected from the smaller group of compounds of the sub-formulae [sic] Ib



Ib

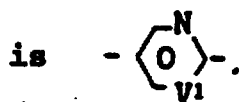
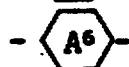
in which

Q² is



one of the rings

5 - A⁵ - and



in which V¹ is N or CH, and the other, if present, is trans-1,4-cyclohexylene or 1,4-phenylene,

10 X² and Y²

independently of one another are H or F

p is

0 or 1, and

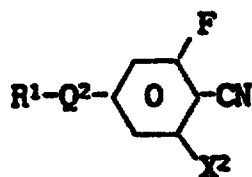
Z⁵ and Z⁶

independently of one another are a single bond or CH₂CH₂,

and R¹ has the meaning given in Claim [lacuna].

15

Particularly preferred liquid crystal mixtures are those which contain one or more compounds of the sub-formulae [sic] Ib, in which at least one of X¹ or Y² is F



IbF

20

The compounds of the sub-formula IbF include 2-ring, laterally monofluorinated or laterally difluorinated compounds of the formulae IbF2-1 - IbF2-8

R¹-Pyd-Phe.3F-CN

IbF2-1

R¹-Pyd-Phe.3F5F-CN

IbF2-2

R¹-Pyr-Phe.3F-CN

IbF2-3

R¹-Pyr-Phe.3F5F-CN

IbF2-4

R¹-Pyd-CH₂CH₂-Phe.3F-CN

IbF2-5

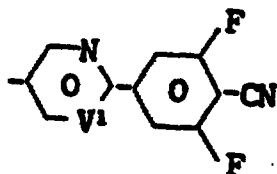
R^1 -Pyd-CH ₂ CH ₂ -Phe.3F5F-CN	IbF2-6
R^1 -Pyr-CH ₂ CH ₂ -Phe.3F-CN	IbF2-7
R^1 -Pyr-CH ₂ CH ₂ -Phe.3F5F-CN	IbF2-8

- In the compounds of the formulae IbF2-1 - IbF2-8, R^1 is preferably alkyl or alkoxy having 1-10, but in particular having 1-8 C atoms, and in addition also n-alkoxyalkyl and in particular n-alkoxymethyl and n-alkoxyethyl. Liquid crystals which contain compounds of the formulae IbF2-2, IbF2-4, IbF2-6 and/or IbF2-8 containing a 3,5-difluoro-4-cyanophenyl group have particularly advantageous values for the dielectric anisotropy. Very particularly preferred compounds are those of the formulae IbF2-1 - IbF2-8 in which R^1 is methyl, ethyl, n-propyl, n-butyl, n-pentyl, n-hexyl, n-heptyl, n-octyl, n-nonyl, n-decyl, n-methoxy, n-ethoxy, n-propoxy, n-butoxy, n-pentoxo, n-hexoxy, n-heptoxy, n-octoxy, n-nonoxo, n-decoxy or n-undecoxy.
- The compounds of the formula IbF include additionally preferred 3-ring compounds of the formulae IbF3-1 - IbF3-36, which are laterally mono- or difluorinated.

R^1 -Pyd-Phe-Phe.3F-CN	IbF3-1
R^1 -Pyr-Phe-Phe.3F-CN	IbF3-2
R^1 -Pyd-Phe-Phe.3F5F-CN	IbF3-3
R^1 -Pyr-Phe-Phe.3F5F-CN	IbF3-4
R^1 -Phe-Pyd-Phe.3F-CN	IbF3-5
R^1 -Phe-Pyd-Phe.3F5F-CN	IbF3-6
R^1 -Phe-Pyr-Phe.3F-CN	IbF3-7
R^1 -Phe-Pyr-Phe.3F5F-CN	IbF3-8

R ¹ -Cyc-Pyd-Phe.3F-CN	IbF3-9
R ¹ -Cyc-Pyd-Phe.3F5F-CN	IbF3-10
R ¹ -Cyc-Pyr-Phe.3F-CN	IbF3-11
R ¹ -Cyc-Pyr-Phe.3F5F-CN	IbF3-12
R ¹ -Pyd-Phe-CH ₂ CH ₂ -Phe.3F-CN	IbF3-13
R ¹ -Pyd-Phe-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-14
R ¹ -Pyr-Phe-CH ₂ CH ₂ -Phe.3F-CN	IbF3-15
R ¹ -Pyr-Phe-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-16
R ¹ -Phe-Pyd-CH ₂ CH ₂ -Phe.3F-CN	IbF3-17
R ¹ -Phe-Pyd-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-18
R ¹ -Phe-Pyr-CH ₂ CH ₂ -Phe.3F-CN	IbF3-19
R ¹ -Phe-Pyr-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-20
R ¹ -Cyc-Pyd-CH ₂ CH ₂ -Phe.3F-CN	IbF3-21
R ¹ -Cyc-Pyd-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-22
R ¹ -Cyc-Pyr-CH ₂ CH ₂ -Phe.3F-CN	IbF3-23
R ¹ -Cyc-Pyr-CH ₂ CH ₂ -Phe.3F5F-CN	IbF3-24
R ¹ -Pyd-CH ₂ CH ₂ -Phe-Phe.3F-CN	IbF3-25
R ¹ -Pyd-CH ₂ CH ₂ -Phe-Phe.3F5F-CN	IbF3-26
R ¹ -Pyr-CH ₂ CH ₂ -Phe-Phe.3F-CN	IbF3-27
R ¹ -Pyr-CH ₂ CH ₂ -Phe-Phe.3F5F-CN	IbF3-28
R ¹ -Phe-CH ₂ CH ₂ -Pyd-Phe.3F-CN	IbF3-29
R ¹ -Phe-CH ₂ CH ₂ -Pyd-Phe.3F5F-CN	IbF3-30
R ¹ -Phe-CH ₂ CH ₂ -Pyr-Phe.3F-CN	IbF3-31
R ¹ -Phe-CH ₂ CH ₂ -Pyr-Phe.3F5F-CN	IbF3-32
R ¹ -Cyc-CH ₂ CH ₂ -Pyd-Phe.3F-CN	IbF3-33
R ¹ -Cyc-CH ₂ CH ₂ -Pyd-Phe.3F5F-CN	IbF3-34
R ¹ -Cyc-CH ₂ CH ₂ -Pyr-Phe.3F	IbF3-35
R ¹ -Cyc-CH ₂ CH ₂ -Pyr-Phe.3F5F	IbF3-36

In the compounds of the sub-formulae IbF3-1 - IbF3-36, R¹ is preferably n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms. The compounds of the formulae IbF3-1 - IbF3-36, which are preferred, have high or relatively high values for the dielectric anisotropy $\Delta\epsilon$; in this case, the difluorinated compounds of the formulae IbF3-6, IbF3-8, IbF3-9, IbF3-12, IbF3-30, IbF3-32, IbF3-34 and IbF3-36, which contain the structural element



are distinguished by very particularly high values for $\Delta\epsilon$.

The compounds of the formula IbF are preferably prepared by the methods described in DE 3,209,178, DE 4,002,609, DE 4,001,022, DE 4,012,014, DE 4,012,023 and 3,315,295.

Liquid crystal mixtures which [lacuna] one or more compounds of the formula IbF and in particular of the formulae IbF2-1 - IbF2-8 and IbF3-1 - IbF3-36, and electrooptical systems filled with these liquid crystal mixtures are distinguished by advantageous values for the birefringence Δn and the flow viscosity η , a high stability, low miscibility with the polymer used for the matrix, by a broad mesogenic range, a relatively high clear point and in particular by advantageous values for the dielectric anisotropy, the threshold voltage and temperature dependence of the electrooptical parameters.

The liquid crystal mixtures preferably contain 1-40% and, in particular, 5-30% of compounds of the formula IbF and in particular of the formulae IbF2-1 - IbF2-8 and IbF3-1 - IbF3-36. In this case, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula IbF and in particular of the formulae IbF2-1 - IbF2-8 and IbF3-1 - IbF3-36.

Liquid crystal mixtures are particularly

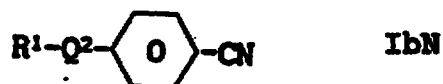
preferred which contains [sic] one or more compounds,
selected from the group of compounds of the formula IbF
and in particular of the formulae IbF2-1 - IbF2-8 and
IbF3-1 - IbF3-36, and additionally at least one compound,
5 selected from the group of compounds III1-II28, III1-III3
and IV1-IV8. The mass content of the component mixture
consisting of at least one compound of the formula IbF
and in particular of the formulae IbF2-1 - IbF2-8 and
IbF3-1 - IbF3-36 and additionally of one or more com-
10 pounds of the formulae III1-II28, III1-III3 and IV1-IV8 in
the liquid crystal mixture according to the invention is
preferably 15%-100%, but in particular 25%-100%. Com-
ponent mixtures T(IbF)1 - T(IbF)8 are very particularly
preferred which, in addition to at least one compound
15 selected from the compounds of the formula IbF and in
particular of the formulae IbF2-1 - IbF2-8 and IbF3-1 -
IbF3-36, contain at least one compound selected from the
class of compounds shown in each case:

- T(IbF)1: IbF
20 R-Phe-Phe.(F)-X where X = CN, F or Cl
- T(IbF)2: IbF
R-Cyc-Phe-COO-Phe.(F)-X where X = CN, F or Cl
- T(IbF)3: IbF
R-Phe-COO-Phe.(F)-X where X = CN, F or Cl
- 25 T(IbF)4: IbF
R-Cyc-(CH₂CH₂)_u-Phe.(F)-X where X = CN, F or Cl
and u = 0 or 1
- T(IbF)5: IbF
R-Cyc-Cyc-(CH₂CH₂)_u-Phe.(F)-X
30 where X = CN; F or Cl
and u = 0 or 1
- T(IbF)6: IbF
R-Cyc-(CH₂CH₂)_u-Phe-Phe.F-X
where X = CN, F or Cl
35 and u = 0 or 1
- T(IbF)7: IbF
R-Phe-Phe-Phe.(F)-X where X = CN, F or Cl
- T(IbF)8: R-Phe-Phe-COO-Phe.(F)-X where X = CN, F or Cl
- Liquid crystal mixtures which are based on the

following component mixtures T(IBf) 9-13 which contain at least one compound each from the compound classes of the formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

Mixture	Formula	Mass content in the component mixture [%]
T (IbF) 9	IbF	5-75
	II	5-80, in particular 6-65
T (IbF) 10	IbF	5-75, in particular 5-48
	IV	5-63
T (IbF) 11	IbF	5-55
	II	5-65, in particular 5-52
	III	5-29
5 T (IbF) 12	IbF	5-55, in particular 6-45
	II	5-65, in particular 5-49
	IV	5-50
T (IbF) 13	IbF	5-50
	II	5-75, in particular 5-65
	III	5-37, in particular 5-25
	IV	5-42

10 Liquid crystal mixtures are additionally preferred which contain one or more compounds of the formula Ib, in which the terminal group - O -CN [sic] is not fluorinated:



These compounds of the sub-formula IbN include 2-ring compounds of the formulae IV1-IV2 and IbN2-1 - IbN2-2

R ¹ -Pyd-Phe-CN	IV1
R ¹ -Pyr-Phe-CN	IV2
R ¹ -Pyd-CH ₂ CH ₂ -Phe-CN	IbN2-1
R ¹ -Pyr-CH ₂ CH ₂ -Phe-CN	IbN2-2

R¹ in the compounds of the formulae IV1-IV2 and IbN2-1 - IbN2-2 is preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms. Additionally preferred are n-alkoxyalkyl compounds and in particular
5 n-alkoxymethyl and n-alkoxyethyl compounds.

Very particularly preferred compounds of the formulae IV1-IV2 and IbN2-1 - IbN2-2 are those in which R¹ is methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy,
10 butoxy, pentoxy, hexoxy, hetoxy [sic] or octoxy. The compounds of the formulae IV1-IV2 and IbN2 and in particular the compounds of the formulae IV2 and IbN2-2 have high or relatively high values for the dielectric anisotropy Ae. Which of the compounds IV1, IV2 and IbN2-1 -
15 IbN2-2 the liquid crystal media according to the invention preferably contain is largely determined by the intended application of the electrooptical systems according to the invention. Thus, for example, the compounds of the formulae IV1 and IV2 have a relatively
20 high clear point and in particular a relatively high optical anisotropy, while the compounds of the formulae IbN2-1 and IbN2-2 are distinguished, for example, by a comparatively low flow viscosity.

Liquid crystal mixtures which contain compounds
25 of the formulae IV1 and/or IV2 are particularly preferred for matrix systems, but in contrast are sometimes less suitable for network systems inter alia; on the other hand, the compounds IbN2-1 - IbN2-2 are generally particularly preferred as components of mixtures for matrix
30 and network [lacuna].

The compounds of the formula IbN additionally include 3-ring compounds of the formulae IV3-IV8 and IbN3-1 - IbN3-18:

R ¹ -Pyd-Phe-Phe-CN	IV3
R ¹ -Pyr-Phe-Phe-CN	IV4
R ¹ -Pyd-Cyc-Phe-CN	IbN3-1
R ¹ -Pyr-Cyc-Phe-CN	IbN3-2
R ¹ -Phe-Pyd-Phe-CN	IV5
R ¹ -Phe-Pyr-Phe-CN	IV6
R ¹ -Cyc-Pyd-Phe-CN	IV8
R ¹ -Cyc-Pyr-Phe-CN	IV7
R ¹ -Pyd-Phe-CH ₂ CH ₂ -Phe-CN	IbN3-3
R ¹ -Pyr-Phe-CH ₂ CH ₂ -Phe-CN	IbN3-4
R ¹ -Pyd-Cyc-CH ₂ CH ₂ -Phe-CN	IbN3-5
R ¹ -Pyr-Cyc-CH ₂ CH ₂ -Phe-CN	IbN3-6
R ¹ -Phe-Pyd-CH ₂ CH ₂ -Phe-CN	IbN3-7
R ¹ -Phe-Pyr-CH ₂ CH ₂ -Phe-CN	IbN3-8
R ¹ -Cyc-Pyd-CH ₂ CH ₂ -Phe-CN	IbN3-9
R ¹ -Cyc-Pyr-CH ₂ CH ₂ -Phe-CN	IbN3-10
R ¹ -Pyd-CH ₂ CH ₂ -Phe-Phe-CN	IbN3-11
R ¹ -Pyr-CH ₂ CH ₂ -Phe-Phe-CN	IbN3-12
R ¹ -Pyd-CH ₂ CH ₂ -Cyc-Phe-CN	IbN3-13
R ¹ -Pyr-CH ₂ CH ₂ -Cyc-Phe-CN	IbN3-14
R ¹ -Phe-CH ₂ CH ₂ -Pyd-Phe-CN	IbN3-15
R ¹ -Phe-CH ₂ CH ₂ -Pyr-Phe-CN	IbN3-16
R ¹ -Cyc-CH ₂ CH ₂ -Pyd-Phe-CN	IbN3-17
R ¹ -Cyc-CH ₂ CH ₂ -Pyr-Phe-CN	IbN3-18

In the compounds of the formulae IV3-IV8 and IbN3-1 - IbN3-18, R¹ is preferably methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl.

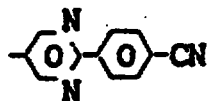
The compounds of the formula IbN are preferably

prepared by the methods described in DE 3,600,052, DE 3,315,295, SU 1,063,100, SU 1,063,101, SU 1,069,413, SU 1,171,456, GB 2,118,934, EP 0,097,033 and DE 3,411,571.

5 Liquid crystal mixtures which contain one or more compounds selected from the compounds of the formulae IbN and IV and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 - IbN3-18 and IV1-IV8 are distinguished by advantageous values for the optical anisotropy A_n , a high
10 stability, low miscibility with the polymer used for the matrix, by a broad mesogenic range, a relatively high clear point and in particular by advantageous values for the dielectric anisotropy and an advantageous temperature dependence of the electrooptical parameters. These
15 mixtures are preferred.

 The liquid crystal mixtures according to the invention preferably contain 1-40% and in particular 5-30% of compounds of the formula IbN and IV and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 -
20 IbN3-18 and IV1-IV8. In this case, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula IbN and IV and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 - IbN3-18 and IV1-IV8.

25 The compounds of the formulae IV3-IV4, which are preferred, have high or relatively high values for the dielectric anisotropy A_e ; in this case, the compounds of the formulae IV6, IV7, IbN3-8, IbN3-16 and IbN3-18, which contain the structural element



30 are distinguished by particularly high values for A_e .

 Particularly preferred compounds are those of the formulae IV3, IV4, IV5, IV6, IbN3-3, IbN3-4, IbN3-7, IbN3-8, IbN3-11, IbN3-12, IbN3-15 and IbN3-16 which are distinguished by a high optical anisotropy at the same
35 time as relatively high dielectric anisotropy. Liquid crystal mixtures which contain these preferred compounds

are particularly preferred.

Liquid crystal mixtures which contain compounds of the formulae IV3, IV4, IV5, IV6 and/or IV7 are sometimes less suitable for network systems. On the other hand, liquid crystal mixtures of this type are generally particularly suitable for matrix applications.

Liquid crystal mixtures are particularly preferred which contain one or more compounds, selected from the group of compounds of the formula IbN and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 - IbN3-18 and IV1-IV8, and additionally one or more compounds selected from the group of compounds III1-II28 and III1-III3. The mass content of the component mixture consisting of at least one compound of the formulae IbN and IV and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 - IbN3-18 and IV1-IV8 and additionally of at least one compound of the formulae III1-II28 and III1-III3 in the liquid crystal mixture used according to the invention is preferably 15%-100%, but in particular 25%-100%.

The following component mixtures T(IbN), which contain at least one compound each from the substance classes shown, are particularly suitable for matrix applications, but frequently less suitable for network systems; R has the abovementioned meaning:

T(IbN)1: IV5

R-Phe-(COO)₁-Phe.(F)-X where X = F, CN and
l = 0 or 1

T(IbN)2: IV7

R-Phe-Phe.(F)-X where X = F, CN

T(IbN)3: IV6

R-Phe-Phe.(F)-X where X = F, CN

T(IbN)4: IV3

R-Phe-Phe.(F)-X where X = F, CN

T(IbN)5: IV4

R-Phe-Phe-Y-Phe.(F)-X where X = F, CN
and Y = COO,
-CH₂CH₂- or a single
bond

T(IbN)6: IV2

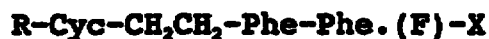


where X = F, CN

$\langle E \rangle$ is Cyc or
Phe and l = 0
or 1

5

T(IbN)7: IV2



where X = F, CN

T(IbN)8: IV1

10



where X = F, CN

and l = 0 or 1

Furthermore, the following component mixtures, which contain at least one compound each, selected from the compound classes of the formulae IbN and IV shown in each case, are frequently less preferred for network systems:

15

T(IbN)9: IV2

IbN3-1

T(IbN)10: IV2

20

IV7

T(IbN)11: IV2

IV6

T(IbN)12: IV2

IV3 or IV 4

25

The component mixtures T(IbN)9 - T(IbN)12 are preferred for matrix applications.

Liquid crystal mixtures which contain one or more of the following component mixtures T (IbN) 13-18, which for their part in each case contain at least one compound each from the substances classes mentioned, are occasionally less suitable for network applications; however they generally can be preferably employed for matrix applications:

30

T(IbN) 13: IV1

35

III1

T (IbN) 14: IV1

IV2 and/or IV5

T (IbN) 16: IV 1

IV4

T (IbN) 15: IV 1
II5 and/or
II16
T (IbN) 17: IV1
5 IV3
T (IbN) 18: IV2
II5

On the other hand liquid crystal mixtures of this type can frequently be modified by the addition of further compounds such that they are also suitable for network applications.

Thus, e.g. liquid crystal mixtures containing, in addition to one or more of the above component mixtures T (IbN) 1-18, one or more compounds selected from the group of compounds of the formulae Ia, IbF, Ic, Id and Ie and in particular of the preferred sub-formulae are suitable inter alia for network applications.

Liquid crystal mixtures are also particularly suitable for network applications, which in addition to one of the above component mixtures contain one or more compounds of the formula If and in particular of the preferred sub-formulae, the mass content of the compounds of the formula If in the liquid crystal mixture preferably being not less than 5%, in particular greater than 7.5% and very particularly greater than 10%.

Liquid crystal mixtures used according to the invention which contain one or more of the component mixtures T (IbN) 1-18 are particularly preferred, inter alia, for matrix applications.

For network applications, liquid crystal mixtures which contain at least one compound selected from the group of compounds IV1, IV2 IV3, IV4, IV5 and IV6, and additionally at least one compound selected from the group of compounds II5, II6, II7, II9, II11, II14, II16, II22 and II23 are in general additionally less preferred; however, mixtures of this type are particularly suitable for matrix applications. On the other hand, liquid crystal mixtures used according to the invention, which contain a component mixture of this type and additionally

one or more compounds selected from the group of compounds of the formulae Ia, Ic, Id, Ie and IbF and in particular of the preferred sub-formulae are preferred, inter alia for network applications. This also applies to
5 liquid crystal mixtures which contain one or more compounds of the formulae [sic] If and in particular of the preferred sub-formulae, the mass content of the compounds of the formula If in the liquid crystal mixture preferably being greater than 5%, in particular greater than 10%
10 and very particularly greater than 12.5%.

For network systems and also for matrix systems, liquid crystal mixtures are particularly preferred which contain at least one compound of the formulae IbN2-1, IbN-2 and IbN3-3 - IbN3-18.

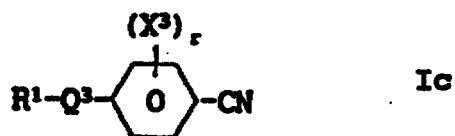
15 Furthermore, liquid crystal mixtures which, in addition to one or more compounds of the formula IbN and in particular of the formulae IbN2-1 - IbN2-2, IbN3-1 - IbN3-18 and IV1-IV8, contains [sic] at least one compound selected from the following compound classes
20 II2, II4, II3, II8, II10, II15, II17, II18, II19, II25, II26, II27, II28, III1, III2, III3, II12, II13, II20, II21, II24, IV7 and IV8

are very particularly suitable for use in the electro-optical systems according to the preamble of Claim 1.

25 Liquid crystal mixtures which are based on the following component mixtures T(IbN) 19-23 which contain at least one compound each from the compound classes of the formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in
30 the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The mass content of the component mixture in the liquid
35 crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

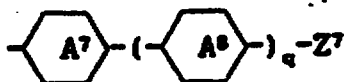
Mixture	Formula	Mass content in the component mixture [%]
T (IbN) 19	IbN	5-75
	II	6-90, in particular 11-75
T (IbN) 20	IbN	5-55
	II	5-75, in particular 5-52
	III	5-29
T (IbN) 21	IbN	5-75
	IV	5-63
5 T (IbN) 22	IbN	5-50
	II	5-75, in particular 10-65
	III	5-37
	IV	5-42
T (IbN) 23	IbN	5-50
	II	5-72, in particular 5-65
	IV	5-46

Electrooptical liquid crystal systems according to the invention are additionally particularly suitable, whose liquid crystal mixture contains at least one compound of the formula Ic

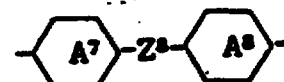


in which

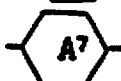
Q³ is



or



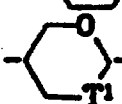
one of the rings



or



is



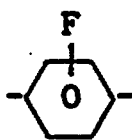
, in which

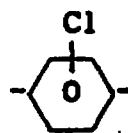
T¹ is -CH₂- or -O-, and the other, if present, is trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene

5 Z' and Z² independently of one another are a single bond, -COO-, -OCO- or -CH₂CH₂-,

X³ is F or Cl

r and q independently of one another are 0 or 1,

10  is 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene and

 is correspondingly 2-chloro-1,4-phenylene or 3-chloro-1,4-phenylene

and the meaning of R¹ is given in Claim 1.

15 The compounds of the formula Ic include 2-ring tetrahydropyran derivatives and dioxane derivatives of the formulae IcT2 and IcD2, in which Z' and X³ have the abovementioned meaning and Phe.(X) is Phe, Phe.F or Phe.Cl:



20 R¹ in the compounds of the formula IcT2 and IcD2 is preferably methyl or alkoxy having 1-10, but in particular having 1-8, C atoms. Additionally preferred are n-alkoxyalkyl compounds and in particular n-alkoxy-methyl and n-alkoxyethyl compounds. In addition R is preferably also alkenyl having 1-7 C atoms. Very particularly preferred compounds are those of the formula

25 IcT2 and IcD2, in which R is methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy or octoxy.

30 In the compounds of the formula IcT2 and IcD2, Z is -CH₂CH₂-, -COO-, -OCO- or a single bond, but in particular -CH₂-CH₂-, -COO- or a single bond and very particularly -COO- or a single bond. The phenyl ring can

be monosubstituted ($r = 1$) by $X^3 = F$ or Cl or unsubstituted. Unsubstituted compounds and compounds which contain an F atom in the 2- or 3-position or a Cl atom in the 3-position are preferred.

- 5 The following smaller group of compounds of the formulae $IcT2-1 - IcT2-5$ [sic] and $IcD2-1 - IcD2-6$ is particularly preferred.

R-Thp-Phe-CN	IcT2-1
R-Thp-Phe.3F-CN	IcT2-2
R-Thp-Phe.3Cl-CN	IcT2-3
R-Thp-COO-Phe. (F) -CN	IcT2-4
R-Thp-CH ₂ CH ₂ -Phe. (F) -CN	IcT2-5
R-Dio-Phe-CN	IcD2-1
R-Dio-Phe.3F-CN	IcD2-2
R-Dio-Phe.3Cl-CN	IcD2-3
R-Dio-COO-Phe.3F-CN	IcD2-4
R-Dio-COO-Phe.3Cl-CN	IcD2-5
R-Dio-CH ₂ CH ₂ -Phe. (F) -CN	IcD2-6

- 10 Liquid crystal mixtures which contain one or more compounds selected from the group of preferred compounds of the formulae $IcT2-1 - IcT2-5$ and $IcD2-1 - IcD2-6$ are particularly preferred. Very particularly preferred liquid crystal mixtures are those which contain a compound selected from the group of compounds $IcT2-1$, $IcT2-2$, $IcT2-4$, $IcT2-5$, $IcD2-1$, $IcD2-2$, $IcD2-4$ and
- 15 $IcD2-6$.

The compounds of the formula Ic additionally include 3-ring tetrahydropyran and dioxane derivatives of the formulae $IcT3-1 - IcT3-8$ and $IcD3-1 - IcD3-8$:

R^1 -Phe. (F) -Thp-Z ⁷ -Phe. (X) -CN	IcT3-1
R^1 -Cyc-Thp-Z ⁷ -Phe. (X) -CN	IcT3-2
R^1 -Thp-Phe. (F) -Z ⁷ -Phe. (X) -CN	IcT3-3
R^1 -Thp-Cyc-Z ⁷ -Phe. (X) -CN	IcT3-4

R ¹ -Phe. (F) -Z ⁸ -Thp-Phe. (X) -CN	IcT3-5
R ¹ -Cyc-Z ⁸ -Thp-Phe. (X) -CN	IcT3-6
R ¹ -Thp-Z ⁸ -Phe. (F) -Phe. (X) -CN	IcT3-7
R ¹ -Thp-Z ⁸ -Cyc-Phe. (X) -CN	IcT3-8
R ¹ -Phe. (F) -Dio-Z ⁷ -Phe. (X) -CN	IcD3-1
R ¹ -Cyc-Dio-Z ⁷ -Phe. (X) -CN	IcD3-2
R ¹ -Dio-Phe. (F) -Z ⁷ -Phe. (X) -CN	IcD3-3
R ¹ -Dio-Cyc-Z ⁷ -Phe. (X) -CN	IcD3-4
R ¹ -Phe. (F) -Z ⁸ -Dio-Phe. (X) -CN	IcD3-5
R ¹ -Cyc-Z ⁸ -Dio-Phe. (X) -CN	IcD3-6
R ¹ -Dio-Z ⁸ -Phe. (F) -Phe. (X) -CN	IcD3-7
R ¹ -Dio-Z ⁸ -Cyc-Phe. (X) -CN	IcD3-8

In the preferred compounds of the formulae IcT3-1 - IcT3-8 and IcD3-1 - IcD3-8, R¹ is preferably methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl [sic], methoxyethyl, ethoxyethyl, propoxyethyl, pent-2-enyl, pent-3-enyl, pent-4-enyl, hex-2-enyl, hex-3-enyl, hex-4-enyl or hex-5-enyl. In the compounds of the formulae IcT3-1 - IcT3-8 and IcD3-1 - IcD3-8, Z is -COO-, -OCO-, -CH₂CH₂- or a single bond, but preferably -COO-, -CH₂CH₂- or a single bond and very particularly a single bond.

Compounds of the formulae IcT3-1 - IcT3-8 and IcD3-1 - IcD3-8, in which Phe.(F) is a 2- or 3-fluoro-1,4-phenylene group, in general have a relatively low viscosity η in comparison to the laterally unsubstituted compounds.

The following smaller group of 3-ring compounds is very particularly preferred:

R ¹ -Phe-Thp-Phe-CN	IcT3-1a
R ¹ -Phe-Thp-Phe.3F-CN	IcT3-1b
R ¹ -Phe-Dio-Phe-CN	IcD3-1a
R ¹ -Phe-Dio-Phe.3F-CN	IcD3-1b

R ¹ -Cyc-Thp-Phe-CN	IcT3-2a
R ¹ -Cyc-Dio-Phe-CN	IcD3-2a
R ¹ -Thp-Phe-Phe-CN	IcT3-3a
R ¹ -Dio-Phe-Phe-CN	IcD3-3a
R ¹ -Dio-Phe-Phe.3F-CN	IcD3-3b

The tetrahydropyrans and dioxanes of the formulae IcT3-1, IcD3-1, IcT3-3, IcD3-3, IcT3-5, IcD3-5, IcT3-6 and IcD3-6, in which Z is -COO- or -CH₂CH₂-, are additionally very particularly preferred.

5 The compounds of the formulae IcT2, IcD2, IcT3 and IcD3 have favourable values for the flow viscosity η , the optical anisotropy A_n and, in particular, high values for the dielectric anisotropy A_e . Compounds of the formulae IcT2, IcD2, IcT3 and IcD3, which contain the
10 structural element



have very particularly high values for A_e .

The compounds of the formula IcT or IcD are preferably prepared by the methods described in
15 DE 3,447,359, DE 3,306,960, GB 89 28 583.7 and
DE 3,146,249.

Liquid crystal mixtures which contain at least one compound of the formulae IcT2, IcD2, IcT3, IcD3 and very particularly of the preferred formulae IcT2-1 -
20 IcT2-5, IcD2-1 - IcD2-6, IcT3-1a-b, IcD3-1a-b, IcT3-2a, IcD3-2a, IcT3-3a and IcD3-3a-b are distinguished by advantageous values for the birefringence A_n and the flow viscosity η , a high stability, low miscibility with the polymer used for the matrix, a broad mesogenic range, a
25 relatively high clear point and in particular by advantageous values for the dielectric anisotropy and the temperature dependence of the electrooptical parameters.

The liquid crystal mixtures used in the electro-optical liquid crystal systems according to the invention

preferably contain 1-40%, in particular 5-30%, of compounds of the formulae IcT and IcD and in particular of the preferred sub-formulae; in this case, the liquid crystal mixtures preferably contain 1-5, but in particular 1-3, compounds of the formulae IcT and IcD and in particular of the preferred sub-formulae.

Particularly preferred liquid crystal mixtures are those which contain one or more compounds selected from the group of compounds of the formulae IcT2, IcD2, IcT3 and IcD3 and in particular of the preferred formulae IcT2-1 - IcT2-5, IcD2-1 - IcD2-6, IcT3-1a-b, IcD3-1a-b, IcT3-2a, IcD3-2a, IcT3-3a and IcD3-3a-b, and additionally one or more compounds selected from the group of compounds III1-II28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formulae IcT2, IcD2, IcT3, IcD3 and in particular of the preferred sub-formulae shown and additionally of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixture used according to the invention is preferably 15%-100%, but in particular 25%-100%.

The following component mixtures which contain at least one compound from the following group A and at least one compound from the following group B are particularly preferred:

Group A

Group B

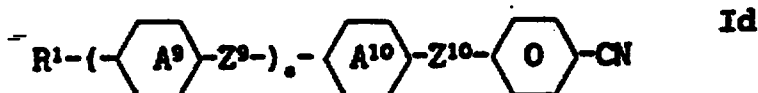
IcD2-1, IcD2-2, IcD2-4,	III1, II4, II5, II6, II9
IcD2-6, IcD3-1a, IcD3-1b	III1, III6, III7, II22, II23,
IcD3-2a, IcD3-3a	II26, II27, II28, III1, III2,
IcD3-3b	IV1, IV2, IV3, IV4, IV5, IV6,
	IV7, IV8, II3, II7

Liquid crystal mixtures which are based on the following component mixtures T(Ic) 1-5 which contain at least one compound each from the compound classes of the

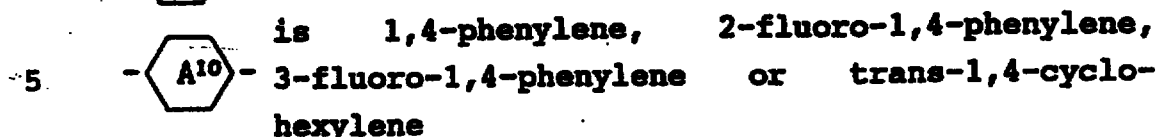
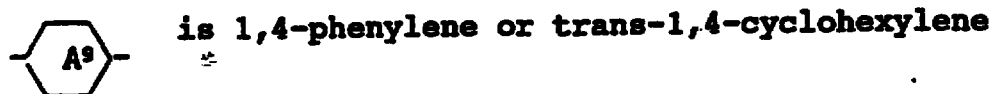
formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

Mixture	Formula	Mass content in the component mixture [%]
T (Ic) 1	IC	5-75, in particular 5-55
	II	6-85, in particular 6-85
T (Ic) 2	IC	5-75, in particular 5-55
	IV	5-80, in particular 5-13
T (Ic) 3	IC	5-50
	II	5-72, in particular 10-65
	IV	5,65, in particular 5-46
15 T (Ic) 4	IC	5-55
	II	5-52
	III	5-29
T (Ic) 5	IC	5-50
	II	5-75, in particular 10-75
	III	5-37
	IV	5-42

Electrooptical liquid crystal systems are additionally preferred whose liquid crystal contains one or more compounds of the formula Id



in which



Z^9 is a single bond, ---COO--- , ---OCO--- or $\text{---CH}_2\text{CH}_2\text{---}$

Z^{10} is a single bond, ---COO--- or $\text{---CH}_2\text{CH}_2\text{---}$, and

s is 0 or 1

10 and the meaning of R^1 is given above.

Particularly preferred systems are those whose liquid crystal contains one or more compounds selected from the smaller group of compounds of the formulae IdE2-1 and IdE3-1 - IdE3-8

$R^1\text{---Cyc---CH}_2\text{CH}_2\text{---Phe---CN}$	IdE2-1
$R^1\text{---Cyc---CH}_2\text{CH}_2\text{---Phe---Phe---CN}$	IdE3-1
$R^1\text{---Phe---CH}_2\text{CH}_2\text{---Cyc---Phe---CN}$	IdE3-2
$R^1\text{---Cyc---CH}_2\text{CH}_2\text{---Cyc---Phe---CN}$	IdE3-3
$R^1\text{---Cyc---Phe---CH}_2\text{CH}_2\text{---Phe---CN}$	IdE3-4
$R^1\text{---Phe---Cyc---CH}_2\text{CH}_2\text{---Phe---CN}$	IdE3-5
$R^1\text{---Cyc---Cyc---CH}_2\text{CH}_2\text{---Phe---CN}$	IdE3-6
$R^1\text{---Phe---Phe---CH}_2\text{CH}_2\text{---Phe---CN}$	IdE3-7
$R^1\text{---Phe---CH}_2\text{CH}_2\text{---Phe---Phe---CN}$	IdE3-8

15 where the meaning of R^1 is given above.

In the two-ring compounds of the formula IdE2-1, R^1 [sic] is preferably n-alkyl [sic] or n-alkoxy having 1-10 C atoms, but in particular having 1-8 C atoms. Additionally preferred are n-alkoxyalkyl compounds and in particular n-alkoxymethyl and n-alkoxyethyl compounds.

20 In the 3-ring compounds of the formulae IdE3-1 - IdE3-8, R^1 is preferably n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl, where n-alkoxy contains 1-6 C atoms.

25 Very particularly preferably, R^1 is methyl,

ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxymethyl [sic], ethoxymethyl [sic] or propoxyethyl.

The compounds of the formulae IdE2 and IdE3 are preferably prepared by the methods described in DE 2,636,684, DE 2,922,236, EP 0,102,047, EP 0,129,177, DE 3,040,362, DE 3,317,597 and US 4,035,056.

Liquid crystal mixtures which contain at least one compound selected from the compounds of the formulae IdE2-1 and IdE3-1 - IdE3-8 are distinguished by advantageous values for the dielectric anisotropy A_e , a high stability, low miscibility with the polymer used for the matrix and in particular by a broad mesogenic range, a relatively high clear point and favourable values for the birefringence.

The liquid crystal mixtures used in the electro-optical liquid crystal systems according to the invention preferably contain 1-40%, in particular 5-30%, of compounds of the formula Id and in particular of the preferred sub-formulae; in this connection, the liquid crystal mixtures preferably contain 1-5, but in particular 1-3, compounds of the formulae Id and in particular of the preferred sub-formulae.

Particularly preferred liquid crystal mixtures are those which contain one or more compounds selected from the group of compounds of the formulae IdE2-1 and IdE3-1 - IdE3-8 and additionally one or more compounds selected from the group of compounds III1-II28, III1-III3 and IV1-IV8. The mass content of the component mixtures consisting of at least one compound of the formulae IdE2-1 and IdE3-1 - IdE3-8 and additionally of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixtures according to the invention is preferably 15%-100%, but in particular 25%-100%.

The following component mixtures T(IdE), which contain at least one compound each from the substance

classes shown in each case, are particularly suitable for matrix applications and very particularly suitable for network applications:

	T(IdE)1:	IdE2-1
5		II3
	T(IdE)2:	IdE2-1
		II4
	T(IdE)3:	IdE2-1
		II5
10	T(IdE)4:	IdE2-1
		II6 or II7
	T(IdE)5:	IdE2-1
		II15
	T(IdE)6:	IdE2-1
15		II16 or 17
	T(IdE)7:	IdE2-1
		IV1
	T(IdE)8:	IdE2-1
		IV2
20	T(IdE)9:	IdE2-1
		IV3
	T(IdE)10:	IdE2-1
		IV4
	T(IdE)11:	IdE2-1
25		IV5
	T(IdE)12:	IdE2-1
		IV6

The following component mixtures which contain one or more compounds selected from the substance classes shown in each case are very particularly suitable for matrix systems:

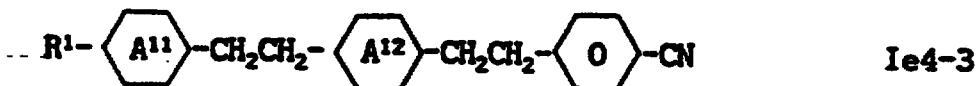
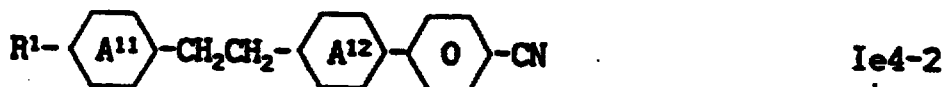
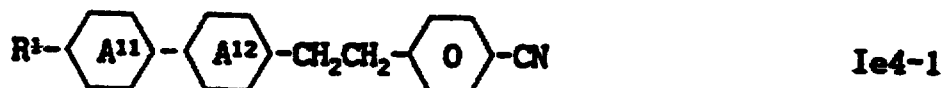
	T(IdE)13:	IdE2-1
		IV7
	T(IdE)14:	IdE2-1
35		IV8
	T(IdE)15:	IdE2-1
		II2
	T(IdE)16:	IdE2-1
		II6

Liquid crystal mixtures are preferred both for matrix applications and in particular for network applications which contain at least one compound of the formula IdE2-1 and one or more compounds selected from the group of compounds II1, II3-II5, II7-II28 and IV1-IV6. The properties of these mixtures can be additionally improved, inter alia, by the addition of one or more compounds selected from the group of compounds of the formula [sic] Ia, IbF, Ic, Id and If and in particular of the preferred sub-formulae.

The following component mixtures T(IdE)17 - T(IdE)19, which contain at least one compound each of the formulae shown in each case in the mass per cent range given are additionally very particularly preferred; in this connection, for any component mixture the sum of the mass contents in the component mixture is 100%, while the mass content of the component mixture in the liquid crystal mixture employed in the system according to the invention is between 10% and 100%, in particular between 10% and 90% and very particularly between 15% and 85%:

Mixture	Formula	Mass content of the component mixture [%]
25	T(IdE)17 IdE3	5-35
	II1-II28	6-60
	T(IdE)18 IdE3	5-35
	IV1-IV8	5-45
30	T(IdE)19 IdE2 and/or IdE3	4-32
	II1-II28	5-58
	IV1-IV8	5-37

Electrooptical liquid crystal systems are additionally preferred whose liquid crystal contains one or more 4-ring compounds selected from the group of carbonitriles of the formulae Ie4-1 - Ie4-4

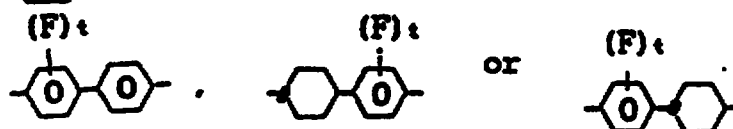


in which

$-\text{A}^{11}-$ in each case independently of one another is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene,

5

$-\text{A}^{12}-$ in each case independently of one another is



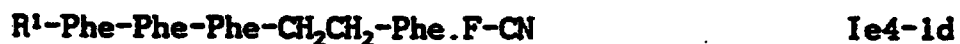
t is 0 or 1 and

F is 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene

10

and the meaning of R¹ is given in Claim 1.

The compounds of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k, Ie4-3a - Ie4-3-f [sic] and Ie4-4a - Ie4-4l shown in the following are particularly preferred:



$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-3F-Phe-CN}$	Ie4-2d
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-Phe. (F) -CN}$	Ie4-2e
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Cyc-Phe-CN}$	Ie4-2f
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe-Phe-CN}$	Ie4-2g
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe-2F-Phe-CN}$	Ie4-2h
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe-3F-Phe-CN}$	Ie4-2i
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe-Phe. (F) -CN}$	Ie4-2k
$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Phe-Phe. (F) -CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3a
$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Cyc-Phe. (F) -CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3b
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3c
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-2F-CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3d
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-3F-CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3e
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe. (F) -CH}_2\text{CH}_2\text{-Phe-CN}$	Ie4-3f
$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe-Phe-CN}$	Ie4-4a
$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe-2F-Phe-CN}$	Ie4-4b
$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe-3F-Phe-CN}$	Ie4-4c
$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Cyc-Phe-CN}$	Ie4-4d
$R^1\text{-Cyc-Phe-CH}_2\text{CH}_2\text{-Phe. (F) -Phe-CN}$	Ie4-4e
$R^1\text{-Cyc-Phe-CH}_2\text{CH}_2\text{-Cyc-Phe-CN}$	Ie4-4f
$R^1\text{-Phe-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe-CN}$	Ie4-4g
$R^1\text{-Phe-Cyc-CH}_2\text{CH}_2\text{-Cyc-Phe-CN}$	Ie4-4h
$R^1\text{-Cyc-Phe-CH}_2\text{CH}_2\text{-Phe-Cyc-CN}$	Ie4-4i
$R^1\text{-Cyc-Phe-CH}_2\text{CH}_2\text{-Phe-2F-Cyc-CN}$	Ie4-4k
$R^1\text{-Cyc-Phe-CH}_2\text{CH}_2\text{-Phe-3F-Cyc-CN}$	Ie4-4l

R in the compounds of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k, Ie4-3a - Ie4-3f and Ie4-4a - Ie4-4l is preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms. n-Alkoxyalkyl compounds and in particular n-alkoxymethyl and n-alkoxyethyl compounds are additionally preferred.

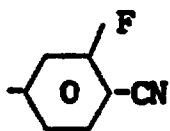
The compounds of the formulae Ie4-1 - Ie4-4 are preferably prepared by the methods described [lacuna] DE 3,401,320 and DE 2,617,593.

10 Liquid crystal mixtures which contain one or more

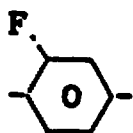
compounds selected from the group of compounds of the formulae Ie4-1 - Ie4-4 and in particular of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k, Ie4-3a - Ie4-3f and Ie4-4a - Ie4-4l are preferred. Liquid crystal mixtures are particularly preferred which contain one or more compounds selected from the group of compounds of the formulae Ie4-1, Ie4-2 and Ie4-4 and in particular of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k and Ie4-4a - Ie4-4l.

The compounds of the formula Ie4-1 - Ie4-4 have high clear points and relatively high values for the flow viscosity η .

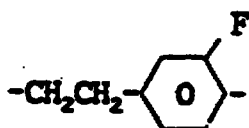
To reduce the flow viscosity, a 1,4-phenylene group of the compounds of the formulae Ie4-1 - Ie4-4 can also be monosubstituted laterally by X = F or Cl and in particular by F; the substituted compounds particularly preferably have one of the following structural features S1-S3:



S1



S2



S3

The liquid crystals according to the invention preferably contain 2-40%, but in particular 5-30%, of compounds selected from the group of 4-ring carbonitriles [sic] of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k [sic], Ie4-3a - Ie4-3f and Ie4-4a - Ie4-4l; in this case, the liquid crystal mixtures preferably contain 1-5, but in particular 1-3, compounds of the formula Ie4 and of the preferred sub-formulae.

The selection of the compounds of the formulae Ie4-1 - Ie4-4 and in particular of the preferred sub-formulae is carried out with respect to the specific embodiments of the electrooptical system according to the invention desired in each case. If, for example, highly viscous and highly clearing liquid crystal media having high optical anisotropy are required, the medium contains, for example, in particular one or more laterally unsubstituted compounds of the formulae Ie4-1a, Ie4-2a, Ie4-3a and/or Ie4-4a, while highly clearing media having comparatively low viscosity and relatively low optical anisotropy preferably contain one or more laterally monosubstituted compounds of the formulae Ie4-1g, Ie4-2h-k, Ie4-3f and/or Ie4-4i-l.

Particularly preferred liquid crystal mixtures are those which contain one or more compounds selected from the group of compounds of the formulae Ie4-1 - Ie4-3, in particular of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k, Ie4-3a - Ie4-3f and Ie4-4a - Ie4-4l and very particularly of the formulae Ie4-1a - Ie4-1g, Ie4-2a - Ie4-2k and Ie4-4a - Ie4-4l, and additionally one or more compounds selected from the group of compounds III1-II28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formulae Ie4-1 - Ie4-4 and in particular of the preferred sub-formulae and additionally of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixtures used according to the invention is preferably 15%-100%, but in particular 25%-100%.

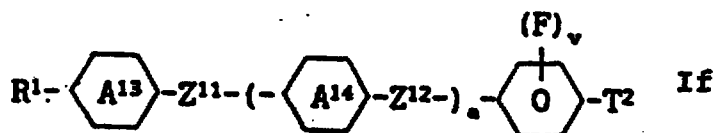
The following component mixtures T(Ie4) which, in addition to at least one compound selected from the group of compounds of the formulae Ie4-1 - Ie4-4 and in particular of the preferred sub-formulae of these compounds, contain one or more compounds selected from the compounds of the formulae III1-II6, II8, II9, III1, III4, III6, II23, II22 and IV1-IV8 are very particularly preferred.

Liquid crystal mixtures which are based on the following component mixtures T(Ie4) 1-3 which contain at

least one compound each from the compound classes of the formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

Mixture	Formula	Mass content of the component mixture [%]
15 T (Ie4) 1	Ie4	5-75, in particular 5-45
	II	6-65
	IV	5-63
20 T (Ie4) 2	Ie4	5-75, in particular 5-35
	IV	5-63
	II	5-53
20 T (Ie4) 3	Ie4	5-55, in particular 5-25
	II	5-53
	IV	5-50

Electrooptical liquid crystal systems are additionally preferred whose liquid crystal contains one or more compounds of the formula If



in which

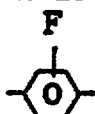
at least one of the rings A^{13} and, if present, A^{14} is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene, trans-1,4-cyclohexylene, pyridine-2,5-diyl, pyrimidine-2,5-diyl or

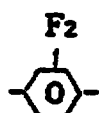
1,3-dioxane-2,5-diyl and the other, if present, is trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene,

5 Z^{11} and Z^{12} in each case independently of one another are a single bond, $-C\equiv C$, $-CH_2CH_2-$, $-COO-$, $-OCO-$ or a combination of 2 or more of these bridge members,

v is 0, 1 or 2

10 a is 0 or 1,

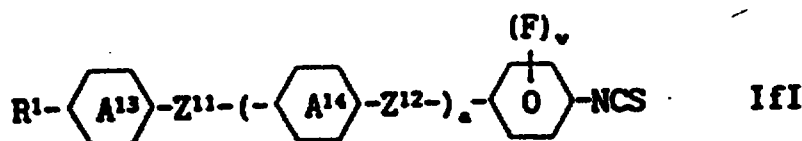
 is 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene,

 is 3,5-difluoro-1,4-phenylene and

15 T^2 is $-Cl$, $-F$, $-CF_3$, $-OCF_3$, $-OCHF_2$ or NCS and R^1 has the meaning given in Claim 1.

In the following, Phe.(F,2) is a laterally unsubstituted 1,4-phenylene group, a 1,4-phenylene group laterally monofluorinated in the 2- or 3-position or a 1,4-phenylene group difluorinated in the 3- and 20 5-position.

Preferred compounds of the formula If are those in which T^2 is $-NCS$:



25 The compounds of the formula IfI include 2-ring compounds of the formulae IfI2-1 - IfI2-4, which are preferred:

$R^1\text{-Phe-Z}^{11}\text{-Phe-NCS}$	IfI2-1
$R^1\text{-Cyc-Z}^{11}\text{-Phe-NCS}$	IfI2-2
$R^1\text{-Pyr-Z}^{11}\text{-Phe-NCS}$	IfI2-3
$R^1\text{-Pyd-Z}^{11}\text{-Phe-NCS}$	IfI2-4

R^1 is preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms, where the straight-

chain radicals are preferred; additionally preferred are n-alkoxyalkyl compounds and in particular n-alkoxymethyl [sic] and n-alkoxyethyl compounds.

5 In the compounds of the formulae IfI2-1 - IfI2-4, Z¹¹ is preferably a single bond, -CH₂CH₂-, COO or OCO. Liquid crystal mixtures which contain one or more compounds of the formulae IfI2-3 or IfI2-4 in which Z is a single bond or COO and in particular a single bond, have particularly advantageous values for the dielectric
10 anisotropy Δε.

The compounds of the formula IfI2-1 and IfI2-2 are particularly preferred. The following smaller group of 2-ring compounds of the formulae IfI2-1a-b and IfI2-2a-b is very particularly preferred:

R-Phe-Phe.(F)-NCS IfI2-1a

R-Phe-Phe.(F)-NCS IfI2-1b

R-Cyc-Phe.(F)-NCS IfI2-2a

R-Cyc-CH₂CH₂-Phe.(F)-NCS IfI2-2b

15 Liquid crystal mixtures which, in addition to one or more laterally non-fluorinated compounds of the formulae IfI2-2a, contain at least one or more compounds selected from the group of compounds of the formulae II5, IV1 and IV2 are in particular suitable for matrix
20 systems, but less suitable for network systems.

The compounds of the formula IfI additionally include 3-ring compounds of the formulae IfI3-1 - IfI3-20

R¹-Phe-Phe-Z¹²-Phe.(F)-NCS IfI3-1

R¹-Phe-Cyc-Z¹²-Phe.(F)-NCS IfI3-2

R¹-Phe-Pyr-Z¹²-Phe.(F)-NCS IfI3-3

R¹-Phe-Pyd-Z¹²-Phe.(F)-NCS IfI3-4

R¹-Cyc-Phe-Z¹²-Phe.(F)-NCS IfI3-5

R¹-Cyc-Cyc-Z¹²-Phe.(F)-NCS IfI3-6

R¹-Cyc-Pyr-Z¹²-Phe.(F)-NCS IfI3-7

R¹-Cyc-Pyd-Z¹²-Phe.(F)-NCS IfI3-8

R¹-Pyr-Phe-Z¹²-Phe.(F)-NCS IfI3-9

R¹-Pyd-Phe-Z¹²-Phe.(F)-NCS IfI3-10

R¹-Phe-Z¹¹-Phe-Phe.(F)-NCS IfI3-11

R¹-Phe-Z¹¹-Cyc-Phe.(F)-NCS IfI3-12

R ¹ -Phe-Z ¹¹ -Pyr-Phe. (F) -NCS	IfI3-13
R ¹ -Phe-Z ¹¹ -Pyd-Phe. (F) -NCS	IfI3-14
R ¹ -Cyc-Z ¹¹ -Phe-Phe. (F) -NCS	IfI3-15
R ¹ -Cyc-Z ¹¹ -Cyc-Phe. (F) -NCS	IfI3-16
R ¹ -Cyc-Z ¹¹ -Pyr-Phe. (F) -NCS	IfI3-17
R ¹ -Cyc-Z ¹¹ -Pyd-Phe. (F) -NCS	IfI3-18
R ¹ -Pyr-Z ¹¹ -Phe-Phe. (F) -NCS	IfI3-19
R ¹ -Pyd-Z ¹¹ -Phe-Phe. (F) -NCS	IfI3-20

In the compounds of the formulae IfI3-1 - IfI3-20, R¹ is preferably n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms. Particularly preferred compounds are those of the formulae Ibf3-1 - Ibf3-20 in which R¹ is methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl.

The compounds of the formulae IfI3-1, IfI3-5, IfI3-11 and IfI3-15 are particularly preferred. The compounds of the formula IfI3, in which Z¹¹ and Z¹² independently of one another are a single bond or COO and in particular a single bond, and those of the formula IfI3-13 have particularly advantageous values for Δε, in particular if the terminal 1,4-phenylene group is fluorinated in the 3-position.

The following smaller group of 3-ring compounds of the formulae IfI3-1a, IfI3-1b, IfI3-5a, IfI3-5b, IfI3-11a and IfI3-15a is very particularly preferred:

R-Phe-Phe-Phe. (F) -NCS	IfI3-1a
R-Phe-Phe-CH ₂ CH ₂ -Phe. (F) -NCS	IfI3-1b
R-Cyc-Phe-Phe. (F) -NCS	IfI3-5a
R-Cyc-Phe-CH ₂ CH ₂ -Phe. (F) -NCS	IfI3-5b
R-Cyc-Cyc-Phe. (F) -NCS	IfI3-6a
R-Cyc-Cyc-CH ₂ CH ₂ -Phe. (F) -NCS	IfI3-6b
R-Phe-CH ₂ CH ₂ -Phe-Phe. (F) -NCS	IfI3-11a
R-Cyc-CH ₂ CH ₂ -Phe-Phe. (F) -NCS	IfI3-15a

The compounds of the formula IfI are preferably

prepared by the methods described in EP 0,169,327, JP 61-189263, EP 0,126,883, EP 0,215,800, DE 327,115,10, EP 0,242,716, DE 3,545,345, EP 0,227,004, EP 0,272,580 and DE 3,929,765.

5 The selection of the compounds of the formula IfI and in particular of the preferred sub-formulae is carried out with respect to the particular specific embodiment of the electrooptical system according to the invention. If, for example, a liquid crystal medium
10 having high or relatively high optical viscosity [sic] is required, the medium in particular contains those compounds of the formulae IfI2-1, IfI2-3, IfI3-1, IfI3-3, IfI3-9, IfI3-11, IfI3-13 and/or IfI3-19 in which Z is a single bond; particularly preferred compounds are those
15 in which the terminal 1,4-phenylene group or, alternatively, another 1,4-phenylene group of the compound is laterally fluorinated in the 2- or 3-position and in particular in the 3-position. The person skilled in the art can make a selection from the pool of compounds of the formula IfI for other embodiments without
20 inventive assistance.

 Liquid crystal mixtures which contain one or more compounds of the formula IfI and in particular of the preferred sub-formulae are distinguished by advantageous
25 values for the birefringence Δn and the dielectric anisotropy $\Delta \epsilon$, a high stability, a low miscibility with the polymer used for the matrix and in particular a broad mesogenic range, a relatively high clear point and advantageous values for the flow viscosity η .

30 The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula IfI and in particular of the preferred sub-formulae. In this connection, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the
35 formula IfI and in particular of the preferred sub-formulae.

 Liquid crystal mixtures are particularly preferred which contain one or more compounds selected from the group of compounds of the formula IfI, in

particular of the formulae IfI2-1 - IfI2-4 and IfI3-1 - IfI3-20 and very particularly of the formulae IfI2-1a, IfI2-1b, IfI2-2a, IfI2-2b, IfI3-1a, IfI3-1b, IfI3-5a, IfI3-5b, IfI3-11a and IfI3-15a, and additionally one or more compounds selected from the group of compounds III1-III28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formulae IfI2 and IfI3 and in particular of the preferred sub-formulae of these compounds and additionally of at least one compound of the formulae III1-III28, III1-III3 and IV1-IV8 in the liquid crystal mixtures used according to the invention is preferably 15%-100%, but in particular 25%-100%.

Liquid crystal component mixtures which, in addition to at least one laterally non-fluorinated compound selected from the group of compounds of the formulae IfI2-2a, IfI3-5a and IfI3-6a, contain one or more compounds selected from the group of compounds II5, IV1 and IV2, are generally particularly suitable for matrix systems, but frequently less suitable for network systems. The properties of component mixtures of this type, however, are frequently distinctly improved by the addition of at least one, preferably not less than 3, compounds, selected from the group of compounds of the formulae Ia, Ib, Ic, Id, Ie, IfF, IfCl and IfCl.F and in particular of the preferred sub-formulae, such that these mixtures are then also preferred for network applications.

Liquid crystal mixtures which contain at least one compound selected from the group including compounds of the formulae IfI2-1b and IfI3-6b and laterally fluorinated compounds of the formulae IfI2-1a and IfI3-6a, and additionally a compound selected from the group of compounds of the formulae III1, II3, II2, II5, II9, III1, III4, II16, II22, II23 and IV1-IV8 are particularly suitable for matrix systems and very particularly suitable for network systems.

Furthermore, the following component mixtures which contain at least one compound each from the

compound classes shown are particularly suitable both for matrix systems and for network systems:

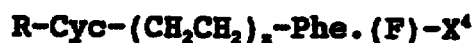
T(IfI)1: IfI2-1a



5

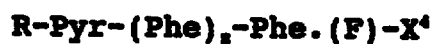
where $X^4 = \text{CN, F, Cl, OCF}_3 \text{ or CF}_3$
and z and y independently of one another are 0 or 1

10 T(IfI)2: IfI2-1a



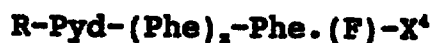
where $X^4 = \text{CN, F, Cl, OCF}_3 \text{ or CF}_3$
and $z = 0 \text{ or } 1$

15 T(IfI)3: IfI2-1a



where $z = 0 \text{ or } 1$
and $X^4 = \text{CN, F or Cl}$

T(IfI)4: IfI2-1a



20

where $z = 0 \text{ or } 1$
and $X^4 = \text{CN, F or Cl}$

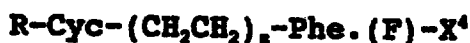
T(IfI)5: IfI2-1b



25

where $X^4 = \text{CN, F, Cl, OCF}_3 \text{ or CF}_3$
and z and y independently of one another are 0 or 1

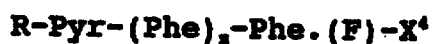
T(IfI)6: IfI2-1b



30

where $X^4 = \text{CN, F, Cl, OCF}_3 \text{ or CF}_3$
and $z = 0 \text{ or } 1$

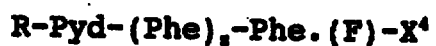
T(IfI)7: IfI2-1b



35

where $z = 0 \text{ or } 1$
and $X^4 = \text{CN, F or Cl}$

T(IfI)8: IfI2-1b



where $z = 0 \text{ or } 1$
and $X^4 = \text{CN, F or Cl}$

T(IfI)9: IfI2-2a

$$\text{R-Phe-(COO)}_x\text{-(Phe.(F))}_y\text{-Phe.(F)-X}^4$$

where $X^4 = \text{CN, F, Cl}$

OCF₃ or CF₃

and z and y independently of one another are 0 or 1

5

T(IfI) 10: IfI2-2a

$$\text{R-Cyc-(CH}_2\text{CH}_2)_n\text{-Phe. (F)-X}^4$$

where $X^4 = \text{CN, F, Cl,}$

OCF₃ or CF₃

and $z = 0$ or 1

10

T(IfI)11: IfI2-2a

R-Pyr-(Phe)₃-Phe.(F)-X⁴

where $z = 0$ or 1

and $X^4 = \text{CN, F or Cl}$

15

T(IfI)12: IfI2-2a

R-Pyd-(Phe)_n-Phe.(F)-X⁴

where $z = 0$ or 1

and $X^4 = \text{CN, F or Cl}$

20

T(IfI) 13: IfI2-5a

$$\text{R-Phe-(COO)}_x\text{-(Phe.(F))}_y\text{-Phe.(F)-X}^4$$

where $X^i = \text{CN, F, Cl}$

OCF₃ or CF₃

and z and y independ-
ently of one another
are 0 or 1

25 ·

T(IfI)14: IfI2-5a

$$\text{R-Cyc-(CH}_2\text{CH}_2)_n\text{-Phe. (F)-X}^4$$

where $X^i = \text{CN, F, Cl,}$

OCF₃ or CF₃

and $z = 0$ or 1

30

T(IfI) 15: IfI2-5a

R-Pyr-(Phe)₄-Phe.(F)-X⁴

where $z = 0$ or 1

and $X^4 = \text{CN, F or Cl}$

35

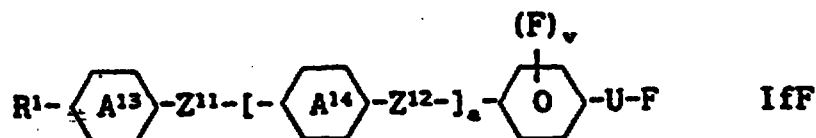
T(IfI) 16: IfI2-5a

R-Pyd-(Phe)_n-Phe. (F)-X¹

where $z = 0$ or 1

and $X^4 = \text{CN, F or Cl}$

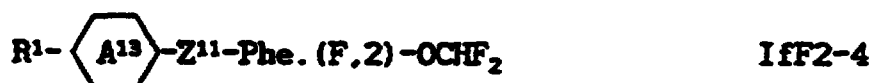
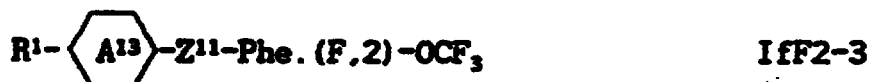
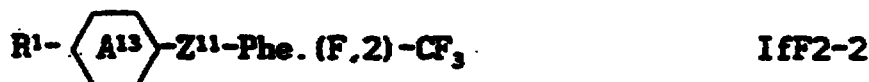
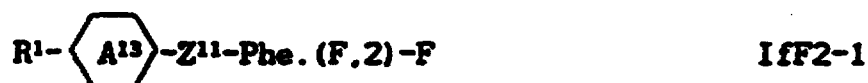
Additionally preferred compounds of the formula
If are those in which T² is -U-F



in which

U is a single bond, -CF₂-, -OCF₂- or -OCHF- and R¹ has the
5 meaning mentioned above in Claim 1 [sic].

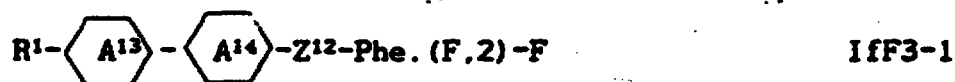
The compounds of the formula IfF include 2-ring
compounds of the formulae IfF2-1 - IfF2-4, which are
preferred:

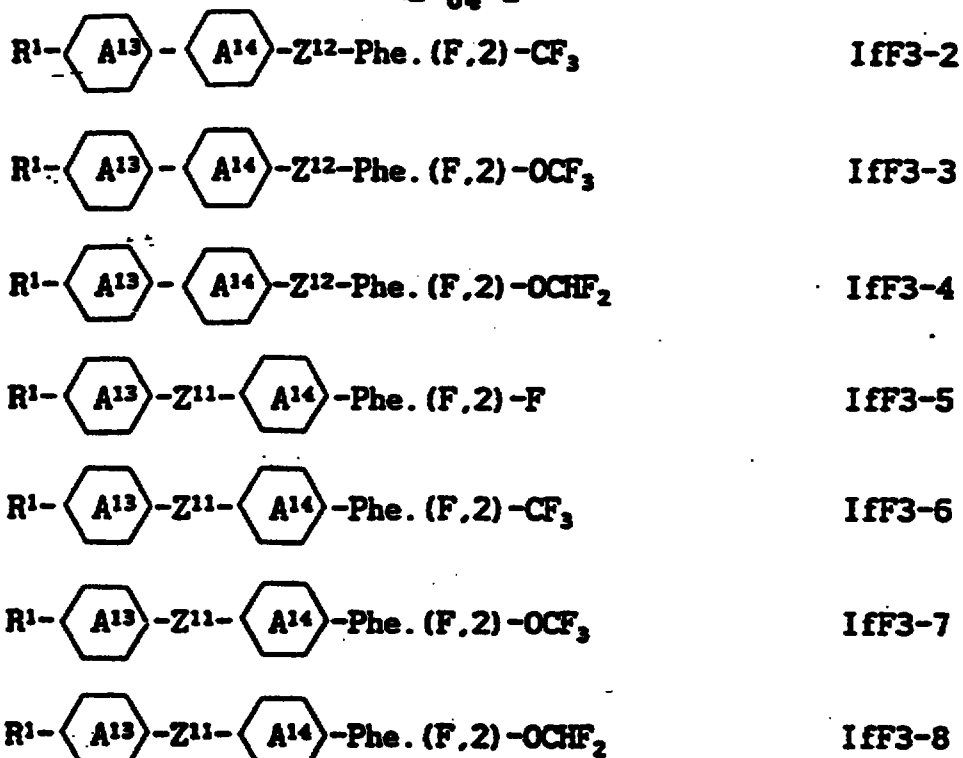


In the compounds of the formulae IfF2-1 - IfF2-4,
10 R¹ is preferably alkyl or alkoxy having 1-10, but in
particular having 1-8, C atoms, where the straight-chain
radicals are preferred. Additionally preferred are
n-alkoxyalkyl compounds and in particular n-alkoxymethyl
and n-alkoxyethyl compounds. Z¹¹ [sic] is preferably
15 -CH₂CH₂-, -COO- or a single bond, in particular a single
bond or -CH₂CH₂- and very particularly a single bond.

-A¹³- is preferably Cyc, Phe.(F), Pyr or Pyd.

The compounds of the formula IfF additionally
include the following small groups [sic] of 3-ring
20 compounds of the formulae IfF3-1 - IfF3-8, which are
preferred:



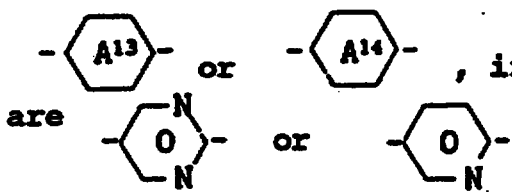


In the compounds of the formulae Iff3-1 - Iff3-8, R^1 is preferably n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms.

5 Very particularly preferred compounds are those of the formulae Iff3-1 - Iff3-8, in which R^1 is methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl. Z^{11} and Z^{12} in the compounds of the formulae Iff3-1 - Iff3-8 are preferably independently of one another -CH₂CH₂-, -COO-, a single bond or a combination of 2 or more of these bridge members and in particular 10 -CH₂CH₂- or a single bond.

15 The compounds of the formula Iff are preferably prepared by the processes described in DE 3,102,017, JP 57-140,747, DE 3,233,641, DE 2,937,911, EP 0,097,033, DE 3,509,260, DE 3,732,284, DE 3,928,783, EP 0,194,153, 20 JP 58-126,839, JP 58-210,045, WO 85/04874, DE 3,315,295, EP 0,193,191, JP 63-280,063, DE 3,825,428, DE 3,929,525, DE 4,024,760, DE 4,009,907, DE 4,007,040, DE 4,012,051, DE 3,939,116, PCT/EP 90/00186, WO 90/08757, DE 3,929,764, DE 4,004,650, DE 4,013,854 and DE 3,913,554.

Liquid crystal mixtures which contain one or more compounds of the formulae IfF2-1 - IfF2-4 and IfF3-1 - IfF3-8 where Phe.(F,2) = Phe.3F or Phe.3F5F, have advantageous values for the dielectric anisotropy $\Delta\epsilon$ and are preferred. Mixtures which contain those compounds of the formulae IfF2-1 - IfF2-4 and IfF3-1 - IfF3-8 in which Ph.(F,2) = Phe.3F or Phe.3F5F and

are  , if present, are particularly preferred.

2-Ring compounds of the formulae IfF2-1 - IfF2-4 in which Phe.(F) is Phe, Phe.3F or Phe.3F5F are particularly preferred. 2-Ring compounds of the formulae IfF2-1 - IfF2-4 in which Phe.(F) is Phe.2F are distinguished by a good miscibility with other liquid crystals and are likewise particularly preferred. Liquid crystal mixtures which contain these preferred compounds are preferred.

Liquid crystal mixtures which contain one or more of the following particularly preferred 2-ring compounds are additionally particularly preferred:

R ¹ -Cyc-Phe-F	IfF2-1a
R ¹ -Cyc-Phe.2F-F	IfF2-1b
R ¹ -Cyc-Phe.3F-F	IfF2-1c
R ¹ -Cyc-Phe.3F5F-F	IfF2-1d
R ¹ -Cyc-CH ₂ CH ₂ -Phe-F	IfF2-1e
R ¹ -Cyc-CH ₂ CH ₂ -Phe.2F-F	IfF2-1f
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F-F	IfF2-1g
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F5F-F	IfF2-1h
R ¹ -Pyr-Phe-F	IfF2-1i
R ¹ -Pyr-Phe.2F-F	IfF2-1k
R ¹ -Pyr-Phe.3F-F	IfF2-1l
R ¹ -Pyr-Phe.3F5F-F	IfF2-1m
R ¹ -Pyd-Phe-F	IfF2-1n
R ¹ -Pyd-Phe.2F-F	IfF2-1o

R ¹ -Pyd-Phe.3F-F	Iff2-1p
R ¹ -Pyd-Phe.3F5F-F	Iff2-1q
R-Dio-Phe-F	Iff2-1r
R-Dio-Phe.2F-F	Iff2-1s
R-Dio-Phe.3F-F	Iff2-1t
R-Dio-Phe.3F5F-F	Iff2-1u

R ¹ -Cyc-Phe-CF ₃	Iff2-2a
R ¹ -Cyc-Phe.2F-CF ₃	Iff2-2b
R ¹ -Cyc-Phe.3F-CF ₃	Iff2-2c
R ¹ -Cyc-Phe.3F5F-CF ₃	Iff2-2d
R ¹ -Cyc-CH ₂ CH ₂ -Phe-CF ₃	Iff2-2e
R ¹ -Cyc-CH ₂ CH ₂ -Phe.2F-CF ₃	Iff2-2f
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F-CF ₃	Iff2-2g
R ¹ -Cyc-CH ₂ CH ₂ -Phe.3F5F-CF ₃	Iff2-2h

R ¹ -Pyr-Phe-CF ₃	Iff2-2i
R ¹ -Pyr-Phe-2F-CF ₃	Iff2-2k
R ¹ -Pyr-Phe.3F-CF ₃	Iff2-2l
R ¹ -Pyr-Phe.3F5F-CF ₃	Iff2-2m

R^1 -Pyd-Phe- CF_3	Iff2-2n
R^1 -Pyd-Phe-2F- CF_3	Iff2-2o
R^1 -Pyd-Phe-3F- CF_3	Iff2-2p
R^1 -Pyd-Phe-3F5F- CF_3	Iff2-2q
R-Dio-Phe- CF_3	Iff2-2r
R-Dio-Phe-2F- CF_3	Iff2-2s
R-Dio-Phe-3F- CF_3	Iff2-2t
R-Dio-Phe-3F5F- CF_3	Iff2-2u
R^1 -Cyc-Phe- OCF_3	Iff2-3a
R^1 -Cyc-Phe-2F- OCF_3	Iff2-3b
R^1 -Cyc-Phe-3F- OCF_3	Iff2-3c
R^1 -Cyc-Phe-3F5F- OCF_3	Iff2-3d
R^1 -Cyc- CH_2CH_2 -Phe- OCF_3	Iff2-3e
R^1 -Cyc- CH_2CH_2 -Phe-2F- OCF_3	Iff2-3f
R^1 -Cyc- CH_2CH_2 -Phe-3F- OCF_3	Iff2-3g
R^1 -Cyc- CH_2CH_2 -Phe-3F5F- OCF_3	Iff2-3h
R^1 -Pyr-Phe- OCF_3	Iff2-3i
R^1 -Pyr-Phe-2F- OCF_3	Iff2-3k

R^1 -Pyr-Phe.3F-OCF ₃	Iff2-3l
R^1 -Pyr-Phe.3F5F-OCF ₃	Iff2-3m
R^1 -Pyd-Phe-OCF ₃	Iff2-3n
R^1 -Pyd-Phe.2F-OCF ₃	Iff2-3o
R^1 -Pyd-Phe.3F-OCF ₃	Iff2-3p
R^1 -Pyd-Phe.3F5F-OCF ₃	Iff2-3q
R-Dio-Phe-OCF ₃	Iff2-3r
R-Dio-Phe.2F-OCF ₃	Iff2-3s
R-Dio-Phe.3F-OCF ₃	Iff2-3t
R-Dio-Phe.3F5F-OCF ₃	Iff2-3u
R^1 -Cyc-Phe-OCHF ₂	Iff2-4a
R^1 -Cyc-Phe.2F-OCHF ₂	Iff2-4b
R^1 -Cyc-Phe.3F-OCHF ₂	Iff2-4c
R^1 -Cyc-Phe.3F5F-OCHF ₂	Iff2-4d
R^1 -Cyc-CH ₂ CH ₂ -Phe-OCHF ₂	Iff2-4e
R^1 -Cyc-CH ₂ CH ₂ -Phe.2F-OCHF ₂	Iff2-4f
R^1 -Cyc-CH ₂ CH ₂ -Phe.3F-OCHF ₂	Iff2-4g
R^1 -Cyc-CH ₂ CH ₂ -Phe.3F5F-OCHF ₂	Iff2-4h
R^1 -Pyr-Phe-OCHF ₂	Iff2-4i
R^1 -Pyr-Phe.2F-OCHF ₂	Iff2-4k
R^1 -Pyr-Phe.3F-OCHF ₂	Iff2-4l

R ¹ -Pyr-Phe.3F5F-OCHF ₂	Iff2-4m
R ¹ -Pyd-Phe-OCHF ₂	Iff2-4n
R ¹ -Pyd-Phe.2F-OCHF ₂	Iff2-4o
R ¹ -Pyd-Phe.3F-OCHF ₂	Iff2-4p
R ¹ -Pyd-Phe.3F5F-OCHF ₂	Iff2-4q
R-Dio-Phe-OCHF ₂	Iff2-4r
R-Dio-Phe.2F-OCHF ₂	Iff2-4s
R-Dio-Phe.3F-OCF ₃	Iff2-4t
R-Dio-Phe.3F5F-OCF ₃	Iff2-4u

The following small group of 3-ring compounds is additionally preferred:

R ¹ -Phe-Phe-Z ¹² -Phe. (F,2) -F	Iff3-1a
R ¹ -Phe-Phe-Z ¹² -Phe. (F,2) -CF ₃	Iff3-2a
R ¹ -Phe-Phe-Z ¹² -Phe. (F,2) -OCF ₃	Iff3-3a
R ¹ -Phe-Phe-Z ¹² -Phe. (F,2) -OCHF ₂	Iff3-4a
R ¹ -Cyc-Phe-Z ¹² -Phe. (F,2) -F	Iff3-1b
R ¹ -Cyc-Phe-Z ¹² -Phe. (F,2) -CF ₃	Iff3-2b
R ¹ -Cyc-Phe-Z ¹² -Phe. (F,2) -OCF ₃	Iff3-3b
R ¹ -Cyc-Phe-Z ¹² -Phe. (F,2) -OCHF ₂	Iff3-4b

$R^1\text{-Cyc-Cyc-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1c
$R^1\text{-Cyc-Cyc-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2c
$R^1\text{-Cyc-Cyc-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3c
$R^1\text{-Cyc-Cyc-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4c
$R^1\text{-Pyd-Phe-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1d
$R^1\text{-Pyd-Phe-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2d
$R^1\text{-Pyd-Phe-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3d
$R^1\text{-Pyd-Phe-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4d
$R^1\text{-Pyr-Phe-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1e
$R^1\text{-Pyr-Phe-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2e
$R^1\text{-Pyr-Phe-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3e
$R^1\text{-Pyr-Phe-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4e
$R^1\text{-Phe-Pyd-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1f
$R^1\text{-Phe-Pyd-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2f
$R^1\text{-Phe-Pyd-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3f
$R^1\text{-Phc-Pyd-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4f
$R^1\text{-Phe-Pyr-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1g
$R^1\text{-Phe-Pyr-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2g
$R^1\text{-Phe-Pyr-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3g
$R^1\text{-Phe-Pyr-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4g
$R^1\text{-Cyc-Dio-Z}^{12}\text{-Phe. (F,2)-F}$	Iff3-1h
$R^1\text{-Cyc-Dio-Z}^{12}\text{-Phe. (F,2)-CF}_3$	Iff3-2h
$R^1\text{-Cyc-Dio-Z}^{12}\text{-Phe. (F,2)-OCF}_3$	Iff3-3h
$R^1\text{-Cyc-Dio-Z}^{12}\text{-Phe. (F,2)-OCHF}_2$	Iff3-4h

$R^1\text{-Phe-Z}^{11}\text{-Phe-Phe. (F,2)-F}$	Iff3-5a
$R^1\text{-Phe-Z}^{11}\text{-Phe-Phe. (F,2)-CF}_3$	Iff3-6a
$R^1\text{-Phe-Z}^{11}\text{-Phe-Phe. (F,2)-OCF}_3$	Iff3-7a
$R^1\text{-Phe-Z}^{11}\text{-Phe-Phe. (F,2)-OCHF}_2$	Iff3-8a
$R^1\text{-Cyc-Z}^{11}\text{-Phe-Phe. (F,2)-F}$	Iff3-5b
$R^1\text{-Cyc-Z}^{11}\text{-Phe-Phe. (F,2)-CF}_3$	Iff3-6b
$R^1\text{-Cyc-Z}^{11}\text{-Phe-Phe. (F,2)-OCF}_3$	Iff3-7b
$R^1\text{-Cyc-Z}^{11}\text{-Phe-Phe. (F,2)-OCHF}_2$	Iff3-8b

In these compounds, Phe.(F,2) is in particular Phe, Phe.3F or Phe.3F5F. Compounds of the formulae Iff3-1a-1h, 2a-2h, 3a-3h and 3a-3h [sic] and 4a-4h in which Z^{12} is $-\text{COO}-$ and Phe.(F,2) is Phe.2F are additionally preferred. Compounds of the formulae Iff3-1a-1h, 2a-2h, 3a-3h and 4a-4h in which Z^{12} is $-\text{CH}_2\text{CH}_2-$ or a single bond and Phe.(F,2) is Phe, Phe.2F, Phe.3F or Phe.3F5F and in particular Phe, Phe.3F and Phe.3F5F are additionally preferred. In the compounds of the formulae Iff3-5a, 6a, 7a, 8a, 5b, 6b, 7b and 8b Z^{11} is preferably $-\text{CH}_2\text{CH}_2-$ or $-\text{COO}-$ and in particular $-\text{CH}_2\text{CH}_2-$. Liquid crystal mixtures which contain one or more of these preferred compounds have particularly favourable properties.

Liquid crystal mixtures which contain at least one of the following particularly preferred 3-ring compounds are additionally particularly preferred:

$R^1\text{-Phe-Phe-Phe-F}$	Iff3-1a1
$R^1\text{-Phe-Phe-Phe.2F-F}$	Iff3-1a2
$R^1\text{-Phe-Phe-Phe.3F-F}$	Iff3-1a3
$R^1\text{-Phe-Phe-Phe.3F5F-F}$	Iff3-1a4

R¹-Phe-Phe-Phe-CF₃	Iff3-1a5
R¹-Phe-Phe-Phe.3F-CF₃	Iff3-1a6
R¹-Phe-Phe-Phe-OCF₃	Iff3-1a7
R¹-Phe-Phe-Phe.3F-OCF₃	Iff3-1a8
R¹-Cyc-Phe-Phe-F	Iff3-1b1
R¹-Cyc-Phe-Phe.2F-F	Iff3-1b2
R¹-Cyc-Phe-Phe.3F-F	Iff3-1b3
R¹-Cyc-Phe-Phe.3F5F-F	Iff3-1b4
R¹-Cyc-Phe-Phe-CF₃	Iff3-1b5
R¹-Cyc-Phe-Phe.3F-CF₃	Iff3-1b6
R¹-Cyc-Phe-Phe-OCF₃	Iff3-1b7
R¹-Cyc-Phe-Phe.3F-OCF₃	Iff3-1b8
R¹-Cyc-Cyc-Phe-F	Iff3-1c1
R¹-Cyc-Cyc-Phe.2F-F	Iff3-1c2
R¹-Cyc-Cyc-Phe.3F-F	Iff3-1c3
R¹-Cyc-Cyc-Phe.3F5F-F	Iff3-1c4
R¹-Cyc-Cyc-Phe-CF₃	Iff3-1c5
R¹-Cyc-Cyc-Phe.3F-CF₃	Iff3-1c6
R¹-Cyc-Cyc-Phe-OCF₃	Iff3-1c7
R¹-Cyc-Cyc-Phe.3-OCF₃	Iff3-1c8

R ¹ -Pyd-Phe-Phe-F	Iff3-1d1
R ¹ -Pyd-Phe-Phe.2F-F	Iff3-1d2
R ¹ -Pyd-Phe-Phe.3F-F	Iff3-1d3
R ¹ -Pyd-Phe-Phe.3F5F-F	Iff3-1d4
R ¹ -Pyd-Phe-Phe-CF ₃	Iff3-1d5
R ¹ -Pyd-Phe-Phe.3F-CF ₃	Iff3-1d6
R ¹ -Pyd-Phe-Phe-OCF ₃	Iff3-1d7
R ¹ -Pyd-Phe-Phe.3F-OCF ₃	Iff3-1d8
R ¹ -Pyr-Phe-Phe-F	Iff3-1e1
R ¹ -Pyr-Phe-Phe.2F-F	Iff3-1e2
R ¹ -Pyr-Phe-Phe.3F-F	Iff3-1e3
R ¹ -Pyr-Phe-Phe.3F5F-F	Iff3-1e4
R ¹ -Pyr-Phe-Phe-CF ₃	Iff3-1e5
R ¹ -Pyr-Phe-Phe.3F-CF ₃	Iff3-1e6
R ¹ -Pyr-Phe-Phe-OCF ₃	Iff3-1e7
R ¹ -Pyr-Phe-Phe.3F-OCF ₃	Iff3-1e8

Liquid crystal mixtures which contain one or more compounds of the formulae [sic] IfF and in particular of the preferred sub-formulae are distinguished by a broad mesogenic range, a relatively high clear point, advantageous values for the birefringence and flow

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viscosity, low miscibility with the polymer used for the matrix and in particular by advantageous values for the dielectric anisotropy and a high UV and temperature stability.

5 The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula IfF and in particular of the preferred sub-formulae. In this case, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula IfF
10 and in particular of the preferred sub-formulae.

 Particularly preferred liquid crystal mixtures are those which contain one or more compounds selected from the group of compounds of the formulae IfF, in particular of the formulae IfF2-1 - IfF2-4 and IfF3-1 -
15 IfF3-8 and very particularly of the preferred sub-formulae, and additionally one or more compounds selected from the group of compounds of the formulae III1-III28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of
20 the formula IfF and in particular of the formulae IfF2 and IfF3 and very particularly of the preferred sub-formulae and additionally of at least one compound of the formulae III1-III28, III1-III3 and IV1-IV8 in the liquid crystal mixtures used according to the invention is
25 preferably 15%-100% and in particular 25%-100%.

 Liquid crystal mixtures which are based on the following component mixtures, which each contain at least one compound from the substance classes shown in each case, are particularly suitable for matrix applications,
30 while they are frequently less suitable for network systems, in particular if the mass content of the compounds of the formula IfF and in particular of the preferred sub-formulae or of the other terminally fluorinated compounds in the liquid crystal mixture is not
35 more than 10% and in particular not more than 5%.

T(IfF)1: R-Cyc-(COO)_c-Phe-C≡C-Phe.(F)-F where c = 0 or 1
 IV2

T(IfF)2: R-Cyc-(COO)_c-Phe-C≡C-Phe.(F)-F
 III1 where c = 0 or 1

T(IfF)3: IfF2-1i or IfF3-1e1

R-Cyc-Cyc-Phe.(F)-X^s where X^s = F or CN

T(IfI)3: R-Cyc-Cyc-Phe.(F)-X^s where X^s = F or CN

R -Pyr-(Phe)_c-Phe-R¹ and c = 0 or 1

5 T(IfI)4: IfF2-1i, IfF3-1e1 or IfF3-1d1

IV1 or IV2

On the other hand, liquid crystal mixtures containing component mixtures of this type are preferred, inter alia even for network applications, if the mass content of the compounds of the formula IfF and in particular of the preferred sub-formulae or of the other terminally fluorinated compounds contained in these component mixtures is greater than 5%, in particular greater than 10% and very particularly not less than 12.5%. Both for matrix and for network applications, liquid crystal mixtures of this type are also preferred which contain one of the abovementioned component mixtures and additionally one or more compounds selected from the group of compounds Ia, Ic, Id, Ie, IfCl, IfCl.F, Ig, Ih or Ii and in particular of the preferred sub-formulae; in these mixtures the mass content of the terminally fluorinated compounds can also be 5% or less. Both for matrix and for network applications, liquid crystal mixtures are also preferred which contain at least one compound of the formula IfF, in which U = -CF₂, -OCF₂ or -OCHF and additionally at least one compound selected from the group of compounds of the formulae III1-III28, III1-III3 and IV1-IV8.

Furthermore, the following component mixtures which contain at least one compound each from the substance classes shown are suitable both for matrix systems and for network systems:

T(IfF)5: R¹-Cyc-(CH₂CH₂)_d-Phe.(F,2)-X^s

II5 or II16

where X^s = F, CF₃, OCF₃,

and d = 0.1

T(IfF)6: R¹-Cyc-(CH₂CH₂)_d-Phe.(F,2)-X^s

IV1, IV2, IV3, IV4,

where X^s = F, CF₃, OCF₃,

IV5, IV6, IV7 or IV8

and d = 0.1

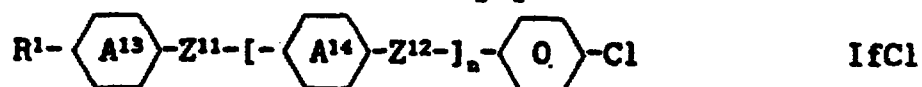
- T(IfF)7: $R^1\text{-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe. (F,2)-X}^6$
 II3, II4, II14, II19, where $X^6 = F, CF_3, OCF_3$,
 II2, II20, II22 or II23 and $d = 0.1$
- 5 T(IfF)8: $R^1\text{-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe. (F,2)-X}^6$
 II1 or II9 where $X^6 = F, CF_3, OCF_3$,
 and $d = 0.1$
- T(IfF)9: $R^1\text{-Pyr-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II6 or II16
- 10 T(IfF)10: $R^1\text{-Pyr-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 IV1, IV2, IV3, IV4, IV5,
 IV6, IV7 or IV8
- T(IfF)11: $R^1\text{-Pyr-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II3, II4, II14, II19, II2,
 II20, II22 or II23
- 15 T(IfF)12: $R^1\text{-Pyd-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II1 or II9
- T(IfF)13: $R^1\text{-Pyd-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II5 or II16
- 20 T(IfF)14: $R^1\text{-Pyd-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 IV1, IV2, IV3, IV4, IV5
 or IV6
- T(IfF)15: $R^1\text{-Pyd-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II3, II4, II14, II19, II2,
 II20, II22 or II23
- 25 T(IfF)16: $R^1\text{-Dio-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 III1, III2 or III3
- T(IfF)17: $R^1\text{-Dio-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II5 or II16
- 30 T(IfF)18: $R^1\text{-Dio-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 IV1, IV2, IV3, IV4, IV7
 or IV8
- T(IfF)19: $R^1\text{-Dio-Phe. (F)-X}^6$ where $X^6 = F, CF_3, OCF_3$,
 II1 or II9
- 35 T(IfF)20: $R^1\text{-Cyc-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe. (F,2)-X}^6$
 II5 or II16 where $X^6 = F, CF_3, OCF_3$,
 and $d = 0.1$
- T(IfF)21: $R^1\text{-Cyc-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe. (F,2)-X}^6$
 IV1, IV2, IV3, IV4 where $X^6 = F, CF_3, OCF_3$,
 IV5, IV6, IV7 or IV8 and $d = 0.1$

- T(IfF)22: $R^1\text{-Cyc-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe.(F,2)-X}^6$
 II3, II4, II14, II19, where $X^6 = F, CF_3,$
 $OCF_3,$
 II2, II20, II22 or II23 and $d = 0.1$
- 5 T(IfF)23: $R^1\text{-Cyc-Cyc-(CH}_2\text{CH}_2)_d\text{-Phe.(F,2)-X}^6$
 III1 or II9 where $X^6 = F, CF_3, OCF_3,$
 and $d = 0.1$
- T(IfF)24: $R^1\text{-Pyd-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 II5 or II16 $OCHF_2$
- 10 T(IfF)25: $R^1\text{-Pyd-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 III1 or II9 $OCHF_2$
- T(IfF)26: $R^1\text{-Pyd-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 IV1, IV2, IV3 or IV4
 $OCHF_2$
- 15 T(IfF)27: $R^1\text{-Pyr-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 II5 or II16 $OCHF_2$
- T(IfF)28: $R^1\text{-Pyr-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 III1 or II9 $OCHF_2$
- T(IfF)29: $R^1\text{-Pyr-Phe-Phe.(F)-X}^6$ where $X^6 = F, CF_3, OCF_3,$
 20 IV1, IV2, IV3, IV4, IV5
 $OCHF_2$
 or IV6

Liquid crystal mixtures which are based on the
 following component mixtures T(IfF) 30-35 which contain
 25 at least one compound each from the compound classes of
 the formulae mentioned in each case are preferred. In the
 table, the preferred mass content of these compounds in
 the component mixtures is additionally given. The compo-
 nent mixtures contain 2-38, preferably 2-35 and in
 30 particular 2-25 compounds; the sum of the mass contents
 of these compounds in the component mixture is 100%. The
 mass content of the component mixture in the liquid
 crystal according to the invention is between 10% and
 100%, in particular between 15% and 100% and very par-
 35 ticularly between 25% and 100%.

Mixture	Formula	Mass content in the component mixture [%]
T (IfF) 30	IfF	5-75, in particular 5-55
	II	5-85, in particular 6-65
T (IfF) 31	IfF	5-55
	III	2-29
T (IfF) 32	IfF	5-75, in particular 5-60
	IV	5-63
5 T (IfF) 33	IfF	5-55
	II	5-65, in particular 5-52
	III	5-29
T (IfF) 34	IfF	5-50
	II	5-72, in particular 5-52
	IV	5-56, in particular 5-46
T (IfF) 35	IfF	
	II	5-50 5-75, in particular
	III	5-47 5-37, in particular
	IV	5-15 5-50, in particular
		5-42

Those compounds of the formula If, in which T² is Cl and v is 0 are additionally preferred



where the meaning of R^1 is given above.

The compounds of the formula IfCl include the following preferred 2- and 3-ring compounds of the sub-formulae IfCl2-1 - IfCl2-8 and IfCl3-1 - IfCl3-12:

R^1 -Phe-Phe-Cl	IfCl2-1
R^1 -Pyr-Phe-Cl	IfCl2-2
R^1 -Cyc-Phe-Cl	IfCl2-3
R^1 -Phe-C-C-Phe-Cl	IfCl2-4
R^1 -Phe-COO-Phe-Cl	IfCl2-5
R^1 -Phe-OOC-Phe-Cl	IfCl2-6
R^1 -Pyd-Phe-Cl	IfCl2-7
R^1 -Cyc-COO-Phe-Cl	IfCl2-8
R^1 -Phe-Phe-Phe-Cl	IfCl3-1
R^1 -Cyc-Phe-Phe-Cl	IfCl3-2
R^1 -Cyc-Cyc-Phe-Cl	IfCl3-3
R^1 -Phe-Cyc-Phe-Cl	IfCl3-4
R^1 -Phe-CH ₂ CH ₂ -Phe-Phe-Cl	IfCl3-5
R^1 -Phe-COO-Phe-Phe-Cl	IfCl3-6
R^1 -Phe-Phe-CH ₂ CH ₂ -Phe-Cl	IfCl3-7
R^1 -Phe-Phe-COO-Phe-Cl	IfCl3-8
R^1 -Phe-Phe-OOC-Phe-Cl	IfCl3-9
R^1 -Cyc-CH ₂ CH ₂ -Phe-Phe-Cl	IfCl3-10
R^1 -Cyc-COO-Phe-Phe-Cl	IfCl3-11
R^1 -Cyc-Phe-CH ₂ CH ₂ -Cl	IfCl3-12

R^1 -Cyc-Phe-C=C-Phe-Cl	IfC13-13
R^1 -Cyc-CH ₂ CH ₂ -Phe-C=C-Phe-Cl	IfC13-14
R^1 -Cyc-Phe-COO-Phe-Cl	IfC13-15
R^1 -Cyc-Phe-OOC-Phe-Cl	IfC13-16
R^1 -Cyc-CH ₂ CH ₂ -Phe-COO-Phe-Cl	IfC13-17
R^1 -Phe-Cyc-COO-Phe-Cl	IfC13-18
R^1 -Phe-COO-Cyc-Phe-Cl	IfC13-19
R^1 -Phe-OOC-Cyc-Phe-Cl	IfC13-20
R^1 -Cyc-Cyc-CH ₂ CH ₂ -Phe-Cl	IfC13-21
R^1 -Cyc-Cyc-COO-Phe-Cl	IfC13-22
R^1 -Cyc-Cyc-OOC-Phe-Cl	IfC13-23
R^1 -Cyc-CH ₂ CH ₂ -Cyc-COO-Phe-Cl	IfC13-24
R^1 -Cyc-CH ₂ CH ₂ -Cyc-Phe-Cl	IfC13-25
R^1 -Cyc-COO-Cyc-Phe-Cl	IfC13-26
R^1 -Cyc-OOC-Cyc-Phe-Cl	IfC13-27
R^1 -Phe-COO-Phe-COO-Phe-Cl	IfC13-28
R^1 -Phe-COO-Phe-OOC-Phe-Cl	IfC13-29
R^1 -Phe-OOC-Phe-COO-Phe-Cl	IfC13-30
R^1 -Phe-OOC-Phe-OOC-Phe-Cl	IfC13-31
R^1 -Cyc-COO-Phe-COO-Phe-Cl	IfC13-32
R^1 -Cyc-COO-Phe-OOC-Phe-Cl	IfC13-33
R^1 -Cyc-OOC-Phe-OOC-Phe-Cl	IfC13-34
R^1 -Cyc-OOC-Phe-COO-Phe-Cl	IfC13-35
R^1 -Cyc-COO-Cyc-COO-Phe-Cl	IfC13-36
R^1 -Cyc-OOC-Cyc-COO-Phe-Cl	IfC13-37
R^1 -Cyc-COO-Cyc-OOC-Phe-Cl	IfC13-38
R^1 -Cyc-OOC-Cyc-OOC-Phe-Cl	IfC13-39

R-Pyr-Phe-Phe-Cl	IfC13-40
R-Pyd-Phe-Phe-Cl	IfC13-41
R-Phe-Pyr-Phe-Cl	IfC13-42
R-Phe-Pyd-Phe-Cl	IfC13-43
R-Cyc-Pyr-Phe-Cl	IfC13-44
R-Cyc-Pyd-Phe-Cl	IfC13-45
R-Pyr-CH ₂ CH ₂ -Phe-Phe-Cl	IfC13-46
R-Pyd-CH ₂ CH ₂ -Phe-Phe-Cl	IfC13-47

In the compounds of the formulae IfC12 and IfC13, R¹ is preferably alkyl, alkenyl or alkoxy having 1-10, but in particular having 1-8, C atoms, where the straight-chain radicals are preferred. Additionally preferred are
5 n-alkoxyalkyl compounds and in particular n-alkoxymethyl and n-alkoxyethyl compounds.

Very particularly preferred compounds are those of the formulae IfC12-1 - IfC12-8 and IfC13-1 - IfC13-47, in which R¹ is methyl, ethyl, propyl, butyl, pentyl,
10 hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl [sic], propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl.

The compounds of the formula IfC1 and the preferred sub-formulae IfC12-1 - IfC12-8 and IfC13-1 - IfC13-47 are for the largest part known and, for example, described in JP 60/260679 A2, JP 59/81375 A2, EP 0,123,907, JP 58/79938 A2, DE 3,136,624, J. Malthete et al., Mol. Cryst. Liq. Cryst. 23, 233 (1973), J.
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20 Liquid crystal mixtures which contain one or more compounds selected from the group of compounds of the formulae IfCl and in particular of the preferred compounds of the formulae IfCl₂-1 - IfCl₂-8 and IfCl₃-1 - IfCl₃-47 are distinguished by advantageous values for the 25 birefringence A_n and the dielectric anisotropy, a high stability, comparatively simple preparation capability, low miscibility with the polymer used for the matrix and in particular by a broad mesogenic range, a relatively high clear point, advantageous values for the flow 30 viscosity and the temperature dependence of the electro-optical parameters.

The liquid crystal mixtures according to the invention preferably contain 1-40% and in particular 5-30% of compounds of the formula IfCl and in particular 35 of the preferred sub-formulae; in this case, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula IfCl and in particular of the preferred sub-formulae.

Particularly preferred liquid crystal mixtures

are those which contain one or more compounds selected from the group of compounds of the formulae [sic] IfC1 and in particular of the formulae IfC12-1 - IfC12-8 and IfC13-1 - IfC13-47, and additionally at least one compound selected from the group of compounds of the formulae III1-II28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formulae IfC1 and in particular of the preferred sub-formulae and additionally of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixtures used according to the invention is preferably 15%-100% and in particular 25%-100%.

Very particularly preferred liquid crystal mixtures are those which contain at least one compound from the following group C and at least one compound from the following group D:

Group C

Group D

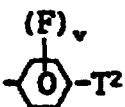
IfC12-1, IfC12-2,
IfC12-3, IfC12-7,
IfC12-8, IfC13-1,
IfC13-2, IfC13-3,
IfC13-40, IfC13-41,
IfC13-43, IfC13-43,
IfC13-44, IfC13-45,
IfC13-46, IfC13-47

II1, II2, II3, II4, II5, II6,
II7, II8, II9, II10, II11,
II15, II16, II17, II21, II22,
II23, II25, II26, II27, II28,
III1, III2, IV1, IV2, IV3, IV4,
IV5, IV6, IV7, IV8

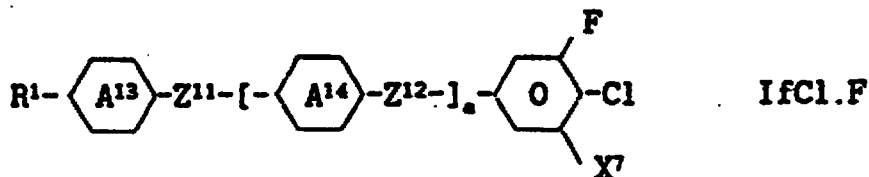
Liquid crystal mixtures which are based on the following component mixtures T(IC1) 1-3 which contain at least one compound each from the compound classes of the formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The

mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

5 Mixture	Formula	Mass content in the component mixture [%]
T (IC1) 1	IC1	5-55
	II	5-75, in particular
		5-65
T (IC1) 2	IC1	5-50
	IV	5-75, in particular
		5-70
T (IC1) 3	IC1	5-45, in particular
		5-40
	II	5-55
	IV	5-53

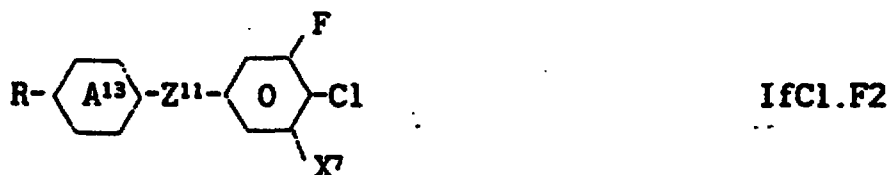
Those compounds of the formula If in which  (F)_v -T²

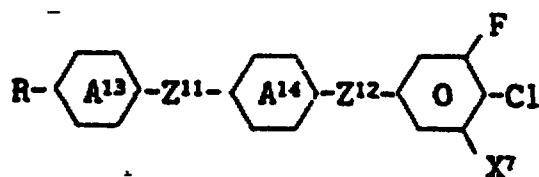
10 is Phe.3F-Cl or Phe.3F5F-Cl,



where the meaning of R¹ is given above and X⁷ is F or H, are additionally preferred.

The compounds of the formula IfCl.F include 2- and 3-ring compounds of the formulae





IfCl.F3

In the 2-ring compounds of the formulae IfCl.F2,

5  is preferably Phe, Phe.F, Cyc, Pyr, Pyd or Dio and in particular Phe, Cyc, Pyd or Dio. Z¹¹ is a single bond, -COO-, -OCO- or -CH₂CH₂- and in particular a single bond, -CH₂CH₂- or -COO-.

The following small group of 2-ring compounds of the formulae IfCl.F2-1 - IfCl.F2-19 is particularly preferred.

R-Phe-Phe.3F-Cl	IfCl.F2-1
R-Phe.3F-Phe.3F-Cl	IfCl.F2-2
R-Cyc-Phe.3F-Cl	IfCl.F2-3
R-Pyr-Phe.3F-Cl	IfCl.F2-4
R-Pyd-Phe.3F-Cl	IfCl.F2-5
R-Dio-Phe.3F-Cl	IfCl.F2-6
R-Phe-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F2-7
R-Phe-COO-Phe.3F-Cl	IfCl.F2-8
R-Cyc-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F2-9
R-Cyc-COO-Phe.3F-Cl	IfCl.F2-10
R-Cyc-OCO-Phe.3F-Cl	IfCl.F2-11
R-Phe-Phe.3F5F-Cl	IfCl.F2-12
R-Cyc-Phe.3F5F-Cl	IfCl.F2-13
R-Pyr-Phe.3F5F-Cl	IfCl.F2-14
R-Pyd-Phe.3F5F-Cl	IfCl.F2-15
R-Dio-Phe.3F5F-Cl	IfCl.F2-16
R-Phe-CH ₂ CH ₂ -Phe.3F5F-Cl	IfCl.F2-17
R-Phe-COO-Phe.3F5F-Cl	IfCl.F2-18
R-Cyc-CH ₂ CH ₂ -Phe.3F5F-Cl	IfCl.F2-19

In the 3-ring compounds of the formulae IfCl.F3, Z¹¹ and Z¹² independently of one another are a single bond, -COO-, -OCO-, or -CH₂CH₂-; one of the bridge groups Z¹¹ and Z¹² is preferably a single bond.

5 of one  and  are preferably independently of one another Phe, Phe.F, Cyc, Pyr, Pyd or Dio; if one of  and  is a heterocyclic compound, the other ring is preferably Phe, Phe.F or Cyc and in particular Phe or Cyc.

10

The following small group of 3-ring compounds of the formulae IfCl.F3-1 - IfCl.F3-38 is particularly preferred:

R ¹ -Phe-Phe.F-Phe.3F-Cl	IfCl.F3-1
R ¹ -Phe-Phe-Phe.3F-Cl	IfCl.F3-2
R ¹ -Cyc-Phe-Phe.F-Phe.3F-Cl	IfCl.F3-3
R ¹ -Cyc-Cyc-Phe.3F-Cl	IfCl.F3-4
R ¹ -Phe-Pyr-Phe.3F-Cl	IfCl.F3-5
R ¹ -Phe-Pyd-Phe.3F-Cl	IfCl.F3-6
R ¹ -Dio-Cyc-Phe.3F-Cl	IfCl.F3-7
R ¹ -Dio-Phe-Phe.3F-Cl	IfCl.F3-8
R ¹ -Pyr-Phe-Phe.3F-Cl	IfCl.F3-9
R ¹ -Pyd-Phe-Phe.3F-Cl	IfCl.F3-10
R ¹ -Cyc-Pyr-Phe.3F-Cl	IfCl.F3-11
R ¹ -Cyc-Pyd-Phe.3F-Cl	IfCl.F3-12
R ¹ -Phe.F-Pyd-Phe.3F-Cl	IfCl.F3-13
R ¹ -Pyd-Phe.F-Phe.3F-Cl	IfCl.F3-14
R ¹ -Cyc-CH ₂ CH ₂ -Phe-Phe.3F-Cl	IfCl.F3-15
R ¹ -Cyc-Cyc-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F3-16
R ¹ -Dio-Cyc-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F3-17
R ¹ -Dio-Phe-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F3-18
R ¹ -Phe-Phe.F-CH ₂ CH ₂ -Phe.3F-Cl	IfCl.F3-19
R ¹ -Phe-COO-Phe.F-Phe.3F-Cl	IfCl.F3-20
R ¹ -Phe-COO-Phe-COO-Phe.3F-Cl	IfCl.F3-21
R ¹ -Cyc-COO-Phe-Phe.3F-Cl	IfCl.F3-22

R ¹ -Cyc-Phe-COO-Phe.3F-Cl	IfCl.F3-23
R ¹ -Cyc-COO-Cyc-Phe.3F-Cl	IfCl.F3-24
R ¹ -Cyc-Cyc-COO-Phe3.F-Cl	IfCl.F3-25
R ¹ -Phe-Phe-Phe.3F5F-Cl	IfCl.F3-26
R ¹ -Cyc-Phe-Phe.3F5F-Cl	IfCl.F3-27
R ¹ -Cyc-Cyc-Phe.3F5F-Cl	IfCl.F3-28
R ¹ -Pyr-Phe-Phe.3F5F-Cl	IfCl.F3-29
R ¹ -Pyd-Phe-Phe.3F5F-Cl	IfCl.F3-30
R ¹ -Phe-Pyr-Phe.3F5F-Cl	IfCl.F3-31
R ¹ -Phe-Pyd-Phe.3F5F-Cl	IfCl.F3-32
R ¹ -Dio-Phe-Phe.3F5F-Cl	IfCl.F3-33
R ¹ -Cyc-CH ₂ CH ₂ -Phe-Phe.3F5F-Cl	IfCl.F3-34
R ¹ -Cyc-Cyc-CH ₂ CH ₂ -Phe.3F5F-Cl	IfCl.F3-35
 R ¹ -Phe-Phe-COO-Phe.3F5F-Cl	 IfCl.F3-36
R ¹ -Cyc-COO-Phe-Phe.3F5F-Cl	IfCl.F3-37
R ¹ -Cyc-Cyc-COO-Phe.3F5F-Cl	IfCl.F3-38

5 In the compounds of the formulae IfCl.F and in particular of the preferred sub-formulae IfCl.F2-1 - IfCl.F2-19 and IfCl.F3-1 - IfCl.F3-28, R¹ is preferably alkyl, alkoxy, alkoxyalkyl and alkenyl having 1-10 C atoms. R¹ is particularly preferably methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, methoxyethyl, ethoxyethyl or propoxyethyl.

10 The compounds of the formula IfCl.F2 and IfCl.F3 are preferably prepared by the processes described in DE 3,929,525.

15 Liquid crystal mixtures which contain one or more compounds selected from the group of compounds of the formula IfCl.F and in particular of the formulae IfCl.F2-1 If Cl.F2-19 [sic] and IfCl.F3-1 - IfCl.F3-38 are characterized by advantageous values for the birefringence, the clear point and the viscosity and in

particular by advantageous values for $\Delta\epsilon$, a high UV and temperature stability and a high specific resistance. These mixtures are preferred.

5 The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula IfCl.F and in particular of the preferred sub-formulae. In this connection, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula IfCl.F and in particular of the preferred
10 sub-formulae.

The person skilled in the art can always select from the limited group of compounds of the formula IfCl.F and in particular from the smaller group of compounds of the formulae IfCl.F2-1 - IfCl.F2-19 and IfCl.F3-1 -
15 IfCl.F3-38 without inventive assistance in such a way that the liquid crystal and the electrooptical system filled with it is optimized within certain limits with respect to the particular application. If the liquid crystal mixture is intended to have, for example, a high
20 or even very high birefringence, the person skilled in the art will preferably select those compounds of the formulae IfCl.F and in particular of the preferred sub-formulae which have no saturated ring systems, such as, for example, the compounds of the formulae IfCl.F2-1
25 IfCl.F2-2 [sic], IfCl.F2-4, IfCl.F2-5, IfCl.F2-7, IfCl.F2-8, IfCl.F2-12, IfCl.F2-14, IfCl.F2-15, IfCl.F2-17, IfCl.F2-18, IfCl.F3-1, IfCl.F3-2, IfCl.F3-5, IfCl.F3-6, IfCl.F3-9, IfCl.F3-10, IfCl.F3-13, IfCl.F3-14, IfCl.F3-19, IfCl.F3-20, IfCl.F3-21, IfCl.F3-26,
30 IfCl.F3-29, IfCl.F3-30, IfCl.F3-31, IfCl.F3-32 and IfCl.F3-36.

Additionally, for example, for mixtures which are intended to have a relatively high or high $\Delta\epsilon$, compounds can advantageously be used which have a pyridine or
35 pyrimidine ring and/or a Phe.3F5F-Cl group.

Particularly preferred liquid crystal mixtures are those which contain one or more compounds selected from the group of compounds of the formula IfCl.F and in particular of the preferred compounds of the formulae

IfCl.F2-1 - IfCl.F2-19 and IfCl.F3-1 - IfCl.F3-38, and additionally one or more compounds selected from the group of compounds II1-II27, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formula IfCl.F and in particular of the preferred sub-formulae and additionally of at least one compound of the formulae II1-II27, III1-III3 and IV1-IV8 in the liquid crystal mixture used according to the invention is preferably 15%-100%, but in particular 25%-100%.

The following component mixtures T(IfCl.F), which contain at least one compound each from the substance classes shown, are particularly preferred and suitable both for matrix applications and network systems:

- 15 T(IfCl.F)1: IfCl.F2-1 and/or IfCl.F2-12
II1
- T(IfCl.F)2: IfCl.F2-1 and/or IfCl.F2-12
II5
- 20 T(IfCl.F)3: IfCl.F2-1 and/or IfCl.F2-12
IV1
- T(IfCl.F)4: IfCl.F2-1 and/or IfCl.F2-12
IV2
- T(IfCl.F)5: IfCl.F2-3 and/or IfCl.F2-13
II1
- 25 T(IfCl.F)6: IfCl.F2-3 and/or IfCl.F2-13
II5
- T(IfCl.F)7: IfCl.F2-3 and/or IfCl.F2-13
III1
- T(IfCl.F)8: IfCl.F2-3 and/or IfCl.F2-13
IV1
- 30 T(IfCl.F)9: IfCl.F2-3 and/or IfCl.F2-13
IV2
- T(IfCl.F)10: IfCl.F2-4
II1
- 35 T(IfCl.F)11: IfCl.F2-4
II5
- T(IfCl.F)12: IfCl.F2-4
IV4
- T(IfCl.F)13: IfCl.F2-4

		IV5
	T(IfCl.F)14:	IfCl.F2-5
		II1
	T(IfCl.F)15:	IfCl.F2-5
5		II5
	T(IfCl.F)16:	IfCl.F2-5
		IV4
	T(IfCl.F)17:	IfCl.F2-5
		IV5
10	T(IfCl.F)18:	IfCl.F3-3 and/or IfCl.F3-27
		II1
	T(IfCl.F)19:	IfCl.F3-3 and/or IfCl.F3-27
		II5
	T(IfCl.F)20:	IfCl.F3-3 and/or IfCl.F3-27
15		IV1
	T(IfCl.F)21:	IfCl.F3-3 and/or IfCl.F3-27
		IV5
	T(IfCl.F)22:	IfCl.F3-3 and/or IfCl.F3-27
		II4
20	T(IfCl.F)23:	IfCl.F3-4 and/or IfCl.F3-28
		II1
	T(IfCl.F)24:	IfCl.F3-4 and/or IfCl.F3-28
		II4 or II5
	T(IfCl.F)25:	IfCl.F3-4 and/or IfCl.F3-28
25		II6
	T(IfCl.F)26:	IfCl.F3-4 and/or IfCl.F3-28
		III1
	T(IfCl.F)27:	IfCl.F3-4 and/or IfCl.F3-28
		IV1
30	T(IfCl.F)28:	IfCl.F3-4 and/or IfCl.F3-28
		IV2

Liquid crystal mixtures which, in addition to a dielectrically positive component A consisting of dielectrically positive compounds having $\Delta\epsilon > 2$, contains [sic] a dielectrically neutral component B consisting of compounds having $-2 \leq \Delta\epsilon \leq +2$, and optionally a dielectrically negative component C consisting of compounds having $\Delta\epsilon < -2$ are additionally preferred.

If the mass content of the dielectrically posi-

tive compounds in the liquid crystal is designated by a, that of the dielectrically neutral compounds by b and that of the dielectrically negative compounds correspondingly by c, a is $\geq 30\%$ and in particular a is $> 50\%$.

5 If the dielectrically positive component A is based, in particular, on carbonitriles, the liquid crystal preferably contains a dielectrically neutral component in order to suppress the formation of dimers having dipole moments correlated in antiparallel fashion. The quotient
10 of the mass content of dielectrically positive and neutral components is preferably

$$35 \geq \frac{a}{b} \geq 0.5$$

15 and in particular

$$15 \geq \frac{a}{b} \geq 1$$

If, on the other hand, the liquid crystal is
20 based predominantly on liquid crystal compounds which contain F, Cl, CF₃ [sic], OCF₃ [sic], OCHF₂ [sic] or NCS as a polar terminal group, the content of dielectrically neutral compounds may be small or even 0; preferably b is $\leq 45\%$, in particular b is $\leq 35\%$ and very particularly b
25 is $\leq 25\%$.

The content of dielectrically negative compounds is in general small, as low switch voltages are customarily desired. Preferably, c is $\leq 10\%$ and in particular c is $\leq 5\%$; liquid crystal mixtures having c $\leq 3\%$
30 are in general particularly preferred.

Preferred liquid crystals are those which contain one or more dielectrically neutral compounds of the formula Ig

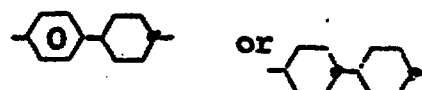


Ig

35 in which the radicals

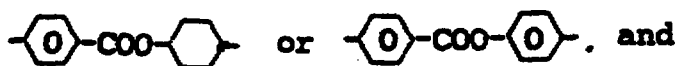
Q^4 and Q^5

in each case independently of one another



40

and one of Q^4 and Q^5 is also .



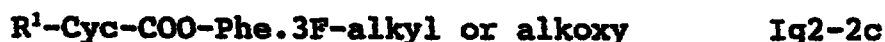
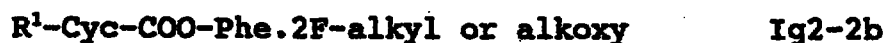
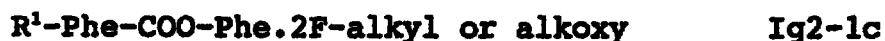
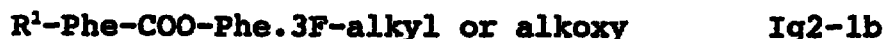
R¹ and R² in each case independently of one another have the meaning given in Claim 1.

The compounds of the formula Ig include 2-ring compounds of the formula Ig2-1 and Ig2-2 which are preferred:

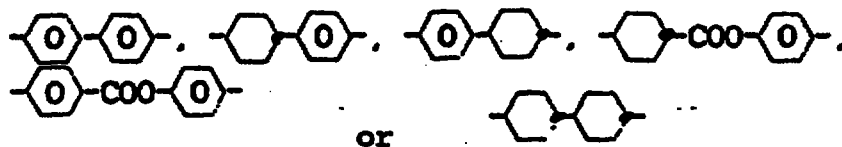


In the compounds of the formulae Ig2-1 and Ig2-2, R¹ and R² independently of one another are preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms, additionally also n-alkoxyalkyl and in particular n-alkoxymethyl and n-alkoxyethyl. One of the two 2,4-phenylene groups of the compounds of the formula Ig2-1 and the 1,4-phenylene group of the compound of the formula Ig2-2 can be substituted in the 2- or 3-position by Cl or F, but in particular by F and/or in the 3-position.

Particularly preferred compounds are those of the formulae



The compounds of the formula Ig additionally include 3-ring compounds in which one of the radicals Q¹ or Q² is 1,4-phenylene or trans-1,4-cyclohexylene and the other is



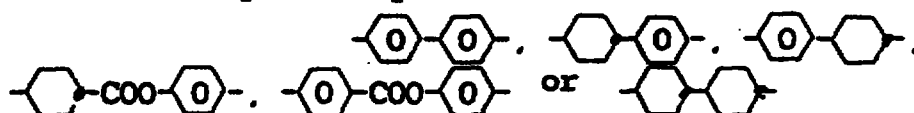
Preferred compounds are those of the formulae

$R^1\text{-Phe-COO-Phe. (F)-Phe.R}^2$	Ig3-1
$R^1\text{-Phe-Phe-COO-Phe. (F).R}^2$	Ig3-2
$R^1\text{-Cyc-Phe. (F)-COO-Phe. (F)-R}^2$	Ig3-3
$R^1\text{-Cyc-COO-Phe-COO-Phe. (F)-R}^2$	Ig3-4
$R^1\text{-Phe-COO-Phe. (F)-COO-Phe-R}^2$	Ig3-5
$R^1\text{-Cyc-Cyc-COO-Phe. (F)-R}^2$	Ig3-6
$R^1\text{-Phe-COO-Cyc-Cyc-R}^2$	Ig3-7
$R^1\text{-Cyc-OCO-Phe-Cyc-R}^2$	Ig3-8
$R^1\text{-Cyc-COO-Phe. (F)-Phe-R}^2$	Ig3-9
$R^1\text{-Phe. (F)-Phe-COO-Cyc-R}^2$	Ig3-10

In the compounds of the sub-formulae Ig3-1 - Ig3-10, R^1 and R^2 are preferably independently of one another n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms. The compounds of the formula Ig3-1 - Ig3-10 can be laterally monosubstituted on one of the 1,4-phenylene groups by $X = F$ or Cl , where substitution by F and/or [lacuna] in the 3-position is preferred.

Laterally un- or monosubstituted compounds of the formulae Ig3-1, Ig3-2, Ig3-3, Ig3-5, Ig3-6, Ig3-8, Ig3-9 and Ig3-10 are very particularly preferred, in which R^1 and R_2 [sic] independently of one another are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, pentoxymethyl, methoxyethyl, ethoxyethyl, propoxyethyl, butoxyethyl or pentoxyethyl.

The compounds of the formula Ig additionally include 4-ring compounds in which the radicals Q^1 and Q^2 in each case independently of one another are



Preferred compounds are those of the formulae Ig4-1 - Ig4-10

$R^1\text{-Phe-Phe-COO-Phe. (F)-Phe-R}^2$	Ig4-1
$R^1\text{-Phe. (F)-Phe-COO-Cyc-Phe-R}^2$	Ig4-2

R^1 -Phe-Phe.(F)-COO-Phe-COO-Phe- R^2	Ig4-3
R^1 -Phe-Phe.(F)-COO-Cyc-Cyc- R^2	Ig4-4
R^1 -Cyc-Phe-COO-Phe.(F)-Phe- R^2	Ig4-5
R^1 -Cyc-Phe-COO-Phe.(F)-COO-Phe.(F)- R^2	Ig4-6
R^1 -Cyc-Phe-COO-Cyc-Cyc- R^2	Ig4-7
R^1 -Cyc-Phe.(F)-COO-Phe-Cyc- R^2	Ig4-8
R^1 -Cyc-Cyc-COO-Phe-Cyc- R^2	Ig4-9
R^1 -Cyc-COO-Phe-COO-Phe.(F)-Phe- R^2	Ig4-10

R^1 and R^2 in the compounds of the formulae Ig4-1 - Ig4-10 are preferably independently of one another methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl, propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl. Particularly preferred are the terminally symmetrically substituted compounds of the formula [sic] Ig4-1, Ig4-3, Ig4-4 and Ig4-8. The compounds of the formula [sic] Ig4-1 - Ig4-10 can be laterally monosubstituted by F or Cl on one of the 1,4-phenylene groups, substitution by F in the 2- or 3-position being preferred. The compounds of the formula Ig4-9 are additionally preferred.

The compounds of the formula Ig are preferably prepared by transesterification of appropriately substituted phenols or phenoxides with appropriately substituted carboxylic acids or reactive carboxylic acid derivatives, such as is described, for example, in DE 2,167,252, DE 2,800,553, DE 2,536,046, DE 2,123,175 and DE 2,139,628.

Liquid crystal mixtures which contain one or more compounds selected from the group of compounds of the formula Ig and in particular of the preferred sub-formulae Ig2-1, Ig2-2, Ig2-1a-1d, Ig2-2a-2c, Ig3-1 - Ig3-10 and Ig4-1 - Ig4-10 are distinguished by advantageous values for the dielectric anisotropy $\Delta\epsilon$, a high stability, easy preparation capability, low miscibility with the polymer used for the matrix and in particular by

a broad mesogenic range, a relatively high clear point and advantageous values for the birefringence and flow viscosity.

5 The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula Ig and in particular of the preferred sub-formulae. In this connection, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula Ig and in particular of the preferred sub-
10 formulae.

 Liquid crystal mixtures are particularly preferred which contain at least one compound selected from the group of compounds of the formula Ig and in particular of the preferred sub-formulae Ig2-1 - Ig2-2, Ig2-1a-1d, Ig2-2a-2c, Ig3-1 - Ig3-10 and Ig4-1 - Ig4-10,
15 and additionally one or more compounds selected from the group of compounds II1-II28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formulae Ig and in particular
20 of the preferred sub-formulae and additionally of at least one compound of the formulae II1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixture used according to the invention is preferably 15%-100%, but in particular 25%-100%.

25 Liquid crystal mixtures which are based on component mixtures which consist of at least one laterally unsubstituted compound of the formula Ig2-1 and of one or more compounds of the formula IV1 are much preferred for matrix systems, but on the other hand less
30 preferred for network systems. However, liquid crystal mixtures which additionally to the compounds of these formulae contain at least one compound selected from the group of compounds of the formulae Ia, Ic, Id, Ie, IfF, IfCl, IfCl.F, Ih or Ii and in particular of the preferred
35 sub-formulae, are preferred inter alia even for network systems.

 The following smaller group of component mixtures T(Ig) which contain at least one compound each from the substance classes shown in each case is also particularly

preferred:

T(Ig)1: Ig2-1a, Ig2-1b and/or Ig2-1c
 II1, II5, II6, IV1, IV2, IV3 and/or IV4
 T(Ig)2: Ig2-2a, Ig2-2b and/or Ig2-2c
 5 II1, II5, II6, III1, III2, IV1, IV2, IV3
 and/or IV4
 T(Ig)3: Ig3-1, Ig3-3, Ig3-6, Ig3-9 and/or Ig3-10
 II1, II2, II3, II4, II5, II6, IV1 and/or
 IV2

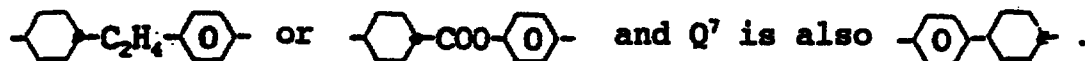
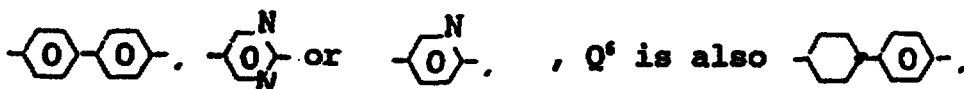
10 Liquid crystal mixtures which are based on the
 following component mixtures T(Ig) 4-6 which contain at
 least one compound each from the compound classes of the
 formulae mentioned in each case are preferred. In the
 table, the preferred mass content of these compounds in
 15 the component mixtures is additionally given. The compo-
 nent mixtures contain 2-38, preferably 2-35 and in
 particular 2-25 compounds; the sum of the mass contents
 of these compounds in the component mixture is 100%. The
 mass content of the component mixture in the liquid
 20 crystal according to the invention is between 10% and
 100%, in particular between 15% and 100% and very par-
 ticularly between 25% and 100%.

Mixture	Formula	Mass content in the component mixture [%]
T (Ig) 4	Ig	5-75
	II	6-65
25 T (Ig) 5	Ig	5-75
	IV	5-75, in particular 5-63
T (Ig) 6	Ig	5-55, in particular 5-50
	II	5-72, in particular 5-53
	IV	5-50, in particular 5-44

Liquid crystal mixtures which are additionally preferred are those which contain one or more compounds of the formula Ih



- 5 in which
at least one of the two radicals R^1 and R^2 has the meaning given in Claim 1,
one of the two radicals R^1 and R^2 is also F, Cl, OCF_3 , $OCHF_2$ or CF_3 , and
10 the radicals Q^6 and Q^7 in each case independently of one another are .

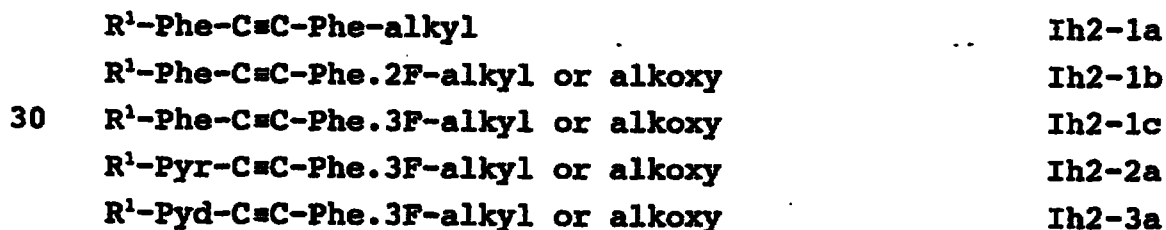


- 15 The compounds of the formula Ih include 2-ring compounds, those of the formulae Ih2-1 - Ih2-3 being preferred:



- 20 In the compounds of the formulae Ih2-1 - Ih2-3, which have 2 non-polar radicals, R^1 and R^2 independently of one another are preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms, additionally also n-alkoxyalkyl and in particular n-alkoxymethyl and -alkoxyethyl. One of the 1,4-phenylene groups contained in the compounds of the formulae Ih2-1 - Ih2-3 can be replaced by Cl or F in the 2- or 3-position, but in
25 particular by F.

The following compounds are particularly preferred:



Compounds of the formulae Ih2-1 -Ih2-3 in which one of the radicals R¹ or R² is F, Cl, OCF₃, OCHF₂ or CF₃, and in particular F or Cl are additionally preferred. These compounds have relatively high values for the optical and dielectric anisotropy and are at the same time characterized by relatively low values for the viscosity η . One of the two 1,4-phenylene groups can be replaced by Cl or F in the 2- or 3-position, but in particular by F and/or in the 3-position.

The following compounds of the formulae Ih2 are particularly preferred

R ¹ -Phe-C≡C-Phe-R ²	Ih2-1d
R ¹ -Phe.3F-C≡C-Phe-R ²	Ih2-1e
R ¹ -Phe.2F-C≡C-Phe-R ²	Ih2-1f
R ¹ -Phe-C≡C-Phe.2F-R ²	Ih2-1g
R ¹ -Phe-C≡C-Phe.3F-R ²	Ih2-1h
R ¹ -Phe-C≡C-Pyr-R ²	Ih2-2b
R ¹ -Phe-C≡C-Pyd-R ²	Ih2-3b
R ¹ -Pyr-C≡C-Phe-R ²	Ih2-2c
R ¹ -Pyd-C≡C-Phe-R ²	Ih2-3c

where R¹ is F, Cl, OCF₃, OCHF₂ or CF₃, and R² is alkyl or alkoxy having 1-7 C atoms.

The compounds of the formula I additionally include 3-ring compounds of which those of the sub-formulae Ih3-1 - Ih3-10 are preferred:

R ¹ -Phe-C≡C-Phe-Phe-R ²	Ih3-1
R ¹ -Phe.(F)-C≡C-Phe-Cyc-R ²	Ih3-2
R ¹ -Pyr-C≡C-Phe-Phe-R ²	Ih3-3
R ¹ -Pyd-C≡C-Phe-Phe-R ²	Ih3-4
R ¹ -Pyr-C≡C-Phe-Cyc-R ²	Ih3-5
R ¹ -Pyd-C≡C-Phe-Cyc-R ²	Ih3-6
R ¹ -Cyc-CH ₂ CH ₂ -Phe-C≡C-Phe-R ²	Ih3-7
R ¹ -Cyc-CH ₂ CH ₂ -Phe-C≡C-Pyd-R ²	Ih3-8
R ¹ -Cyc-CH ₂ CH ₂ -Phe-C≡C-Pyr-R ²	Ih3-9
R ¹ -Cyc-COO-Phe-C≡C-Phe.(F)-R ²	Ih3-10

In the compounds of the sub-formulae Ih3-1 - Ih3-10, R¹ and R² in compounds having 2 non-polar radicals are preferably independently of one another n-alkyl or n-alkoxy having 1-10 C atoms, and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms. Compounds of the formulae Ih3-1 - Ih3-10 which have a polar radical F, Cl, OCHF₂, OCF₃ or CF₃, where the other radical is in particular alkyl or alkoxy having 1-8 C atoms, are preferred. The compounds of the formula Ih3-1 - Ih3-10 can be laterally monosubstituted by X = F or Cl on one of the 1,4-phenylene groups in each case present in the molecule. The following monosubstituted compounds of the formulae Ih3-1a-1d, Ih3-2a-2b, Ih3-5a and Ih3-6a-6b are particularly preferred:

R ¹ -Phe-C=C-Phe-Phe.3F-R ²	Ih3-1a
R ¹ -Phe-C=C-Phe-Phe.3Cl-R ²	Ih3-1b
R ¹ -Phe-C=C-Phe.3F-Phe-R ²	Ih3-1c
R ¹ -Phe-C=C-Phe.3Cl-Phe-R ²	Ih3-1d
R ¹ -Phe-C=C-Phe.3F-Cyc-R ²	Ih3-2a
R ¹ -Phe-C=C-Phe.3Cl-Cyc-R ²	Ih3-2b
R ¹ -Pyr-C=C-Phe-Phe.F-R ²	Ih3-5a
R ¹ -Pyd-C=C-Phe-Phe.F-R ²	Ih3-6a
R ¹ -Pyd-C=C-Phe.F-Phe-R ²	Ih3-6b

where in the compounds of the formulae Ih3-1a-1d, Ih3-5a and Ih3-6a-6b in particular R² and in the compounds of the formulae Ih3-2a-2b in particular R¹ is a polar group.

The compounds of the formula Ih additionally include 4-ring compounds of which those of the sub-formulae Ih4-1 - Ih4-5 are preferred:

R ¹ -Phe-Phe-C=C-Phe.(F)-Phe.(F)-R ²	Ih4-1
R ¹ -Phe-Phe.(F)-C=C-Phe-Cyc-R ²	Ih4-2
R ¹ -Cyc-Phe-C=C-Phe.(F)-Cyc-R ²	Ih4-3
R ¹ -Cyc-CH ₂ CH ₂ -Phe-C=C-Phe.(F)-Cyc-R ²	Ih4-4
R ¹ -Cyc-CH ₂ CH ₂ -Phe-C=C-Phe.(F)-Cyc-R ²	Ih4-5

In the compounds of the formulae Ih4-1 - Ih4-5,

one of the two radicals R^1 and R^2 is preferably polar and the other is preferably independently of one another methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethyl, ethoxymethyl or propoxyethyl.

The symmetrically substituted compounds of the formulae Ih4-1 and Ih4-3 having two non-polar radicals are additionally preferred. The compounds of the formulae Ih4-1 - Ih4-5 can be laterally monosubstituted by F or Cl on one of the 1,4-phenylene groups, substitution in the 3-position being preferred.

The compounds of the formula Ih are preferably prepared by the methods described in DE 2,226,376, GB 2,155,465, GB 2,189,785, DE 3,711,306, JP 61-260,031, DE 3,710,069, JP 02-062,861, JP 63-060,972, EP 0,255,700 and EP 0,276,067.

Liquid crystal mixtures which contain one or more compounds selected from the group of compounds Ih and in particular of the preferred compounds Ih2-1 - Ih2-3 [sic], Ih2-1a-1h, Ih2-2a-2c, Ih2-3a-3c, Ih3-1 - Ih3-10, Ih3-1a-1d, Ih3-2a-2b, Ih3-5a, Ih3-6a-6b and Ih4-1 - Ih4-5 are distinguished by a broad mesogenic range, a relatively high clear point, a high stability, a low miscibility with the polymer used for the matrix and in particular by advantageous values for the dielectric anisotropy and viscosity and by a high birefringence.

The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula Ih and in particular of the preferred sub-formulae. In this case, the liquid crystal mixtures preferably contain 1-5 and in particular 1-3 compounds of the formula Ih and in particular of the preferred sub-formulae.

Liquid crystal mixtures are particularly preferred which contain at least one compound selected from the group of compounds of the formula Ih and in particular of the preferred sub-formulae, and additionally one or more compounds selected from the group of compounds III1-II28, III1-III3 and IV1-IV8. The mass

content of the component mixture consisting of at least one compound of the formula Ih and in particular of the preferred sub-formulae and additionally of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8
5 in the liquid crystal mixture used according to the invention is preferably 15%-100%, but in particular 25%-100%.

Liquid crystal mixtures which are based on component mixtures which contain at least one compound of
10 the formula Ih2-1 and additionally at least one compound of the formula IV1 and/or IV2 are generally particularly preferred for matrix applications, but are frequently less suitable for network applications. The same applies
15 to liquid crystals which are based on component mixtures which contain at least one compound of the formula Ih3-10 and/or Ih3-2 and at least one compound of the formula IV1. However, it has been found that the properties of mixtures of this type can be improved by the
20 addition of at least one compound which are [sic] selected from the group of compounds Ia, Ic, Id, Ie, IfF, IfCl, IfCl.F, Ig and III1-II28 and in particular of the preferred sub-formulae, such that these mixtures can also be employed for network applications.

Liquid crystal mixtures which are based on the
25 following component mixtures T(Ih) [sic] which contain at least one compound each from the compound classes of the formulae shown in each case are preferred both for matrix systems and for network systems. In the table, the preferred mass content of these compounds in the com-
30 ponent mixtures is additionally given.

Mixture	Formula	Mass content in the component mixture [%]
T(Ih)1	Ih	5-75
	II	6-65
5 T(Ih)2	Ih	5-75
	IV	5-63
T(Ih)3	Ih	5-55, in particular 5-50
	II	5-72, in particular 5-53
	IV	5-50, in particular 5-46
10	The following smaller group of component mixtures which in each case contain at least one compound from the compound classes shown in each case, is preferred for matrix applications and particularly preferred for network systems:	
15	T(Ih)4:	Ih2-1a, Ih2-1b and/or Ih2-1c II1, II2, II3, II5, II6, II8, II9 IV1 and/or IV2
	T(Ih)5:	Ih2-2a, 2b and/or 2c II1, II2, II3, II5, II6, II8, II9, IV1, IV2, IV3 and/or IV4
20	T(Ih)6:	Ih2-3a, 3b and/or 3c II1, II2, II3, II5, II6, II8, II9, IV1, IV2, IV3 and/or IV4
	T(Ih)7:	Ih3-2 II1, II2, II3, II5, II6, II8, II9, II10, II11, II13, II14, II15, II16, II21, II22 and/or II23
25	T(Ih)8:	Ih3-3 II1, II2, II3, II5, I6 [sic], II8, II9, II10 and/or II11
30	T(Ih)9:	Ih3-4 II1, II2, II3, II5, II6, II8, II9, II10 and/or II11
35	Liquid crystal mixtures are additionally preferred which contain one or more compounds of the	

formula Ii



in which

R^1 and R^2 in each case independently of one another have the meaning given in Claim 1, and the radicals Q^8 and Q^9 in each case independently of one another are trans-1,4-cyclohexylene, 1,4-phenylene, 4,4'-biphenyl, 4,4'-cyclohexylphenyl, 4,4'-phenylcyclohexyl or trans-,trans-4,4'-bicyclohexyl, where one of the 1,4-phenylene radicals present in the molecule can also be substituted by fluorine or chlorine.

The compounds of the formula Ii include 2-ring compounds of the formulae Ii2-1 and Ii2-2, which are preferred:



R^1 and R^2 in the compounds of the formulae Ii2 independently of one another are preferably alkyl or alkoxy having 1-10, but in particular having 1-8, C atoms. n-Alkoxyalkyl compounds and in particular n-alkoxymethyl and n-alkoxyethyl compounds are additionally preferred. One of the two 1,4-phenylene groups can be substituted by Cl or F in the 2- or 3-position, but in particular by F and/or in the 3-position.

Particularly preferred compounds are those of the formula



The compounds of the formula I additionally include 3-ring compounds of the sub-formulae Ii3, of which those of the sub-formulae Ii3-1 - Ii3-5 are preferred:



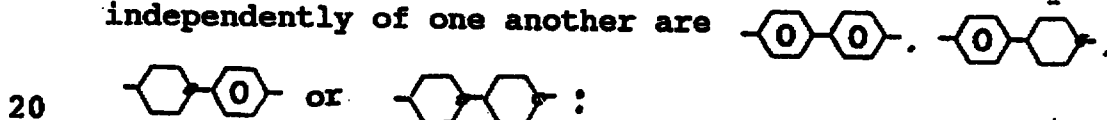
$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Phe-Cyc-R}^2$	Ii3-3
$R^1\text{-Phe-Cyc-CH}_2\text{CH}_2\text{-Phe-R}^2$	Ii3-4
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Cyc-R}^2$	Ii3-5
$R^1\text{-Cyc-Cyc-CH}_2\text{CH}_2\text{-Phe-R}^2$	Ii3-6

- In the compounds of the formulae Ii3-1 - Ii3-6, R^1 and R^2 are preferably independently of one another n-alkyl or n-alkoxy having 1-10 C atoms and in addition also n-alkoxymethyl or n-alkoxyethyl having 1-8 C atoms.
- 5 The compounds of the formula [sic] Ii3-1 - Ii3-6 can be laterally monosubstituted by $X = F$ or Cl on one of the 1,4-phenylene groups. The laterally unsubstituted compounds of the formulae Ii3-1 - Ii3-6 and the laterally monosubstituted compounds of the formulae Ii3-1a-1b, Ii3-2a, Ii3-3a, Ii3-6a and Ii3-5a, in which Phe.X is a
- 10 1,4-phenylene group laterally monosubstituted by F or Cl in the 2- or 3-position, are particularly preferred:

$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Phe-Phe.3X-R}^2$	Ii3-1a
$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Phe.X-Phe-R}^2$	Ii3-1b
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe-Phe.2X-R}^2$	Ii3-2a
$R^1\text{-Phe-CH}_2\text{CH}_2\text{-Phe.X-Cyc-R}^2$	Ii3-3a
$R^1\text{-Cyc-CH}_2\text{CH}_2\text{-Phe.2F-Cyc-R}^2$	Ii3-5a
$R^1\text{-Cyc-Cyc-CH}_2\text{CH}_2\text{-Phe.F-R}^2$	Ii3-6a

- The laterally monosubstituted compounds of the formulae Ii3-1 - Ii3-6 are as a rule distinguished by a
- 15 lower flow viscosity than the corresponding unsubstituted compounds.

The compounds of the formula Ii additionally include 4-ring compounds in which Q^6 and Q^9 in each case independently of one another are



$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe. (F)-Phe-R}^2$	Ii4-1
$R^1\text{-Phe-Phe-CH}_2\text{CH}_2\text{-Phe. (F)-Cyc-R}^2$	Ii4-2
$R^1\text{-Phe-Cyc-CH}_2\text{CH}_2\text{-Phe. (F)-Phe. (F)-R}^2$	Ii4-3
$R^1\text{-Phe-Cyc-CH}_2\text{CH}_2\text{-Phe. (F)-Cyc-R}^2$	Ii4-4
$R^1\text{-Cyc-Phe. (F)-CH}_2\text{CH}_2\text{-Phe-Cyc-R}^2$	Ii4-5
$R^1\text{-Cyc-Cyc-CH}_2\text{CH}_2\text{-Phe. (F)-Phe-R}^2$	Ii4-6

5 R^1 and R^2 in the compounds of the formulae Ii4-1 - Ii4-6 are preferably independently of one another methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, methoxymethy [sic], ethoxy-
10 methyl, propoxymethyl, butoxymethyl, methoxyethyl, ethoxyethyl or propoxyethyl. The compounds of the formulae Ii4-1 - Ii4-6 can be laterally monosubstituted by F or Cl on one of the 1,4-phenylene groups, substi-
15 tution in the 3-position being preferred. These monosubstituted four-ring compounds are distinguished by a high clear point and a comparatively low flow viscosity η .

The compounds of the formula Ii are preferably prepared by the methods described in EP-0,084,194,
15 JP 61-087,777, GB 2,201,415 and DE 3,237,367.

Liquid crystal mixtures which contain one or more compounds selected from the group of compounds of the formula Ii and in particular of the preferred formulae Ii2-1, Ii2-2, Ii2-1a-1c, Ii2-2a, Ii3-1 - Ii3-5,
20 Ii3-1a-1b, Ii3-2a, Ii3-6a, Ii3-3a, Ii3-5a and Ii4-1 - Ii4-5 are distinguished by a high stability, low miscibility with the polymer used for the matrix and in particular by a broad mesogenic range, a relatively high clear point and advantageous values for the optical
25 anisotropy Δn and the flow viscosity η .

The liquid crystal mixtures preferably contain 1-40% and in particular 5-30% of compounds of the formula Ii and in particular of the preferred sub-formulae. In this case, the liquid crystal mixtures preferably contain
30 1-5 and in particular 1-3 compounds of the formula Ii and in particular of the preferred sub-formulae.

Liquid crystal mixtures are particularly preferred which contain at least one compound selected from the group of compounds of the formula Ii and in particular of the preferred sub-formulae, and additionally
5 one or more compounds selected from the group of compounds of the formulae III1-II28, III1-III3 and IV1-IV8. The mass content of the component mixture consisting of at least one compound of the formula Ii and in particular of the preferred sub-formulae and additionally
10 of at least one compound of the formulae III1-II28, III1-III3 and IV1-IV8 in the liquid crystal mixtures used according to the invention is preferably 15%-100%, but in particular 25% - 100%. These component mixtures are preferred for network and matrix systems.

15 The liquid crystal mixtures according to the invention contain one or more compounds which are selected from the group of compounds of the formula I and in particular of the formulae Ia-Ii; in this connection, liquid crystal mixtures which, in addition to one or more
20 compounds of the formula I and in particular of the formulae Ia-Ii, additionally contain one or more compounds selected from the group of compounds of the formulae II-IV are in general preferred.

Liquid crystal mixtures are additionally
25 preferred which contain at least one compound each from two different compound classes; selected from the group of compound classes of the formulae Ia-Ii.

The following smaller group of component mixtures T(Ii) which in each case contain at least one compound
30 from the compound classes shown in each case is very particularly preferred:

T(Ii)1:	T12-1 II1, II2, II3, II5, II9, II16, II17, II18, IV1, IV2, IV3, IV4, IV5 or IV6
35 T(Ii)2:	Ti2-2 II1, II3, II4, II5, II9, IV1, IV2, IV3, IV4, IV7 or IV8
T(Ii)3:	Ii3-2 III1, II2, II5, II6, II7, II8, II9, III1,

		IV1, IV2, IV3 or IV4
	T(Ii)4:	Ii3-5
		III1, II5, IV1, IV2, IV3 or IV4
	T(Ii)5:	Ii3-6
5		III1, II5, II9, II25, II26, II27, II28, III1, IV1, IV2, IV3 or IV4
	T(Ii)6:	Ii3-1a or Ii3-16
		III1, II5, II16, III17, II18, II25, II26, II27, II6, II28, IV1 or IV2
10	T(Ii)7:	Ii4-5
		III1, II5, II6, II7, II8, II16, II17, IV1, IV2, IV3 or IV4
	T(Ii)8:	Ii4-6
15		III1, II2, II5, II6, II7, II8, III1, IV1 or IV2

Liquid crystal mixtures which are based on the following component mixtures T(Ii) 9-13 which contain at least one compound each from the compound classes of the formulae mentioned in each case are preferred. In the table, the preferred mass content of these compounds in the component mixtures is additionally given. The component mixtures contain 2-38, preferably 2-35 and in particular 2-25 compounds; the sum of the mass contents of these compounds in the component mixture is 100%. The mass content of the component mixture in the liquid crystal according to the invention is between 10% and 100%, in particular between 15% and 100% and very particularly between 25% and 100%.

Mixture	Formula	Mass content in the component mixture [%]
T (Ii) 9	Ii	5-75, in particular 5-55
	II	6-85, in particular 6-65
T (Ii) 10	Ii	5-75, in particular 5-55
	IV	5-85, in particular 5-63
T (Ii) 11	Ii	5-55
	II	5-52
	III	5-29
5 T (Ii) 12	Ii	5-55, in particular 5-50
	II	5-72, in particular 5-53
	IV	5-50, in particular 5-46
T (Ii) 13	Ii	5-50
	II	5-75, in particular 5-47
	III	5-37, in particular 1-15
	IV	5-42

10 The component mixtures T(I) shown in the following contain at least one compound each from the compound classes shown in each case, liquid crystal mixtures which contain one or more of these component mixtures are very particularly preferred:

T(I)1: Ia
Ib
T(I)2: Ia
Ic
T(I)3: Ia
Id
T(I)4: Ia
Ie
T(I)5: Ia
If
T(I)6: Ia
Ig
T(I)7: Ia
Ih
T(I)8: Ia
Ii
T(I)9: Ib
Ic
T(I)10: Ib
Id
T(I)11: Ib
Ie
T(I)12: Ib
If
T(I)13: Ib
Ig
T(I)14: Ib
Ih

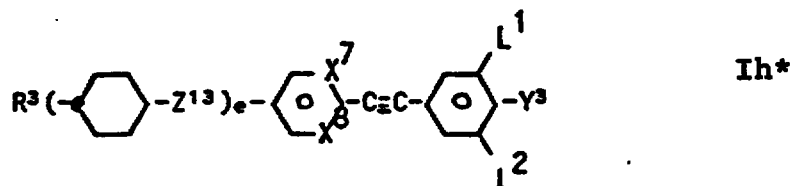
T(I)15:	Ib
	Ii
T(I)16:	If
	Ig
T(I)17:	If
	Ih
T(I)18:	If
	Ii
T(I)19:	Id
	Ie
T(I)20:	Ie
	Ig
T(I)21:	Id
	Ih
T(I)22:	Id
	Ii
T(I)23:	If
	Ic
T(I)24:	If
	Id
T(I)25:	If
	Ie

5 The person skilled in the art can straightaway make a selection from this limited group of preferred component mixtures T(I)1-T(I)22 in such a way that the liquid crystal mixture is optimized with respect to the particular application. Thus, for example, T(I)1 has a particularly high dielectric anisotropy, while the component mixture [sic] T(I)16-T(I)18 have a particularly high stability and the component mixtures T(I)4, T(I)11 and T(I)19 are characterized by relatively high clear

points. The selection of suitable component mixtures presents no difficulties to the person skilled in the art and requires no inventive assistance.

Liquid crystal mixtures which contain at least one compound each from 2 different compound classes selected from the group of compound classes Ia-Ii, and additionally at least one compound selected from the group of compounds of the formulae III1-II28, III1-III3 and IV1-IV8 are additionally particularly preferred. In this connection, liquid crystal mixtures containing one of the preferred component mixtures T(I)1-T(I)22 and a compound selected from the compounds of the formulae II1, II2, II3, II4, II5, II6, II7, II8, II9, II10, II12, II13, II16, II17, II18, II19, II20, II21, II25, II26, II27, II28, III1, III2, IV1, IV2, IV3, IV4, IV5 and IV6 are very particularly preferred.

Liquid crystal mixtures are additionally particularly preferred which, in addition to one or more compounds selected from the compound classes Ia, Ib, Ic, Id, Ie, If, Ig and Ii, and at least one compound selected from the group of compounds of the formulae II-IV, additionally contain a further compound which are [sic] selected from the group of compounds of the formula Ih*



in which

R³ [sic] is an alkyl group having 1-10 C atoms, in which a CH₂ group can also be replaced by -O- or -CH=CH-,

Z¹³ is a single bond, -COO- or -CH₂CH₂-,

X⁷ and

X⁸ independently of one another are CH or N,

L¹ and

L² independently of one another are H or F and

Y³ is F, Cl, CF₃, or OCHF₂.

The compounds of the formula Ih* include a section of the compounds of the formula Ih which have a

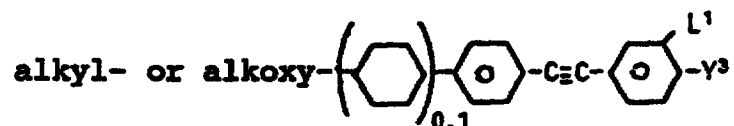
polar radical F, Cl, CF₃, OCF₃, or OCHF₂, and moreover further preferred compounds, of which the following should be explicitly mentioned:

	R ³ -Phe-C≡C-Phe.3F5F-Y ³	Ih* 2-1
5	R ³ -Pyd-C≡C-Phe.3F5F-Y ³	Ih* 2-2
	R ³ -Pyr-C≡C-Phe.3F5F-Y ³	Ih* 2-3
	R ³ -Cyc-Pyr-C≡C-Phe.3F5F-Y ³	Ih* 3-1
	R ³ -Cyc-Pyd-C≡C-Phe.(F,2)-Y ³	Ih* 3-2
	R ³ -Cyc-CH ₂ CH ₂ -Pyr-C≡C-Phe.(F,2)-Y ³	Ih* 3-3
10	R ³ -Cyc-COO-Pyd-C≡C-Phe.(F,2)-Y ³	Ih* 3-4

The preferred liquid crystal mixtures which, in addition to at least one compound of the formulae Ia-Ig and Ii and at least one compound of the formulae II-IV, contain at least one compound of the formula Ih* as a 3rd obligatory component, preferably contain one of the preferred compounds just mentioned and/or one of the preferred compounds of the formulae Ih2-1 - Ih2-2, Ih2-1a - 1h, Ih2-2a - 2c, Ih2-3a - 3c, Ih3-1 - Ih3-10, Ih3-1a - 1d, Ih3-2a - 2b, Ih3-5a, Ih3-6a - 6b and Ih4-1 - 1h4-5.

These mixtures are distinguished by a high stability and high birefringence and are particularly suitable for matrix applications and very particularly suitable for network systems.

In this case, the mass content of the compounds which are selected from the group of compounds of the formulae Ih and Ih* is preferably more than 5%, in particular not less than 7.5% and particularly than 10% and very particularly more than 20%. The 3rd obligatory component of these liquid crystal mixtures very particularly preferably contains compounds of the formula



in which the meaning of L¹ and Y³ is given above.

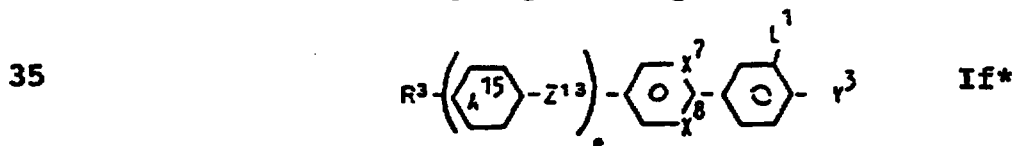
Mixtures are also particularly preferred which are based on component mixtures which contain at least one compound of the formula II, at least one compound of the formulae IV1-IV8 and at least one compound of the

formula Ih*. In this case, the following smaller sub-group of component mixtures is particularly preferred which contains at least one compound each from each of the groups E, F and G; in this case the mass content of the compounds from the respective groups in the component mixture is preferably in the mass per cent ranges given:

Group	E	F	G
Mass content in the component mixture [%]	10-80	5-65	10-50 preferably 18-50, in particular 23-50
Compounds	II1, II2, II3, II4, II5, II6, II7, II8, II9, II16, II17, II18	IV1, IV2, IV3, IV4, IV5, IV6	Ih2-1, Ih2-2, Ih2-3, Ih3-1, Ih3-2, Ih3-3, Ih3-4, Ih3-7, Ih3-8, Ih*2-1, Ih*2-2, Ih*2-3

The sum of the mass contents of the compounds from the groups E, F and G in the component mixture is 100%, and the mass content of the component mixtures in the liquid crystal mixtures which can be used according to the invention is preferably 25%-100%.

Liquid crystal mixtures are further particularly preferred which, in addition to one or more compounds selected from the compound classes Ia, Ib, Ic, Id, Ie, Ig, Ih and Ii, and at least one compound selected from the group of compounds of the formulae II-IV, additionally contains [sic] a further compound which is selected from the group of compounds of the formula If*



in which



is trans-1,4-cyclohexylene or 1,4-phenylene and the meaning of R^3 , Z^{13} , X^7 , X^8 , L^1 , e and Y^3 is given above. The compounds of the formula If* represent a smaller preferred sub-group which is selected from the compounds of the formulae IfF, IfCl and IfCl.F. The mass content of the compounds of the formula If* in at least 3-component liquid crystal mixtures of this type is preferably not less than 5%, in particular more than 10% and very particularly more than 20% and can be up to 55%. Liquid crystal mixtures of this type have advantageous properties and are characterized in particular by a high stability and favourable values of the electrooptical parameters. Liquid crystal mixtures which, in addition to at least one compound of the formulae Ia-Ie and Ig-Ii and in addition to a compound of the formulae II-IV, contain at least one of the following preferred compounds are very particularly preferred:

R^3 -Phe-Phe.(F)-F
 R^3 -Phe-Phe.(F)-Cl
 R^3 -Pyp-Phe-F
 R^3 -Pyp-Phe.3F-F
 R^3 -Pyp-Phe-Cl
 R^3 -Pyp-Phe.3F-Cl
 R^3 -Pyr-Phe-F
 R^3 -Pyr-Phe.3F-F
 R^3 -Pyr-Phe-Cl
 R^3 -Pyr-Phe-.3F-Cl

Component mixtures are particularly preferred in which

- the 1st obligatory component contains at least one compound of the formulae Ia-Ie having a mass content in the component mixture between 10% and 90%,
- the 2nd obligatory component contains one or more compounds which are selected from the group of compounds II1, II2, II3, II4, II5, II6, II7, II8,

II9, II16, II17, II18, II25, II26, II27, II28, III1, III2, IV1, IV2, IV3, IV4, IV7 and IV8, the mass content of this component in the component mixture being between 5 and 80%, and

- 5 - the 3rd obligatory component contains one or more of the abovementioned preferred 2-ring compounds and/or one or more more of the following compounds

R³-Cyc-Phe-Phe.(F)-F
 R³-Cyc-Phe-Phe.(F)-Cl
 R³-Phe-Pyr-Phe.(F)-F
 R³-Phe-Pyr-Phe.(F)-Cl
 R³-Phe-Pyr-Phe.(F)-CF₃
 R³-Phe-Pyd-Phe.(F)-F
 R³-Phe-Pyr-Phe.(F)-Cl
 R³-Phe-Pyr-Phe.(F)-OCF₃

having a mass content in the component mixture of 5%-65%, in particular 10%-65% and very particularly 12.5%-65%.

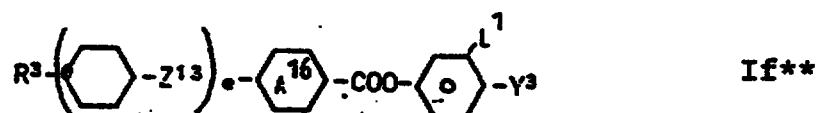
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The sum of the mass contents in the component mixture is 100%, and the mass content of the component mixture in the liquid crystal mixture is preferably 25%-100%.

15

Liquid crystal mixtures are furthermore particularly preferred which, in addition to one or more compounds selected from the group of compounds of the formula [sic] Ia-Ie and Ig-Ii and one or more compounds selected from the group of compounds of the formula [sic] II-IV, additionally contain at least one compound of the formula If**

20



in which A^{16} is trans-1,4-cyclohexylene, 1,4-phenylene or 3-fluoro-1,4-phenylene and the meaning of Z¹³, L¹, Y³, R³ and e is given above. The compounds of the formula If** represent a preferred smaller sub-group which is selected from the compounds of the formulae IfF, IfCl and

25

IfCl.F.

Liquid crystal mixtures which, in addition to a compound of the formulae Ia-Ie and Ig-Ii, contain a compound of the formulae II-IV and additionally a compound of the formula If** are characterized by preferred properties and in particular a high stability, a favourable working temperature range and advantageous threshold voltage. The mass content of compounds of the formula If** in these liquid crystal mixtures is preferably more than 5%, in particular more than 10% and very particularly more than 15%. The following smaller group of compounds of the formula If** is very particularly preferred:

R ³ -Cyc-COO-Phe.(F)-Y ³	If**2-1
R ³ -Phe-COO-Phe.(F)-Y ³	If**2-2
R ³ -Cyc-Cyc-COO-Phe.(F)-Y ³	If**3-1
R ³ -Cyc-Phe-COO-Phe.(F)-Y ³	If**3-2

The following liquid crystal mixtures which contain at least one compound each in the mass ranges mentioned from the groups H, I and K characterized in more detail in the following are additionally very particularly preferred:

Group	H	I	K
5 Mass content of the component mixture	20%-80%	10%-80%	5%-50%
10 Compounds	15 III1, II2, II3, II4, II5, II6 II7, II8, II9, II16 II17, II18, II25, II26, II27, II28, III1	Ib	If**2-1, If**2-2, If**3-1, If**3-2

20 The sum of the mass contents in the component mixtures is 100% in this case, and the mass contents of the component mixtures in the liquid crystal mixtures used according to the invention is preferably 10%-85%.

25 The liquid crystals according to the invention may contain, in addition to the compounds of the formula I according to the invention and in particular of the preferred sub-formulae and very particularly of the preferred liquid crystal mixtures, further components
30 which are preferably selected from nematic or nematogenic (monotropic or isotropic) substances, in particular substances from the classes consisting of the azoxybenzenes, benzylideneanilines, biphenyls, terphenyls, phenyl or cyclohexyl benzoates, cyclohexane-
35 carboxylic acid phenyl or cyclohexyl esters, phenyl or cyclohexyl esters of cyclohexylbenzoic acid, phenyl or cyclohexyl esters of cyclohexylcyclohexanecarboxylic acid, cyclohexylphenyl esters of benzoic acid, cyclohexanecarboxylic acid, or of cyclohexylcyclohexane-
carboxylic acid, phenylcyclohexanes, cyclohexylbiphenyls, phenylcyclohexylcyclohexanes, cyclohexylcyclohexanes, cyclohexylcyclohexenes, cyclohexylcyclohexylcyclohexenes,

1,4-bis-cyclohexylbenzenes, 4,4'-bis-cyclohexylbiphenyls, phenyl- or cyclohexylpyrimidines [sic], phenyl- or cyclohexylpyridines, phenyl- or cyclohexyldioxanes, phenyl- or cyclohexyl-1,3-dithianes, 1,2-dipheylethanes
5 [sic], 1,2-dicyclohexylethanes, 1-phenyl-2-cyclohexylethanes, 1-cyclohexyl-2-(4-phenylcyclohexyl)ethanes, 1-cyclohexyl-2-biphenylethanes, 1-phenyl-2-cyclohexylphenylethanes, optionally halogenated stilbenes, benzyl phenyl ethers, tolans and substituted cinnamic acids. The
10 1,4-phenylene groups in these compounds can also be fluorinated.

In these compounds, the two terminal groups are preferably in each case independently of one another alkyl, alkenyl, alkoxy, alkenyloxy or alkanoyloxy having
15 up to 8 carbon atoms. In most of these compounds, R' and R" are different from one another, one of these radicals usually being alkyl or alkenyl.

However, it is also possible that one and/or both terminal groups are a polar radical -CN, -NCS, -F, -Cl or
20 $(O)_iCX_kH_{3-k}$, where i is 0 or 1, k is 1, 2 or 3 and X is F or Cl. If only one of the terminal groups is one of the polar radicals mentioned, the other is preferably alkyl or alkenyl.

Many substances of this type or, alternatively, mixtures thereof are commercially available. All these
25 substances are obtainable by methods known from the literature or in analogy thereto.

The liquid crystals used in the electrooptical liquid crystal systems according to the invention preferably contain 1%-100%, in particular 10%-100% and very
30 particularly 20%-100% of compounds of the formula I. In this case, liquid crystal mixtures are preferred which contain 1-20 and in particular 1-15 compounds of the formula I. If the liquid crystal compounds of the formula
35 I are selected from only one sub-group of the formulae Ia-Ii, the liquid crystal mixture preferably contains 1-5 and in particular 1-3 compounds of this sub-formula of formula I.

The liquid crystal mixtures are preferably based

on compounds which are selected from the group of the formulae I, II, III and IV. The mass content of the compounds selected from the group of the formulae I, II, III and IV in the liquid crystal mixture is preferably 5%-100%, in particular 10%-100% and very particularly 15%-98%. The liquid crystal mixtures according to the invention preferably contain 2-40, but in particular 2-38 and very particularly 2-35 compounds, selected from the group of compounds of the formulae I, II, III, IV and V.

The dielectric anisotropy of the liquid crystal mixture used is positive $\Delta\epsilon > 0$ and preferably $\Delta\epsilon > 3$.

For smaller values of the dielectric anisotropy $\Delta\epsilon$, very high threshold voltages are observed. Particularly preferred values are $\Delta\epsilon > 5$, very particularly $\Delta\epsilon > 8$.

It has been found that liquid crystal mixtures which are based on medium polarity compounds with

$$3 \leq \Delta\epsilon \leq 20 \quad (*1)$$

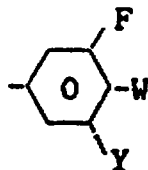
and in particular

$$3 \leq \Delta\epsilon \leq 15 \quad (*2)$$

have particularly advantageous properties and in particular a high temperature and UV stability and a high specific resistance. Mixtures of this type are particularly suitable for systems having a high information content, which are controlled using an active or passive matrix and furthermore in particular also for systems which have to tolerate relatively high operating temperatures (for example systems for outdoor applications). The mass content of medium polarity compounds in the liquid crystal mixture is preferably not less than 50%, in particular at least 60% and very particularly at least 65%.

It has in particular been shown that compounds of the formula I where $W = -F, -Cl, -CF_3, -OCF_3, -OCHF_2$ or NCS and in particular $W = -F, -Cl, -CF_3, -OCF_3$ or $-OCHF_2$ frequently have a dielectric constant in the preferred ranges (*1) or (*2), while liquid crystal compounds where $W = -CN$ frequently have an overhigh dielectric constant and are less suitable for mixtures of this type; the mass

content in compounds which have a terminal carbonitrile group in the liquid crystal mixtures based on medium polarity compounds is preferably less than 15% and in particular not more than 10%. If highly polar additives with $\Delta\epsilon > 20$ are necessary, for example for reducing the threshold voltage, compounds are preferably used in which one terminal group has the meaning given for R^1 while the other terminal group is given by



where

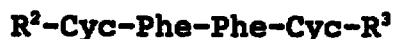
- 10 W is -F, -Cl, -CF₃, -OCF₃, or -OCHF₃, and
 Y is H or F.

Compounds where W = -Cl are as a rule characterized by a higher birefringence Δn in comparison to corresponding compounds where W = -F and are therefore often preferred if a high birefringence is desired, for example for increasing the scattering in the opaque state.

The present invention makes available to the person skilled in the art a limited pool of particularly preferred compounds of the formula I and in particular of the formulae Ia-Ii and particularly preferred liquid crystal component mixtures. Liquid crystal mixtures which contain one or more compounds of the formula I and in particular of the formulae Ia-Ii and very particularly at least one of the component mixtures mentioned have advantageous properties and correspond to the requirements described at the beginning, which are set for use in an electrooptical system according to the preamble of Claim 1, to a particularly high extent and very much better than the liquid crystal mixtures hitherto used in these systems. In this case, on the basis of the detailed description the person skilled in the art can at any time make a selection from the described pool of preferred liquid crystal compounds and liquid crystal component mixtures without inventive assistance in such a way that

the birefringence Δn and/or the ordinary refractive index n_o and/or other refractive indices and/or the viscosity and/or the dielectric anisotropy and/or the clear point and/or additional parameters of the liquid crystal and/or
5 the threshold voltage and/or further electrooptical parameters of the system and/or their temperature dependence and/or the working temperature range and/or the solubility of the liquid crystal in the monomers or oligomers for polymerizing and/or in the cured matrix or
10 the cured network and/or further parameters of the liquid crystal and the system with respect to the particular application are optimized.

If, for example, a high clear point is necessary, the person skilled in the art will preferably make a
15 selection among the compounds of the formula I and in particular the sub-formulae Ia-Ii and the preferred component mixtures such that the mass content of 2-ring compounds in the liquid crystal mixture is not too high. In addition, the person skilled in the art can also add,
20 for example, 4-ring compounds of the formula [sic] Ie4-1 - Ie4-4 or, alternatively, other highly clearing substances such as, for example,



25 to the liquid crystal.

In these compounds, R^2 and R^3 are in each case independently of one another preferably alkyl, methoxy, alkoxycarbonyl or alkanoyloxy having 1-15 C atoms.

Additives of this type are known to the person
30 skilled in the art and he can choose from the substance classes enumerated above without problem. In this connection, the person skilled in the art will preferably choose the concentration of additives of this type in such a way that in particular Δn and/or n_o and/or another
35 refractive index and/or $\Delta\epsilon$ to be adjusted in the particular embodiment of the electrooptical system according to the invention and/or $\Delta\epsilon$ and/or further physical parameters important for the particular application are only influenced to an acceptable and/or small and/or in

particular negligible extent.

If the system according to the invention is controlled, for example using an alternating voltage, the use of a highly viscous liquid crystal mixture is necessary, as otherwise, in particular at low to medium frequencies, a flickering display results. In order to increase the viscosity, the person skilled in the art can add highly viscous liquid crystal compounds to the liquid crystal mixture. These compounds are preferably selected from the group of compounds of the formula I and in particular of the formulae Ia-Ii, but they can also be taken from the abovementioned substance classes. In particular, one or more side chain polymers can also be added to increase the viscosity, as is described in DE 3,919,942. If, on the other hand, the electrooptical system is used, for example, as a matrix display having a high information content, low viscosity liquid crystal mixtures are suitable in particular for achieving small switch times.

The person skilled in the art will in this case preferably make a selection from the group of compounds of the formula I and in particular of the formulae Ia-Ii in such a way that the content of 3- and 4-ring compounds is not too high; if the use of a high content of 3- and 4-ring compounds is necessary for achieving a high clear point, the person skilled in the art will in general prefer laterally fluorinated or chlorinated compounds of the formulae Ia-Ii. However, it is also possible for the person skilled in the art to choose from the substance classes enumerated above those with low viscosity, such as, for example



and to add them to the liquid crystal mixture according to the invention. R^2 and R^3 in this compound mentioned by way of example preferably have the abovementioned meanings.

The person skilled in the art will select the substances used for modifying the viscosity and their concentration such that other crucial parameters of the

liquid crystal mixture such as, for example, $\Delta\epsilon$ and, when using viscosity-reducing agents, in particular T_0 , is only influenced to an acceptable and/or small and/or insignificant extent.

- 5 If desired, highly nematogenic substances such as, for example



- can be added, the person skilled in the art taking into account that other parameters and in particular the solubility of the liquid crystal mixture in the polymer used for the matrix is not to be too greatly altered by additions of this type.
- 10

- In the case of liquid crystal mixtures which contain compounds of the formulae II-IV, for example, in order to modify the birefringence the person skilled in the art can vary the relative content of these compounds in the mixture; for mixtures having very high A_n , compounds of the formulae III1, III6, IV3 or IV4 for example, can in particular be used, while, for example, compounds of the formulae III1-III3 are preferred for liquid crystal mixtures having relatively low values of A_n . The person skilled in the art can of course also make a preferred selection from the compounds of the formula I with respect to the desired value of A_n without problem. Thus, for example, compounds of the formula Ig are in general particularly preferred for mixtures having a relatively high or high A_n , while compounds having 2 or more saturated ring systems are in general particularly suitable [lacuna] liquid crystal mixtures according to the invention having relatively low or low values of A_n .
- 15
- 20
- 25

- In order to achieve low threshold voltages, liquid crystal mixtures having a very high dielectric anisotropy $\Delta\epsilon$ are in general required. The person skilled in the art can make a selection from the group of compounds of the formula I, in particular of the formulae Ia-II, and furthermore from the group of compounds of the formulae II-IV and from the group of preferred component
- 30
- 35

mixtures in such a way that a preferred value is obtained for $\Delta\epsilon$. In order to increase $\Delta\epsilon$, the person skilled in the art can add to the liquid crystal mixture, for example, a compound of the formula II6. These compounds
5 are extremely strongly dielectrically positive; the propyl homologue (alkyl = C_3H_7) has, for example, a value of $\Delta\epsilon = 50$. The person skilled in the art will select the concentration of additives of this type so that the liquid crystal mixture is optimally suited to the particular embodiment of the electrooptical system; in
10 particular, he will take care that Δn and/or n_o and/or one or more further refractive indices of the liquid crystal are only influenced to an acceptable and/or small and/or negligible extent.

15 The person skilled in the art can modify and, within certain limits, optimize the properties of liquid crystal mixtures according to the invention with respect to the particular application by making a selection from the group of compounds of the formula I and in particular
20 of the formulae Ia-Ii, and furthermore optionally from the group of compounds of the formulae II-IV and the group of preferred component mixtures such that the liquid crystal mixture is optimized with respect to the particular application.

25 However, it is crucial that liquid crystals containing compounds of the formula I and in particular of the formulae Ia-Ii and in particular those liquid crystal mixtures which contain one or more compounds of the formulae II-IV are particularly suitable for use in
30 electrooptical liquid crystal systems according to the invention. Very particularly suitable liquid crystal mixtures are those which contain one or more of the preferred component mixtures.

35 The liquid crystal mixtures according to the invention, which contain one or more compounds of the formula I and in particular of the formulae Ia-Ii, also represent particularly suitable "stable structure mixtures" for application in electrooptical systems, which can in general be optimized by the methods and/or

additives described with respect to specific requirements without other parameters of the mixture at the same time undergoing too drastic a change and the utility of the mixture in the electrooptical systems undergoing considerably damaging change.

The liquid crystal mixtures according to the invention are particularly suitable for use in electrooptical systems according to the preamble of Claim 1. Considerable commercial importance is thus ascribed to the liquid crystals according to the invention and to the electrooptical systems according to the invention.

The liquid crystal mixtures according to the invention can be modified by further additives in such a way that they can be used in all electrooptical systems according to the preamble of Claim 1.

Additives of this type are known to the person skilled in the art and are described in detail in the literature. Thus, for example, pleochroitic dyes can be added for the preparation of coloured electrooptical systems or substances can be added to change the dielectric anisotropy, the optical anisotropy, the viscosity and/or the temperature dependence of electrooptical parameters of the liquid crystals. Substances of this type are described, for example, in H. Kelker and R. Hatz, Handbook of Liquid Crystals, Verlag Chemie, Weinheim, 1980 and in DE-OS 2,209,127, 2,240,864, 2,321,632, 2,338,281, 2,450,088, 2,637,430, 2,853,728 and 2,902,177.

Electrooptical liquid crystal systems in which pleochroitic dyes are added to the liquid crystal in a per cent by weight range of 0-25%, in particular 0-20% and very particularly 0-15% are preferred.

In addition, chiral mesogenic or, alternatively, non-mesogenic compounds can be added to the liquid crystal mixtures according to the invention to increase the scattering in the opaque state and/or to influence the slope of the electrooptical curve, as is described, for example, in DE 4,007,039. Liquid crystals according to the invention which contain 0-15% and in particular

0-10% of chiral additives are preferred.

The electrooptical liquid crystal systems according to the invention can be switched on by applying a direct or alternating voltage. However, an alternating voltage is preferably used which has an effective alternating voltage amplitude between 1 and 240 volts and an alternating voltage frequency between 10 Hz and 10 kHz. Amplitudes between 2 and 220 volts and frequencies between 20 and 120 Hz are particularly preferred. The amplitude of the alternating voltage is very particularly preferably between 2 and 130 V.

The liquid crystal mixtures which can be used according to the invention are prepared in a manner customary per se. As a rule, the desired amount of the components used in the smaller amount is dissolved in the components making up the main component, expediently at elevated temperature. It is also possible to mix solutions of the components in an organic solvent, for example in acetone, chloroform or methanol, and to remove the solvent again after thorough mixing, for example by distillation.

The following examples are intended to illustrate the invention without limiting it.

The symbols have the following meaning:

- 25 K: crystalline solid state,
S: smectic phase (the index characterizes the phase type),
N: nematic phase,
I: isotrope phase.

30 The number between 2 symbols gives the transition temperature in degrees Celsius.

The percentage data given are percentages by weight.

Example 1

- 35 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20 %	p-trans-4-pentylcyclohexylbenzonitrile
	12 %	p-trans-4-heptylcyclohexylbenzonitrile
5	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
10	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	20 %	1-(4-(4-pentylphenyl)phenyl)-2-(3-fluoro-4-cyanophenyl)ethane

b) The electrooptical liquid crystal system is prepared by various processes 1.1-1.3 and 2.

1. Microdroplets matrix systems

1.1 The liquid crystal mixture from a) is stirred at room temperature with the adhesive NOA 65 (Norland Products) which can be cured by UV irradiation in the ratio 1.6:1 until a clear solution is obtained, which is put, together with spacers (20 μ m), between 2 transparent glass substrates provided with electrode layers. The glass substrates are pressed together whereby a uniform film having a thickness of 20 μ m is obtained which is cured by UV irradiation for 1 minute.

1.2 The liquid crystal mixture from a) is stirred at room temperature with Epikote 828 and Capcure 3-800 (Miller Stephenson Company) in the ratio 1:1:1 until a clear solution is obtained; the stirring time is kept as brief as possible, as the solution is already cured after about 1/2 h at room temperature. The solution is put, together with spacers (20 μ m), between 2 transparent glass substrates provided with electrode layers, which are pressed together whereby a uniform film having a thickness of 20 μ m is ob-

tained. The films can be heated to temperatures up to 100°C in order to accelerate the curing process.

1.3 5 g of the liquid crystal mixture from a) are stirred at 2,000 rpm at room temperature for 2 minutes with 15 g of 20% aqueous PVA solution. The solution obtained is degassed for 24 h and applied in a thin layer, together with spacers (20 μ m), to a glass substrate provided with an electrode layer. The arrangement is dried at 85°C for 1 h, prior to applying a second glass substrate provided with an electrode layer, whereby a uniform film having a thickness of 20 μ m is obtained. The system thus obtained is dried at 85°C for a further 24 h.

2. Network system

The liquid crystal mixture from a) is stirred with trimethylolpropane triacrylate as a polymerizable compound and 2-hydroxy-2-methyl-1-phenylpropan-1-one (Darocure 1173, commercial product of E. Merck, Darmstadt) as a photoinitiator in the ratio 80 : 19.8 : 0.2 and put between two glass plates provided with electrode layers with addition of spacers having a thickness of 20 μ m. In order to cure the polymer, the system obtained was passed through the field of radiation of a halogen lamp (70 W/cm) at a defined rate (3 m/min).

The electrooptical systems prepared according to processes b) 1.1-1.3 and 2 are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 2

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	9 %	p-trans-4-propylcyclohexylbenzonitrile
	7 %	p-trans-4-butylcyclohexylbenzonitrile
	12.5%	p-trans-4-pentylcyclohexylbenzonitrile
	7.5%	p-trans-4-heptylcyclohexylbenzonitrile
5	3.5%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	8 %	4-pentyl-4"-cyanoterphenyl
	4 %	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
10	11 %	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	3.5%	1-(4-(4-pentylphenyl)phenyl)-2-(4-cyanophenyl)ethane
	3.5%	1-(4-(4-pentylphenyl)phenyl)-2-(3-fluoro-4-cyanophenyl)ethane
15	3.5%	1-(4-(4-propylphenyl)phenyl)-2-(3-fluoro-4-cyanophenyl)ethane
	2.5%	4-propyl-4'-cyanobiphenyl
	7.5%	4-ethyl-4'-cyanobiphenyl
20	17 %	4-pentyl-4'-cyanobiphenyl

and has the following physical paramters [sic]:

	clear point	$T_c = 93^\circ\text{C}$
	viscosity	$\eta = 38 \text{ mm}^2 \text{ S}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.20 (20^\circ\text{C}, 589 \text{ nm})$
25	dielectric anisotropy	$\Delta\epsilon = 15,2 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, 1.1-1.3 and 2.

Example 3

- 30 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

11% 4-ethyl-4'-cyanobiphenyl
5% 4-propyl-4'-cyanobiphenyl

- 10% 4-heptyl-4'-cyanobiphenyl
37% 4-pentyl-4'-cyanobiphenyl
12% 4-octoxy-4'-cyanobiphenyl
15% 4-pentyl-3",5"-difluoro-4"-cyanoterphenyl
5 10% 4-pentyl-3',5'-difluoro-4"-cyanoterphenyl
and has the following physical parameters:

dielectric anisotropy $\Delta\epsilon = 20.0$ (20°C, 1 kHz)
optical anisotropy $\Delta n = 0.233$ (20°C [sic],
589 nm)

- 10 b) The electrooptical liquid crystal system is prepared
by the processes described in Example 1, 1.1-1.3
and 2.

Example 4

- 15 a) An electrooptical liquid crystal system, containing
a liquid crystal mixture which consists of the
following compounds:

- 28% 2-(4-cyanophenyl)-5-ethylpyridine
28% 2-(4-cyanophenyl)-5-propylpyridine
29% 2-(4-cyanophenyl)-5-pentylpyridine
20 15% 4-pentyl-3",5"-difluoro-4"-cyanoterphenyl

- b) The electrooptical liquid crystal system is prepared
by the processes described in Example 1, b).

Example 5

- 25 a) An electrooptical liquid crystal system, containing
a liquid crystal mixture which consists of the
following compounds:

- 19% 2-(4-cyanophenyl)-5-ethylpyridine
19% 2-(4-cyanophenyl)-5-butylpyridine
19% 2-(4-cyanophenyl)-5-pentylpyridine
30 19% 4-pentyl-2-fluoro-4'-cyanobiphenyl
12% 1-(4-(4-pentylphenyl)phenyl)-2-(3-fluoro-4-
cyanophenyl)ethane

12% 4-pentyl-4'-cyanoterphenyl

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, b).

Example 6

- 5 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

20% 2-(4-cyanophenyl)-5-ethylpyrimidine
20% 2-(4-cyanophenyl)-5-propylpyrimidine
10 20% 2-(4-cyanophenyl)-5-pentylpyrimidine
20% 4-pentyl-3",5"-difluoro-4"-cyanoterphenyl
20% 4-pentyl-4'-cyanobiphenyl'

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, b).

15 Example 7

- a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds:

20 20 % 1-(trans-4-(trans-4-propylcyclohexyl)cyclohexyl)-2-(3-fluoro-4-cyanophenyl)ethane
14.4% p-trans-4-propylcyclohexylbenzonitrile
11.2% p-trans-4-butylcyclohexylbenzonitrile
20 % p-trans-4-pentylcyclohexylbenzonitrile
25 [sic]
12 % p-trans-4-heptylcyclohexylbenzonitrile
5.6% 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
4.8% 4-pentyl-4"-cyanoterphenyl
30 6.4% 4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
5.6% 4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 8

- 10 a) A liquid crystal mixture consisting of
- 43% 4-pentyl-4'-cyanobiphenyl
17% 4-propoxy-4'-cyanobiphenyl
13% 4-pentoxy-4'-cyanobiphenyl
17% 4-octoxy-4'-cyanobiphenyl
10% 4-pentyl-4"-cyanoterphenyl
- has the following physical data:
- 15 birefringence $\Delta n = 0.246$ (20°C, 589 nm)
threshold voltage $V[90.0.20] = 1.44$ V

The threshold voltage was measured in a TN cell (twist angle $\Psi = \pi/4$) which has a cell clearance of $d = 7 \mu\text{m}$ and is located between crossed polarizers.

- 20 b) A liquid crystal mixture consisting of
- 30% 4-pentyl-4'-cyanobiphenyl
15% 4-ethyl-4'-cyanobiphenyl
20% 4-(propylphenyl)-3-fluoro-4'-cyanobiphenyl
10% 4-propyl-2-fluoro-4'-cyanobiphenyl
25 15% 4-pentyl-2-fluoro-4'-cyanobiphenyl
10% 4-pentyl-4"-fluoro-4"-cyanoterphenyl
- has the following physical characteristics:

birefringence $\Delta n = 0.246$
threshold voltage $V[90.0.20] = 1.26$ V

- 30 The threshold voltage was measured in a TN cell (twist angle $\Psi = \pi/4$) which has a cell clearance of

$d = 7 \mu\text{m}$ and is located between crossed polarizers.

The advantageous properties of the mixtures according to the present invention are clear from a comparison of the results of Examples 8a) and b).

- 5 c) Electrooptical systems were prepared by the processes described in Example 1b) using the mixtures from Examples 8a) and b). The system prepared with the liquid crystal mixture from Example 8b) has more advantageous properties than the system prepared
10 with the mixture from 8a) and is in particular distinguished by a lower threshold voltage.

Example 9

- a) A liquid crystal mixture consisting of

- 20% 4-(trans-4-pentylcyclohexyl)benzonitrile
15 15% 4-pentyl-4'-cyanobiphenyl
15% 4-ethyl-4'-cyanoterphenyl
5% 4-pentyl-4"-cyanoterphenyl
15% 4-(4-propylphenyl)-3-fluoro-4'-cyanobiphenyl
10% 4-propyl-2-fluoro-4'-cyanobiphenyl
20 15% 4-pentyl-2-fluoro-4'-cyanobiphenyl
5% 4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl

has the following physical characteristics:

- birefringence $\Delta n = 0.218$ (20°C, 589 nm)
ordinary refractive index $n_o = 1.522$ (20°C, 589 nm)
25 dielectric anisotropy $\Delta\epsilon = 16.71$ (20°C, 1 kHz)
threshold voltage $V[90.0.20] = 1.33 \text{ V}$

The threshold voltage was measured in a TN cell (twist angle $\varphi = \pi/4$) which has a cell clearance of $d = 7 \mu\text{m}$ and is located between crossed polarizers.

- 30 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide

working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

5 Example 10

a) A liquid crystal mixture consisting of

	12 %	4-ethyl-4-cyanobiphenyl	
	4 %	4-propyl-4-cyanobiphenyl	
	29.6%	4-pentyl-4-cyanobiphenyl	
10	8.8%	4-propoxy-4-cyanobiphenyl [sic]	
	8.0%	4-pentyl-4"-cyanoterphenyl	
	20.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobi-phenyl	
	5.6%	4-(4-cyanophenyl)phenyl	4-(4-heptyl-phenyl)phenylcarboxylates
15	12 %	4-(trans-4-pentylcyclohexyl)-4'-cyanobi-phenyl	

has the following physical characteristics:

	birefringence	$\Delta n = 0.286$ (20°C, 589 nm)
20	ordinary refractive index n_o	$= 1.530$ (20°C, 589 nm)
	dielectric anisotropy	$\Delta \epsilon = 13.5$ (20°C, 1 kHz)
	threshold voltage	$V[90.0.20] = 1.66$ V
	extinction co-efficient	$\gamma = 1.629$ for $\lambda = 350$ nm
25		$\gamma = 0.130$ for $\lambda = 360$ nm
		$\gamma = 0.006$ for $\lambda = 370$ nm

clear point N 113 I

The extinction coefficient is determined according to

$$\gamma = \frac{A}{l \cdot C_v}$$

where A is the absorption, l is the thickness of the liquid crystal layer crossed by the light in cm and C_w is the mass of the liquid crystal in g per 100 ml of solution.

5 The threshold voltage was measured as indicated in Example 9a).

10 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 11

a) A liquid crystal mixture consisting of

15	14.0%	4-ethyl-4-cyanobiphenyl	
	5.0%	4-propyl-4-cyanobiphenyl	
	33.0%	4-pentyl-4-cyanobiphenyl	
	12.0%	4-propoxy-4-cyanobiphenyl [sic]	
	10.0%	4-pentyl-4"-cyanoterphenyl	
20	23.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobiphenyl	
	3.0%	4-(4-cyanophenyl)phenyl	4-(4-heptylphenyl)phenylcarboxylates

has the following physical characteristics:

25	birefringence	$\Delta n = 0.287$ (20°C, 589 nm)
	ordinary refractive index n_o	$= 1.533$ (20°C, 589 nm)
	dielectric anisotropy	$\Delta \epsilon = 14.1$ (20°C, 1 kHz)
	threshold voltage	$V[90.0.20] = 1.60$ V
	clear point N 96 I	

30 The threshold voltage was measured as indicated in Example 9a).

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 12

- a) A liquid crystal mixture consisting of
- | | | | |
|----|-------|---|---------------------------------------|
| 10 | 35.0% | 4-pentyl-4'-cyanobiphenyl | |
| | 12.0% | 4-propoxy-4'-cyanobiphenyl | |
| | 14.0% | 4-pentoxy-4'-cyanobiphenyl | |
| | 6.0% | 4-pentyl-4''-cyanoterphenyl | |
| | 23.0% | 4-(4-propylphenyl)-3-fluoro-4'-cyanobi-phenyl | |
| 15 | 3.0% | 4-(4-cyanophenyl)phenyl | 4-(4-heptyl-phenyl)phenylcarboxylates |
| | 7.0% | 4-octoxy-4'-cyanobiphenyl | |

has the following physical characteristics:

- | | | |
|----|---------------------------------|--|
| 20 | birefringence | $\Delta n = 0.280$ (20°C, 589 nm) |
| | ordinary refractive index n_o | $= 1.527$ (20°C) |
| | dielectric anisotropy | $\Delta \epsilon = 13.0$ (20°C, 1 kHz) |
| | threshold voltage | $V[90.0.20] = 1.71$ V |
| | clear point | N 97 I |

- 25 The threshold voltage was measured as indicated in Example 9a).

- 30 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 13

a) A liquid crystal mixture consisting of

5	32.0%	4-pentyl-4'-cyanobiphenyl	
	12.0%	4-propoxy-4'-cyanobiphenyl	
	13.0%	4-pentoxy-4'-cyanobiphenyl	
	8.0%	4-pentyl-4''-cyanoterphenyl	
	22.0%	4-(4-propylphenyl)-4-fluoro-4'-cyanobiphenyl	
10	3.0%	4-(4-cyanophenyl)phenyl	4-(4-heptylphenyl)phenylcarboxylates
	5.0%	4-octoxy-4'-cyanobiphenyl	
	5.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl	

has the following physical characteristics:

15 birefringence $\Delta n = 0.284$ (20°C, 589 nm)
 ordinary refractive index $n_o = 1.526$ (20°C, 589 nm)
 clear point N 108 I

20 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 14

25 a) A liquid crystal mixture consisting of

	33.0%	4-pentyl-4'-cyanobiphenyl	
	12.0%	4-propoxy-4'-cyanobiphenyl	
	14.0%	4-pentoxy-4'-cyanobiphenyl	
	10.0%	4-pentyl-4''-cyanoterphenyl	
	23.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobiphenyl	
30	3.0%	4-(4-cyanophenyl)phenyl	4-(4-heptylphenyl)phenylcarboxylates

5.0% 4-octoxy-4'-cyanobiphenyl

has the following physical characteristics:

birefringence $\Delta n = 0.288$ (20°C, 589 nm)
ordinary refractive index $n_o = 1.528$ (20°C, 589 nm)
clear point N 105 I

5

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

10

Example 15

- a) A liquid crystal mixture consisting of

	30%	4-hexyl-4'-cyanobiphenyl
15	10.0%	4-pentoxy-4'-cyanobiphenyl
	7.0%	4-octoxy-4'-cyanobiphenyl
	5.0%	4-pentyl-4'-cyanoterphenyl
	15.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobi- phenyl
20	5.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
	8.0%	1-propoxy-trans-4-(trans-4-propylcyclo- hexyl)cyclohexane
	20.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl

25

has the following physical characteristics:

birefringence $\Delta n = 0.2293$ (20°C, 589 nm)
ordinary refractive index $n_o = 1.5151$ (20°C, 589
nm)
clear point N 102 I

30

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide

working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

5 **Example 16**

a) A liquid crystal mixture consisting of

	32.0%	4-pentyl-4'-cyanobiphenyl	
	12.0%	4-propoxy-4'-cyanobiphenyl	
	13.0%	4-pentoxy-4'-cyanobiphenyl	
10	6.0%	4-pentyl-4"-cyanoterphenyl	
	23.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobi- phenyl	
	3.0%	4-(4-cyanophenyl)phenyl	4-(4-heptyl- phenyl)phenylcarboxylates
15	5.0%	4-octoxy-4'-cyanobiphenyl	
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl	

has the following physical characteristics:

	birefringence	$\Delta n = 0.283$ (20°C, 589 nm)
20	ordinary refractive index n_o	$= 1.564$ (20°C, 589 nm)
	dielectric anisotropy	$\Delta \epsilon = 12.8$ (20°C, 1 kHz)
	threshold voltage	$V[90.0.20] = 1.73$ V
	clear point	N 108 I

25 The threshold voltage is measured by the process indicated in Example 9a).

30 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 17

a) A liquid crystal mixture consisting of

	10.0%	4-pentoxy-4'-cyanobiphenyl
	7.0%	4-octoxy-4'-cyanobiphenyl
	31.0%	4-hexyl-4'-cyanobiphenyl
	12.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
5	20.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl
	15.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobi- phenyl
	5.0%	4-pentyl-4"-cyanoterphenyl

10 has the following physical characteristics:

	birefringence	$\Delta n = 0.2373$ (20°C, 589 nm)
	ordinary refractive index n_o	$= 1.5183$ (20°C, 589 nm)
	dielectric anisotropy	$\Delta \epsilon = 14.0$
15	clear point N 105 I	

20 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 18

a) A liquid crystal mixture consisting of

	20.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
25	15.0%	4-(trans-4-propylcyclohexyl)benzonitrile
	10.0%	4-(trans-4-butylcyclohexyl)benzonitrile
	10.0%	4-pentyl-4'-cyanobiphenyl
	10.0%	4-ethyl-4'-cyanobiphenyl
	7.0%	4-propyl-4'-cyanobiphenyl
30	10.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl
	10.0%	4-(4-propylcyclohexyl)-3-fluoro-4'-cyano- biphenyl
	8.0%	4-pentyl-4"-cyanoterphenyl

has the following physical characteristics:

birefringence $\Delta n = 0.2042$ (20°C, 589 nm)
ordinary refractive index $n_o = 1.5132$ (20°C, 589 nm)
5 dielectric anisotropy $\Delta \epsilon = 14.8$ (20°C, 1 kHz)
clear point N 81 I

b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.
10

Example 19

a) A liquid crystal mixture consisting of

15 30.0% 4-pentyl-4'-cyanobiphenyl
15.0% 4-ethyl-4'-cyanobiphenyl
20.0% 4-(4-propylphenyl)-3-fluoro-4'-cyanobi-
phenyl
10.0% 4-propyl-2-fluoro-4'-cyanobiphenyl
20 15.0% 4-pentyl-2-fluoro-4'-cyanobiphenyl
10.0% 4-pentyl-3"-fluoro-4"-cyanoterphenyl

has the following physical characteristics:

birefringence $\Delta n = 0.246$ (20°C, 589 nm)
threshold voltage $V[90.0.20] = 1.26$ V
25 clear point N 62 I

The threshold voltage is measured by the process indicated in Example 9a).

b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature
30

dependence and in particular by a low threshold voltage.

Example 20

a) A liquid crystal mixture consisting of

5	25.0%	4-pentyl-4'-cyanobiphenyl
	15.0%	4-ethyl-4'-cyanobiphenyl
	18.0%	4-(4-propylphenyl)-3-fluoro-4'-cyanobi- phenyl
	10.0%	4-propyl-2-fluoro-4'-cyanobiphenyl
10	10.0%	4-pentyl-2-fluoro-4'-cyanobiphenyl
	10.0%	4-pentyl-3",5"-difluoro-4"-cyanoterphenyl
	6.0%	4-nonyl-3"-fluoro-4"-cyanoterphenyl
	6.0%	1-[trans-4-(trans-4-propylcyclohexyl)cy- clohexyl]-2-[4-(4-cyanophenyl)phenyl]eth- ane
15		

has the following physical characteristics:

	birefringence	$\Delta n = 0.258$ (20°C, 589 nm)
	threshold voltage	$V[90.0.20] = 1.33$ V
	dielectric anisotropy	$\Delta \epsilon = 19.7$ (20°C, 1 kHz)
20	clear point N 82 I	

The threshold voltage is measured by the process indicated in Example 9a).

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 21

- 30 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
5	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
10	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	20 %	2-(3-fluoro-4-cyanophenyl)-5-pentylpyrimidine

has the following physical parameters:

15	viscosity	$\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.15 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$\Delta \epsilon = 17.8 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 22

- 25 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
30	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl

	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
5	20 %	2-(4-cyanophenyl)-5-propylpyridine

and has the following physical parameters:

	clear point	$T_c = 80^\circ\text{C}$
	viscosity	$\eta = 33 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.16 (20^\circ\text{C}, 589 \text{ nm})$
10	dielectric anisotropy	$\Delta\epsilon = 15.5 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 23

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.5%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
25	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
30	4.8%	4-pentyl-4"-cyanoterphenyl
	20 %	2-(4-cyanophenyl)-5-pentylpyrimidine

and has the following physical parameters:

clear point $T_c = 82^\circ\text{C}$
viscosity $\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.16 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 16.1 (20^\circ\text{C}, 1 \text{ kHz})$

- 5 b) The electrooptical systems prepared by the processes
described in Example 1b) are distinguished by a wide
working temperature range, favourable values for the
electrooptical parameters and their temperature
dependence and in particular by a low threshold
10 voltage.

Example 24

- a) An electrooptical liquid crystal system, containing
a liquid crystal mixture which consists of the
following compounds:
- | | | |
|----|------|---|
| 15 | 17% | 1-difluoromethoxy-2-fluoro-4-[trans-4-(trans-4-ethylcyclohexyl)cyclohexyl]-benzene |
| | 17% | 1-difluoromethoxy-2-fluoro-4-[trans-4-(trans-4-butylcyclohexyl)cyclohexyl]benzene |
| 20 | 17% | 1-difluoromethoxy-2-fluoro-4-[trans-4-(trans-4-pentylcyclohexyl)cyclohexyl]-benzene |
| | 11% | 1-difluoromethoxy-4-[trans-4-(trans-4-pentylcyclohexyl)cyclohexyl]benzene |
| 25 | 6 % | 1-(trans-4-propylcyclohexyl)-2-(4-difluoromethoxyphenyl)ethane |
| | 6 % | 1-(trans-4-pentylcyclohexyl)-2-(4-difluoromethoxyphenyl)ethane |
| 30 | 6 % | 1-difluoromethoxy-4-(trans-4-pentylcyclohexyl)benzene |
| | 8 % | 4-propyl-4'-difluoromethoxybiphenyl |
| | 12 % | 4-(trans-4-propylcyclohexyl)-4'-difluoromethoxybiphenyl |

35 and has the following physical parameters:

clear point $T_c = 87^\circ\text{C}$
viscosity $\eta = 19 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.0985 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 6.3 (20^\circ\text{C}, 1 \text{ kHz})$

- 5 b) The electrooptical liquid crystal system is prepared by the process [sic] described in Example 1b), 1.1-1.3 and 2.

10 The electrooptical systems prepared by process [sic] b) 1.1-1.3 and 2 are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a low threshold voltage and a good contrast and in particular a high stability.

15 Example 25

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

20% 2-(4-cyanophenyl)-5-propylpyridine
20 20% 2-(4-cyanophenyl)-5-butylpyridine
20% 2-(4-cyanophenyl)-5-pentylpyridine
25% 4-pentyl-4'-cyanobiphenyl
15% 4-pentyl-4"-cyanoterphenyl

- 25 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

30 Example 26

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

- 20% 2-(4-cyanophenyl)-5-propylpyridine
20% 2-(4-cyanophenyl)-5-butylpyridine
20% 2-(4-cyanophenyl)-5-pentylpyridine
20% 4-pentyl-2-fluoro-4'-cyanobiphenyl
5 10% 1-(4-(4-pentylphenyl)phenyl)-2-(3-fluoro-4-cyanophenyl)ethane
10% 4-pentyl-4'-cyanoterphenyl
- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.
- 10

Example 27

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

5 30% 2-(4-cyanophenyl)-5-propylpyridine
 30% 2-(4-cyanophenyl)-5-butylpyridine
 20% 2-(4-cyanophenyl)-5-pentylpyridine
 10% 2-(4-cyanophenyl)-5-(4-pentylphenyl)pyridine
 10% 1-(4-(5-pentylpyridin-2-yl)phenyl)-2-(3-fluoro-
10 4-cyanophenyl)ethane

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature
15 dependence and in particular by a low threshold voltage.

Example 28

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the
20 following compounds:

 30% 2-(4-cyanophenyl)-5-propylpyridine
 30% 2-(4-cyanophenyl)-5-butylpyridine
 20% 2-(4-cyanophenyl)-5-pentylpyridine
 10% 1-(4-(4-pentylphenyl)phenyl)-2-(3-fluoro-4-
25 cyanophenyl)ethane
 10% 1-(4-pentylphenyl)-2-(4-(4-cyanophenyl)phenyl)-
 ethane

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide
30 working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 29

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:
- 5 20% 2-(4-cyanophenyl)-5-ethylpyrimidine
 20% 2-(4-cyanophenyl)-5-propylpyrimidine
 20% 2-(4-cyanophenyl)-5-pentylpyrimidine
 20% 4-pentyl-3",5"-difluoro-4"-cyanoterphenyl
 20% 2-fluoro-4-pentyl-4'-cyanobiphenyl
- 10 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold
- 15 voltage.

Example 30

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
- 20 10.0% 2-(4-cyanophenyl)-5-propyl-1,3-dioxane
 15.0% 2-(4-cyanophenyl)-5-butyl-1,3-dioxane
 15.0% 2-(4-cyanophenyl)-5-pentyl-1,3-dioxane
 20.0% 4-(trans-4-propylcyclohexyl)benzonitrile
 15.0% 4-(trans-4-pentylcyclohexyl)benzonitrile
- 25 10.0% 4-(trans-4-heptylcyclohexyl)benzonitrile
 5.0% 4-(trans-4-propylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
 5.0% 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-pentylcyclohexyl)biphenyl
- 30 5.0% 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

and has the following physical characteristics:

clear point

$T_c = 76^\circ\text{C}$

viscosity $\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
 optical anisotropy $\Delta n = 0.131 (589 \text{ nm}, 20^\circ\text{C})$
 dielectric anisotropy $\Delta\epsilon = 17 (1 \text{ kHz}, 20^\circ\text{C})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

10 Example 31

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15.0%	2-(4-cyanophenyl)-5-propyl-1,3-dioxane
15	10.0%	2-(4-cyanophenyl)-5-butyl-1,3-dioxane
	15.0%	2-(4-cyanophenyl)-5-pentyl-1,3-dioxane
	15.0%	2-(4-cyanophenyl)-5-propylpyridine
	15.0%	2-(4-cyanophenyl)-5-butylpyridine
	15.0%	2-(4-cyanophenyl)-5-pentylpyridine
20	5.0%	4-(trans-4-propylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	5.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-pentylcyclohexyl)biphenyl
25	5.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

and has the following physical parameters:

clear point $T_c = 68^\circ\text{C}$
 viscosity $\eta = 45 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
 optical anisotropy $\Delta n = 0.131 (20^\circ\text{C}, 589 \text{ nm})$
 dielectric anisotropy $\Delta\epsilon = 17 (1 \text{ kHz}, 20^\circ\text{C})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the

electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 32

- 5 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15%	2-(4-cyanophenyl)-5-propyl-1,3-dioxane
	15%	2-(4-cyanophenyl)-5-butyl-1,3-dioxane
10	15%	2-(4-cyanophenyl)-5-pentyl-1,3-dioxane
	20%	4-pentyl-4'-cyanobiphenyl
	20%	4-heptyl-4'-cyanobiphenyl
	5%	4-(trans-4-propylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
15	5%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-pentylcyclohexyl)biphenyl
	5%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

and has the following physical parameters:

20	clear point	$T_c = 72^\circ\text{C}$
	viscosity	$\eta = 38 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.166 (589 \text{ nm}, 20^\circ\text{C})$
	dielectric anisotropy	$\Delta\epsilon = 20 (1 \text{ kHz}, 20^\circ\text{C})$

- 25 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

30 Example 33

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	10%	2-(4-cyanophenyl)-5-propyl-1,3-dioxane
	10%	2-(4-cyanophenyl)-5-butyl-1,3-dioxane
	15%	2-(4-cyanophenyl)-5-pentyl-1,3-dioxane
	5%	2-(4-cyanophenyl)-5-pentylpyrimidine
5	10%	2-(4-cyanophenyl)-5-heptylpyrimidine
	15%	4-(trans-4-propylcyclohexyl)benzonitrile
	10%	4-(trans-4-pentylcyclohexyl)benzonitrile
	10%	4-(trans-4-heptylcyclohexyl)benzonitrile
	5%	4-(trans-4-propylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
10	5%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	5%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

15 and has the following physical parameters:

clear point	T_c [sic] = 76°C
viscosity	η = 38 mm ² s ⁻¹ (20°C)
optical anisotropy	Δn = 0.15 (589 nm, 20°C)
dielectric anisotropy	$\Delta \epsilon$ = 21 (1 kHz, 20°C)

- 20 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold
- 25 voltage.

Example 34

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

30	20%	1-(4-(4-pentylphenyl)phenyl)-2-(4-cyanophenyl)ethane
	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile

	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
5	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
10	b)	The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.
15	<u>Example 35</u>	
	a)	An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
	14.4%	p-trans-4-propylcyclohexylbenzonitrile
20	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
25	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
30	20 %	1-(trans-4-pentylcyclohexyl)-2-(4-cyanophenyl)ethane

and has the following physical parameters:

clear point	$T_c = 80^\circ\text{C}$
viscosity	$\eta = 29 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$

optical anisotropy $\Delta n = 0.14$ (20°C, 589 nm)

dielectric anisotropy $\Delta \epsilon = 11.8$ (20°C, 1kHz)b)

5 The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

Example 36

10 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

21.2%	2-(4-cyanophenyl)-5-propylpyridine
21.2%	2-(4-cyanophenyl)-5-butylpyridine
15 21.2%	2-(4-cyanophenyl)-5-pentylpyridine
21.2%	2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine
5.0%	4-propoxy-4'-fluorotolan
5.0%	4-butoxy-4'-fluorotolan
20 5.0%	4-pentoxy-4'-fluorotolan

and has the following physical parameters:

clear point	$T_c = 75^\circ\text{C}$
viscosity	$\eta = 58 \text{ mm}^2 \text{ s}^{-1}$ (20°C)
optical anisotropy	$\Delta n = 0.2627$ (20°C, 589 nm)
25 ordinary refractive index	$n_o = 1.5277$ (20°C, 589 nm)
dielectric anisotropy	$\Delta \epsilon = 22.6$ (20°C, 1 kHz)

30 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, by a low threshold voltage and a high contrast.

Example 37

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

5	16.9%	p-trans-4-propylcyclohexylbenzonitrile
	13.7%	p-trans-4-butylcyclohexylbenzonitrile
	22.5%	p-trans-4-pentylcyclohexylbenzonitrile
	14.5%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
10	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
15	10.0%	1-[4-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]phenyl]-2-(4-cyanophenyl)-ethane

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a good contrast.

25 Example 38

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
30	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
35	4.8%	4-pentyl-4"-cyanoterphenyl

	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
5	20%	3-(4-isothiocyanatophenyl)-5-pentylpyrimidine

and has the following physical parameters:

	clear point	$T_c = 83^\circ\text{C}$
	viscosity	$\eta = 28 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
10	optical anisotropy	$A_n = 0.18 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$\Delta\epsilon = 14.6 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a good contrast.

Example 39

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

	16.2%	p-trans-4-propylcyclohexylbenzonitrile
	12.6%	p-trans-4-butylcyclohexylbenzonitrile
	22.5%	p-trans-4-pentylcyclohexylbenzonitrile
25	13.5%	p-trans-4-heptylcyclohexylbenzonitrile
	6.3%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	5.4%	4-pentyl-4"-cyanoterphenyl
	7.2%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
30	6.3%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	10%	1-(trans-4-pentylcyclohexyl)-4-isothiocyanatobenzene

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, b), 1.1-1.3 and 2.

5 The electrooptical systems prepared by this process are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

10 Example 40

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
15	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
20	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
25	12%	1-(trans-4-propylcyclohexyl)-4-isothiocyanatobenzene
	8%	1-(trans-4-butylcyclohexyl)-4-isothiocyanatobenzene

and has the following physical parameters:

30	clear point	$T_c = 80^\circ\text{C}$
	viscosity	$\eta = 24 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$A_n = 0.15 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$A_e = 11.8 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, b), 1.1-1.3 and 2.

5 The electrooptical systems prepared by this process are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

10 Example 41

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
15	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
20	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
25	10%	4-(trans-4-propylcyclohexyl)-4'-difluoromethoxybiphenyl
	10%	4-(trans-4-pentylcyclohexyl)-4'-difluoromethoxybiphenyl

and has the following physical parameters:

30	clear point	$T_c = 102^\circ\text{C}$
	viscosity	$\eta = 31 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.15 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$\Delta\epsilon = 11.4 (20^\circ\text{C}, 1 \text{ kHz})$

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a good contrast.

Example 42

- 10 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	16.2%	p-trans-4-propylcyclohexylbenzonitrile
	12.6%	p-trans-4-butylcyclohexylbenzonitrile
	22.5%	p-trans-4-pentylcyclohexylbenzonitrile
	5.4%	4-pentyl-4"-cyanoterphenyl
15	7.2%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	6.3%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	10%	4-pentyl-4"-difluoromethoxyterphenyl
20	13.5%	p-trans-4-heptylcyclohexylbenzonitrile
	6.3%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

- 25 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a good contrast.

Example 43

- 30 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile

	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
5	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
10	20%	1-(trans-4-pentylcyclohexyl)-4-fluorobenzene

and has the following physical parameters:

	viscosity	$\eta = 20 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.12 (20^\circ\text{C}, 589 \text{ nm})$
15	dielectric anisotropy	$\Delta \epsilon = 10.2 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a good contrast.

Example 44

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
30	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate

- 5.6% 4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
20% 2-(4-(3,4-difluorophenyl)phenyl)-5-heptylpyrimidine

5 and has the following physical parameters:

clear point $T_c = 97^\circ\text{C}$
viscosity $\eta = 48 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $A_n = 0.16 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 12.9 (20^\circ\text{C}, 1 \text{ kHz})$

- 10 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by
15 a low threshold voltage and a good contrast.

Example 45

- a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds

- 20 5% 4(-trans-4-pentylcyclohexyl)-4'-chlorobiphenyl
17.1% p-trans-4-propylcyclohexylbenzonitrile
13.3% p-trans-4-butylcyclohexylbenzonitrile
23.8% p-trans-4-pentylcyclohexylbenzonitrile
25 14.3% 4-(trans-4-heptylcyclohexyl)benzonitrile
6.7% 4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
6.7% 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
30 5.7% 4-pentyl-4"-cyanoterphenyl
7.6% 4-(trans-4-propylcyclohexyl)phenyl)
trans-4-butylcyclohexylcarboxylate

and has the following physical parameters:

clear point	$T_c = 95^\circ\text{C}$
optical anisotropy	$\Delta n = 0.15$ (20°C , 589 nm)
dielectric anisotropy	$\Delta\epsilon = 11.6$ (20°C , 1 kHz)
flow viscosity	$\eta = 31 \text{ mm}^2/\text{s}$ (20°C)

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and in particular by a high UV stability.

10 Example 46

- a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds

15	20%	1-(trans-4-pentylcyclohexyl)-4-chlorobenzene
	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
20	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
25	6.4%	4-(trans-4-propylcyclohexyl)phenyl)trans-4-butylcyclohexylcarboxylate

and has the following physical parameters:

30	clear point	$T_c = 69^\circ\text{C}$
	optical anisotropy	$\Delta n = 0.13$ (20°C , 589 nm)
	dielectric anisotropy	$\Delta\epsilon = 10.8$ (20°C , 1 kHz)
	flow viscosity	$\eta = 21 \text{ mm}^2/\text{s}$ (20°C)

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide

working temperature range, favourable values for the electrooptical parameters and in particular by a high UV stability.

Example 46 [sic]

- 5 a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds
- | | | |
|----|-------|--|
| | 5.0% | 2-fluoro-4-(trans-4-pentylcyclohexyl)-3",4"-difluoroterphenyl |
| 10 | 8.0% | 1-[4-(2-fluoro-4-propylphenyl)phenyl]-2-(4-fluorophenyl)ethane |
| | 11.0% | 1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane |
| 15 | 7.0% | 1-{4-[4-(trans-4-propylcylcohexyl)-2-fluorophenyl]phenyl}-2-(3,4-difluorophenyl)ethane [sic] |
| | 7.0% | 1-{4-[4-(trans-4-pentylcylcohexyl)-2-fluorophenyl]phenyl}-2-(3,4-difluorophenyl)ethane [sic] |
| 20 | 2.0% | 1-{4-[4-(trans-4-propylcylcohexyl)-2-fluorophenyl]phenyl}-2-(3-fluorophenyl)-ethane [sic] |
| | 6.0% | 1-{4-[4-(trans-4-pentylcylcohexyl)-2-fluorophenyl]phenyl}-2-(3-fluorophenyl)-ethane [sic] |
| 25 | 10.0% | 4-(trans-4-ethylcyclohexyl)-3',4'-difluorobiphenyl |
| | 10.0% | of 1-(4-pentylphenyl)-2-[4-(3,4-difluorophenyl)phenyl]ethane |
| 30 | 10.0% | 4-(trans-4-propylcyclohexyl)-3',4'-difluorobiphenyl |
| | 10.0% | 4-(trans-4-pentylcyclohexyl)-3',4'-difluorobiphenyl |
| 35 | 7.0% | 4-(trans-4-ethylcyclohexyl)-3',4',5'-tri-fluorobiphenyl |
| | 7.0% | 4-(trans-4-pentylcyclohexyl)-3',4',5'- |

trifluorobiphenyl

and has the following physical parameters:

5 clear point $T_c = 97^\circ\text{C}$
 optical anisotropy $A_n = 0.1660$ (20°C, 589 nm)
 ordinary refractive
 index $n_o = 1.5115$ (20°C, 589 nm)
 dielectric anisotropy $\Delta\epsilon = 7.6$ (20°C, 1 kHz)

10 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and in particular by a high UV stability.

Example 47

15 a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds

	12.1%	3-fluoro-4-chlorophenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
	9.9%	3-fluoro-4-chlorophenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
20	9.0%	3-fluoro-4-chlorophenyl trans-4-propylcyclohexylcarboxylate
	9.0%	3-fluoro-4-chlorophenyl trans-4-pentylcyclohexylcarboxylate [sic]
25	10.0%	2-fluoro-4-pentylphenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
	10.0%	2-fluoro-4-pentylphenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
30	10.0%	2-fluoro-4-propylphenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
	15.0%	4-(trans-4-propylcyclohexyl)benzonitrile
	10.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
	5.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl

and has the following physical parameters:

viscosity	$\eta = 30.4 \text{ mm}^2/\text{s} (20^\circ\text{C})$
birefringence	$\Delta n = 0.11 (20^\circ\text{C}, 589 \text{ nm})$
clear point	N 114.9 I

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and in particular by a high UV stability.

10 Example 48

- a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds

15	12.1%	3-fluoro-4-chlorophenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
	9.9%	3-fluoro-4-chlorophenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
	9.0%	3-fluoro-4-chlorophenyl trans-4-propylcyclohexylcarboxylate
20	9.0%	3-fluoro-4-chlorophenyl trans-4-pentylcyclohexylcarboxylate
	8.0%	2-fluoro-4-pentylphenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
	7.0%	2-fluoro-4-pentylphenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
25	7.0%	2-fluoro-4-propylphenyl trans-4-(trans-4-propylcyclohexyl)cyclohexylcarboxylate
	15.0%	4-(trans-4-propylcyclohexyl)benzonitrile
	13.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
30	2.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	8.0%	4-pentylphenyl trans-4-propylcyclohexylcarboxylate

and has the following physical parameters:

viscosity	$\eta = 25.9 \text{ mm}^2/\text{s} (20^\circ\text{C})$
birefringence	$\Delta n = 0.10 (20^\circ\text{C}, 589 \text{ nm})$
clear point	N 94.2 I

- 5 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and in particular by a high UV stability.

Example 49

- 10 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
15	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl
	4.8%	4-pentyl-4"-cyanoterphenyl
20	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	6%	4-propylphenyl-4-heptyl benzoate
25	7%	4-pentylphenyl-4-heptyl benzoate
	7.0%	4-heptylphenyl-4-heptyl benzoate

and has the following physical parameters:

	clear point	$T_c = 77^\circ\text{C}$
	viscosity	$\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
30	optical anisotropy	$\Delta n = 0.14 (20^\circ\text{C}, 589 \text{ nm})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the

electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 50

- 5 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
- | | |
|---------|--|
| 12% | 4-(trans-4-pentylcyclohexyl)benzonitrile |
| 20% | 4-propyl-4'-cyanobiphenyl |
| 10 13% | 4-pentyl-4'-cyanobiphenyl |
| 20% | 4-(trans-4-pentylcyclohexyl)-4'-cyano-biphenyl |
| 15% 15% | 4-propyl-3"-fluoro-4"-cyanoterphenyl |
| 20% | 4-pentoxy-4-fluoro-tolan |
- 15 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by
- 20 a low threshold voltage and a high contrast.

Example 51

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
- | | |
|--------|---|
| 25 18% | 4-cyano-4'-(trans-4-pentylcyclohexyl)bi-phenyl |
| 35% | 4-cyano-4'-hexylbiphenyl |
| 22% | 4-cyano-4'-pentylbiphenyl |
| 9% | 4-cyano-4"-pentylterphenyl |
| 30 5% | 4-cyano-4'-yl-biphenyl 4-heptyl-4'-yl-biphenylcarboxylate |
| 5% | 4-cyano-4'-nonoxybiphenyl |
| 6% | 1-(trans-4-propylcyclohexyl)-2-(4-pentyl-2-fluoro-4'-yl-biphenyl)ethane |

and has the following physical parameters:

clear point $T_c = 100^\circ\text{C}$
viscosity $\eta = 55 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
dielectric anisotropy $\Delta\epsilon = 14.1 (20^\circ\text{C}, 589 \text{ nm})$
5 optical anisotropy $\Delta n = 0.24 (20^\circ\text{C}, 1 \text{ kHz})$

b) The electrooptical systems prepared by the process described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a low threshold voltage, a good preparation capability and a high contrast.
10

Example 52

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
15

25% 2-(4-cyanophenyl)-5-propylpyridine
25% 2-(4-cyanophenyl)-5-butylpyridine
25% 2-(4-cyanophenyl)-5-pentylpyridine
25% 2-(4-cyanophenyl)-5-(pentylphenyl)pyrid-
20 ine

and has the following physical characteristics:

clear point $T_c = 85^\circ\text{C}$
viscosity $\eta = 70 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.269 (20^\circ\text{C}, 589 \text{ nm})$
25 dielectric anisotropy $\Delta\epsilon = 24.1 (20^\circ\text{C}, 1 \text{ kHz})$

b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.
30

Example 53

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

5	17.5%	2-(4-cyanophenyl)-5-propylpyridine
	17.5%	2-(4-cyanophenyl)-5-butylpyridine
	17.5%	2-(4-cyanophenyl)-5-pentylpyridine
	17.5%	2-(4-cyanophenyl)-5-(4-pentylphenyl)pyridine
10	15.0%	1-[4-(4-propylphenyl)phenyl]-2-(3-fluoro-4-cyanophenyl)ethane
	15.0%	1-[4-(4-pentylphenyl)phenyl]-2-(3-fluoro-4-cyanophenyl)ethane

and has the following physical characteristics:

15	clear point	$T_c = 94^\circ\text{C}$
	optical anisotropy	$\Delta n = 0.272$ (20°C, 589 nm)
	dielectric anisotropy	$\Delta\epsilon = 25.6$ (20°C, 1 kHz)

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

25 **Example 54**

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

30	22.5%	2-(4-cyanophenyl)-5-propylpyridine
	22.5%	2-(4-cyanophenyl)-5-butylpyridine
	22.5%	2-(4-cyanophenyl)-5-pentylpyridine
	22.5%	2-(4-cyanophenyl)-5-(4-pentylphenyl)pyridine

10.0% 1-(4-propylphenyl)-2-[4-(3-fluoro-4-cyano-phenyl)phenyl]ethane [sic]

and has the following physical characteristics:

5 clear point $T_c = 82^\circ\text{C}$
viscosity $\eta = 74 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.260 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 25 (20^\circ\text{C}, 1 \text{ kHz})$

10 b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

15 Example 55

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

20 22.5% 2-(4-cyanophenyl)-5-propylpyridine
22.5% 2-(4-cyanophenyl)-5-butylpyridine
22.5% 2-(4-cyanophenyl)-5-pentylpyridine
22.5% 2-(4-cyanophenyl)-5-(4-pentylphenyl)pyridine
10.0% 4-pentyl-3",5"-difluoro-4"-cyanoterphenyl

25 and has the following physical characteristics:

clear point $T_c = 84^\circ\text{C}$
viscosity $\eta = 75 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.266 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 26 (20^\circ\text{C}, 1 \text{ kHz})$

30 b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b)

is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

Example 56

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

10	20.0%	2-(4-cyanophenyl)-5-propylpyridine
	20.0%	2-(4-cyanophenyl)-5-butylpyridine
	20.0%	2-(4-cyanophenyl)-5-pentylpyridine
	20.0%	2-(4-cyanophenyl)-5-(4-pentylphenyl)pyridine
15	10.0%	2-(3-fluoro-4-cyanophenyl)-5-propylpyrimidine
	10.0%	2-(3-fluoro-4-cyanophenyl)-5-pentylpyrimidine

and has the following physical characteristics:

20	clear point	$T_c = 71^\circ\text{C}$
	viscosity	$\eta = 68 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.253 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$\Delta\epsilon = 29.5 (20^\circ\text{C}, 1 \text{ kHz})$

b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and by a low threshold voltage and a high contrast.

Example 57

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the

following compounds

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile
	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
5	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4- propylcyclohexyl)biphenyl [sic]
10	5.0%	4-pentyl-4"-cyanoterphenyl
	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans- 4-butylcyclohexylcarboxylate
	20.0%	1-[trans-4-(trans-4-propylcyclohexyl)- cyclohexyl]-2-(3-fluoro-4-cyanophenyl)- ethane
15		

and has the following physical characteristics:

	clear point	$T_c = 98^\circ\text{C}$
	viscosity	$\eta = 39 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$A_n = 0.139 (20^\circ\text{C}, 589 \text{ nm})$
20	dielectric anisotropy	$\Delta\epsilon = 14 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 58

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile

	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi-phenyl
5	6.0%	4-(trans-4-pentylcylcohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl [sic]
	5.0%	4-pentyl-4"-cyanoterphenyl
	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
10	20.0%	1-(trans-4-pentylcyclohexyl)-2-(3-fluoro-4-phenyl)ethane

and has the following physical characteristics:

	clear point	$T_c = 76^\circ\text{C}$
	viscosity	$\eta = 30 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
15	optical anisotropy	$\Delta n = 0.130 (20^\circ\text{C}, 589 \text{ nm})$
	dielectric anisotropy	$\Delta\epsilon = 13 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 59

- 25 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile
30	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobi-phenyl
	6.0%	4-(trans-4-pentylcylcohexyl)-4'-(trans-4-

		propylcyclohexyl)biphenyl [sic]
	5.0%	4-pentyl-4"-cyanoterphenyl
	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
5	20.0%	4-pentyl-4'-chlorobiphenyl

and has the following physical characteristics:

	clear point	$T_c = 74^\circ\text{C}$
	viscosity	$\eta = 27 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.150 (20^\circ\text{C}, 589 \text{ nm})$
10	dielectric anisotropy	$\Delta\epsilon = 11 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 60

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	16.0%	p-trans-4-propylcyclohexylbenzonitrile
	13.0%	p-trans-4-butylcyclohexylbenzonitrile
	23.0%	p-trans-4-pentylcyclohexylbenzonitrile
25	13.0%	p-trans-4-heptylcyclohexylbenzonitrile
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	6.0%	4-(trans-4-pentylcylcohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl [sic]
30	6.0%	4-pentyl-4"-cyanoterphenyl
	7.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.0%	4-(trans-4-propylcyclohexyl)-4'-ethoxytolan

5.0% 4-(trans-4-propylcyclohexyl)-4'-ethoxy-
tolan

and has the following physical characteristics:

5 clear point $T_c = 106^\circ\text{C}$
viscosity $\eta = 30 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.163 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 10.5 (20^\circ\text{C}, 1 \text{ kHz})$

10 b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

15 Example 61

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

20 15.0% p-trans-4-propylcyclohexylbenzonitrile
10.0% p-trans-4-butylcyclohexylbenzonitrile
20.0% p-trans-4-pentylcyclohexylbenzonitrile
12.0% p-trans-4-heptylcyclohexylbenzonitrile
6.0% 4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
25 6.0% 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl [sic]
5.0% 4-pentyl-4"-cyanoterphenyl
6.0% 4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
30 20.0% 4-(trans-4-propylcyclohexyl)-3',4',5'-trifluorobiphenyl

and has the following physical characteristics:

clear point	$T_c = 82^\circ\text{C}$
viscosity	$\eta = 32 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy	$A_n = 0.138 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy	$A_\epsilon = 13.5 (20^\circ\text{C}, 1 \text{ kHz})$

- 5 b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.
- 10

Example 62

- 15 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile
	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
20	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl [sic]
	5.0%	4-pentyl-4"-cyanoterphenyl
25	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	10.0%	1-(trans-4-(trans-4-propylcyclohexyl)cyclohexyl)-2-(4-cyanophenyl)ethane
	10.0%	1-(trans-4-(trans-4-pentylcyclohexyl)cyclohexyl)-2-(4-cyanophenyl)ethane
30		

and has the following physical characteristics:

clear point	$T_c = 111^\circ\text{C}$
viscosity	$\eta = 36 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
dielectric anisotropy	$A_\epsilon = 11.8 (20^\circ\text{C}, 1 \text{ kHz})$

- 5 b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 63

- 10 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile
	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
15	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
	6.0%	4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)biphenyl [sic]
20	5.0%	4-pentyl-4"-cyanoterphenyl
	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	10.0%	1-(4-propylphenyl)-2-[4-(2-fluoro-4-pentylphenyl)phenyl]ethane
25	10.0%	1-(4-pentylphenyl)-2-[4-(2-fluoro-4-propylphenyl)phenyl]ethane

and has the following physical characteristics:

	clear point	$T_c = 85^\circ\text{C}$
	viscosity	$\eta = 29 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
30	optical anisotropy	$A_n = 0.146 (20^\circ\text{C}, 589 \text{ nm})$

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values

for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 64

- 5 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

	34.65%	4-pentyl-4'-cyanobiphenyl
	13.5 %	4-propoxy-4'-cyanobiphenyl
10	10.35%	4-pentoxy-4'-cyanobiphenyl
	13.5 %	4-octoxy-4'-cyanobiphenyl
	10.0 %	4-(trans-4-pentylcyclohexyl)-4'-cyanobi- phenyl
	9.0 %	4-[2-(p-propylphenyl)ethyl]-4'-cyanobi- phenyl
15		and
	9.0 %	4-[2-(p-pentylphenyl)ethyl]-4'-cyanobi- phenyl

and has the following physical characteristics:

20	N-I	84°
	An	0.247 (20°C, 589 nm)

- 25 b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast and high angular independence of the contrast.

Example 65

- 30 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	20%	4-pentyl-4'-cyanobiphenyl
	23%	2-(4-cyanophenyl)-5-pentylpyridine
	17%	4-propoxy-4'-cyanobiphenyl
	13%	4-pentoxy-4'-cyanobiphenyl
5	17%	4-octoxy-4'-cyanobiphenyl
	10%	4-pentyl-4"-cyanoterphenyl

and has the following physical parameters:

	clear point	$T_c = 70.4^\circ\text{C}$
	viscosity:	$\eta = 61 \text{ mm}^2/\text{s} (20^\circ\text{C})$
10	threshold voltage	$V[90.0.20] = 1.31 \text{ V}$

The threshold voltage is measured as indicated in Example 9a.

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1, b).

15 Example 66

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	12%	2-(4-cyanophenyl)-5-propylpyridine
20	15%	2-(4-cyanophenyl)-5-pentylpyridine
	18%	4-pentyl-4'-cyanobiphenyl
	9%	4-propoxy-4'-cyanobiphenyl
	9%	4-pentyl-4"-cyanoterphenyl
	22%	4-propyl-2'-fluoro-4"-cyanoterphenyl
25	15%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl

and has the following physical parameters:

	clear point	$T_c = 114^\circ\text{C}$
	viscosity:	$\eta = 86.6 \text{ mm}^2/\text{s} (20^\circ\text{C})$
30	threshold voltage	$V[90.0.20] = 1.69 \text{ V}$

The threshold voltage is measured as indicated in Example 9a.

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1b).

5 Example 67

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	12%	2-(4-cyanophenyl)-5-propylpyridine
10	15%	2-(4-cyanophenyl)-4-pentylpyridine
	5%	4-cyanobiphenyl
	8.5%	4-ethyl-4'-cyanobiphenyl
	8.5%	4-propyl-4'-cyanobiphenyl
	20%	4-pentyl-4'-cyanobiphenyl
15	17%	4-propyl-2'-fluoro-4"-cyanoterphenyl
	9%	4-pentyl-4"-cyanoterphenyl

and has the following physical parameters:

	clear point	$T_c = 69.6^\circ\text{C}$
	viscosity:	$\eta = 51 \text{ mm}^2/\text{s} (20^\circ\text{C})$
20	threshold voltage	$V[90.0.20] = 1.29 \text{ V}$

The threshold voltage is measured as indicated in Example 9a.

- b) The electrooptical liquid crystal system is prepared by the processes described in Example 1b).

25 Example 68

- a) A liquid crystal mixture consisting of

	14.0%	4-ethyl-4'-cyanobiphenyl
	15.0%	4-butyl-4'-cyanobiphenyl
	41.9%	4-hexyl-4'-cyanobiphenyl
30	2.5%	4-methoxy-4'-cyanobiphenyl

	12.0%	4-propoxy-4'-cyanobiphenyl	
	7.6%	4-pentyl-4"-cyanoterphenyl	
	3.0%	4-(4-cyanophenyl)phenyl	4-(4-pentyl-phenyl)benzoate
5	4.0%	4-(3-cyanophenyl)phenyl	4(4-heptyl-phenyl)benzoate [sic]

has the following physical characteristics:

	birefringence	$A_n = 0.232$	(20°C, 589 nm)
10	ordinary refractive index	$n_o = 1.766$	(20°C, 589 nm)
	dielectric anisotropy	$\Delta\epsilon = 15.8$	(1 kHz, 20°C)
	threshold voltage	$V[10.0.20] = 1.23$	V
15	clear point	$T_c = 64^\circ\text{C}$	

The threshold voltage was measured in a TN cell (twist angle $\Psi = \pi/4$) which has a cell clearance of 7 μm and is located between parallel polarizers.

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

25 Example 69

- a) A liquid crystal mixture consisting of

	34.0%	4-pentyl-4'-cyanobiphenyl
	10.0%	4-propoxy-4'-cyanobiphenyl
	13.0%	4-ethyl-4'-cyanobiphenyl
30	10.0%	4-pentoxy-4'-cyanobiphenyl
	13.0%	4-(4-pentylphenyl)-4'-cyanobiphenyl
	10.0%	4-octoxy-4'-cyanobiphenyl
	10.0%	1-(trans-4-(trans-4-propylcyclohexyl)-

cyclohexyl)-4-(4-cyanophenyl)phenyl)-
ethane

has the following physical characteristics:

5	birefringence	$\Delta n = 0.243$	(20°C, 589 nm)
	ordinary refractive index	$n_o = 1.765$	(20°C, 589 nm)
	clear point	$T_c = 91^\circ\text{C}$	

- 10 b) The electrooptical systems prepared by the processes
described in Example 1b) are distinguished by a wide
working temperature range, favourable values for the
electrooptical parameters and their temperature
15 dependence and in particular by a low threshold
voltage.

Example 70

- a) A liquid crystal mixture consisting of

20	20.0%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-ethane
	10.0%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
25	30.0%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
	30.0%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-chlorophenyl)ethane
	10.0%	1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane

30 has the following physical characteristics:

clear point	$T_c = 104^\circ\text{C}$
optical anisotropy	$\Delta n = 0.189$ (20°C, 589 nm)

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

Example 71

- 10 a) A liquid crystal mixture consisting of

	17.5%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-ethane
	8.5%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
15	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-chlorophenyl)ethane
20	8.5%	1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane
	8.5%	1-[4-(trans-4-pentylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane
25	8.5%	1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-chlorophenyl)ethane

has the following physical characteristics:

	clear point	$T_c = 98^\circ\text{C}$
	optical anisotropy	$A_n = 0.176$ (20°C, 589 nm)
30	dielectric anisotropy	$\Delta\epsilon = 5.0$ (20°C, 1 kHz)

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values

for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

5 Example 72

a) A liquid crystal mixture consisting of

	17%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-ethane
10	8.5%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
15	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-chlorophenyl)ethane
	8.5%	1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane
	7.8%	4-(trans-4-pentylcyclohexyl)-1-chlorobenzene
20	7.2%	4-(trans-4-heptylcyclohexyl)-1-chlorobenzene

has the following physical characteristics:

	clear point	$T_c = 87^\circ\text{C}$
25	optical anisotropy	$\Delta n = 0.171$ (20°C , 589 nm)

b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

Example 73

a) A liquid crystal mixture consisting of

5	10%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-ethane
	10%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
10	20%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
	10%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-chlorophenyl)ethane
	10%	4-(trans-4-pentylcyclohexyl)-1-chlorobenzene
15	10%	4-(trans-4-heptylcyclohexyl)-1-chlorobenzene
	15%	4-propyl-2'-fluoro-4"-ethylterphenyl
	15%	4-ethyl-2'-fluoro-4"-propylterphenyl

has the following physical characteristics:

20	clear point	$T_c = 75^\circ\text{C}$
	optical anisotropy	$\Delta n = 0.142$ (20°C, 589 nm)

b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

Example 74

a) A liquid crystal mixture consisting of

16.9%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-
-------	---

		ethane
	8.5%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
5	25.3%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
	25.3%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-chlorophenyl)ethane
	8.5%	1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane
10	15.5%	1-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-2-(4-chlorophenyl)ethane

has the following physical characteristics:

	clear point	$T_c = 112^\circ\text{C}$
15	optical anisotropy	$A_n = 0.178$ (20°C, 589 nm)

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

Example 75

- 25 a) A liquid crystal mixture consisting of

	17.0%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-fluorophenyl)-ethane
	8.5%	1-{4-[2-fluoro-4-(trans-4-pentylcyclohexyl)phenyl]phenyl}-2-(4-chlorophenyl)-ethane
30	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-(4-fluorophenyl)ethane
	25.5%	1-[4-(2-fluoro-4-pentylphenyl)phenyl]-2-

		(4-chlorophenyl)ethane
8.5%		1-[4-(trans-4-propylcyclohexyl)phenyl]-2-(4-fluorophenyl)ethane
7.6%		4-(trans-4-pentylcyclohexyl)-1-fluorobenzene
7.4%		4-(trans-4-hexylcyclohexyl)-1-fluorobenzene

has the following physical characteristics:

	clear point	$T_c = 80^\circ\text{C}$
10	optical anisotropy	$\Delta n = 0.172$ (20°C , 589 nm)

- b) The electrooptical liquid crystal system which is prepared by the processes described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a good contrast, a high angular independence of the contrasts [sic] and in particular also by a high UV stability.

Example 76

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds
- | | |
|-------|--|
| 14.4% | p-trans-4-propylcyclohexylbenzonitrile |
| 11.2% | p-trans-4-butylcyclohexylbenzonitrile |
| 20% | p-trans-4-pentylcyclohexylbenzonitrile |
| 12% | p-trans-4-heptylcyclohexylbenzonitrile |
| 5.6% | 4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate |
| 4.8% | 4-pentyl-4''-cyanoterphenyl |
| 6.4% | 4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate |
| 5.6% | 4-(trans-4-pentylcyclohexyl)-4'-cyano-biphenyl |

6%	4-propylphenyl 4-heptylbenzoate
7%	4-pentylphenyl 4-heptylbenzoate
7%	4-heptylphenyl 4-heptylbenzoate

and has the following physical parameters:

5	clear point	$T_c = 77.5^\circ\text{C}$
	viscosity	$\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$An = 0.14 (20^\circ\text{C}, 589 \text{ nm})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 77

- a) An electrooptical system, containing a liquid crystal mixture which consists of the following compounds:

20%	1-(trans-4-(trans-4-propylcyclohexyl)-cyclohexyl)-2-(3-fluoro-4-cyanophenyl)-ethane
14.4%	p-trans-4-propylcyclohexylbenzonitrile
11.2%	p-trans-4-butylcyclohexylbenzonitrile
20%	p-trans-4-pentylcyclohexylbenzonitrile [sic]
12%	p-trans-4-heptylcyclohexylbenzonitrile
5.6%	4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexyl-carboxylate
4.8%	4-pentyl-4'-cyanoterphenyl
6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyano-biphenyl

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 78

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

14.5%	p-trans-4-propylcyclohexylbenzonitrile
11.2%	p-trans-4-butylcyclohexylbenzonitrile
20%	p-trans-4-pentylcyclohexylbenzonitrile
12%	p-trans-4-heptylcyclohexylbenzonitrile
5.6%	4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyano-biphenyl
4.8%	4-pentyl-4"-cyanoterphenyl
20%	2-(4-cyanophenyl)-5-pentylpyrimidine

and has the following physical parameters:

clear point	$T_c = 82.5^\circ\text{C}$
viscosity	$\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy	$\Delta n = 0.16 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy	$\Delta \epsilon = 16.1 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold voltage.

Example 79

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

5	10.0%	2-(4-cyanophenyl)-5-propyl-1,3-dioxane
	15.0%	2-(4-cyanophenyl)-5-butyl-1,3-dioxane
	15.0%	2-(4-cyanophenyl)-5-pentyl-1,3-dioxane
	20.0%	4-(trans-4-propylcyclohexyl)benzonitrile
	15.0%	4-(trans-4-pentylcyclohexyl)benzonitrile
10	10.0%	4-(trans-4-heptylcyclohexyl)benzonitrile
	5.0%	4-(trans-4-propylcyclohexyl) phenyl trans-4-(trans-4-propylcyclohexyl)cyclohexyl- carboxylate
	5.0%	4-(trans-4-pentylcyclohexyl)phenyl trans-
15		4-(trans-4-pentylcyclohexyl)cyclohexyl- carboxylate [sic]
	5.0%	4-(trans-4-propylcyclohexyl)phenyl trans- 4-(trans-4-pentylcylcohexyl)cyclohexyl- carboxylate [sic]

20 and has the following physical characteristics:

clear point	$T_c = 76^\circ\text{C}$
viscosity	$\eta = 34 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy	$A_n = 0.131 (589 \text{ nm}, 20^\circ\text{C})$
dielectric anisotropy	$\Delta\epsilon = 17 (1 \text{ kHz}, 20^\circ\text{C})$

25 b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence and in particular by a low threshold
30 voltage.

Example 80

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	16.9%	p-trans-4-propylcyclohexylbenzonitrile
	13.7%	p-trans-4-butylcyclohexylbenzonitrile
	22.5%	p-trans-4-pentylcyclohexylbenzonitrile
	14.5%	p-trans-4-heptylcyclohexylbenzonitrile
5	5.6%	4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
	4.8%	4-pentyl-4"-cyanoterphenyl
10	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyanobiphenyl
15	10.0%	1-[4-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]phenyl]-2-(4-cyanophenyl)ethane

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, and a low threshold voltage and a good contrast.

Example 81

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

	14.4%	p-trans-4-propylcyclohexylbenzonitrile
	11.2%	p-trans-4-butylcyclohexylbenzonitrile
	20%	p-trans-4-pentylcyclohexylbenzonitrile
	12%	p-trans-4-heptylcyclohexylbenzonitrile
30	5.6%	4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate
	4.8%	4-pentyl-4"-cyanoterphenyl
35	6.4%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexylcarboxylate
	5.6%	4-(trans-4-pentylcyclohexyl)-4'-cyano-

	biphenyl
10%	4-(trans-4-propylcyclohexyl)-4'-difluoromethoxybiphenyl
10%	4-(trans-4-pentylcyclohexyl)-4'-difluoromethoxybiphenyl

5

and has the following physical parameters:

	clear point	$T_c = 102.3^\circ\text{C}$
	viscosity	$\eta = 31 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
	optical anisotropy	$\Delta n = 0.15 (20^\circ\text{C}, 589 \text{ nm})$
10	dielectric anisotropy	$\Delta\epsilon = 11.4 (20^\circ\text{C}, 1 \text{ kHz})$

- b) The electrooptical systems prepared by the processes described in Example 1b) are distinguished by a good preparation capability, a wide working temperature range, favourable values for the electrooptical parameters and their temperature dependence, a low threshold voltage and a good contrast.

15

Example 82

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds

20

	15.0%	p-trans-4-propylcyclohexylbenzonitrile
	10.0%	p-trans-4-butylcyclohexylbenzonitrile
	20.0%	p-trans-4-pentylcyclohexylbenzonitrile
	12.0%	p-trans-4-heptylcyclohexylbenzonitrile
25	6.0%	4-(trans-4-pentylcyclohexyl)-4'-cyano-biphenyl
	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-butylcyclohexyl)carboxylate
	5.0%	4-pentyl-4"-cyanoterphenyl
30	6.0%	4-(trans-4-propylcyclohexyl)phenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexyl-carboxylate
	20.0%	1-(trans-4-pentylcyclohexyl)-2-(3-fluoro-4-phenyl)ethane

and has the following physical characteristics:

clear point $T_c = 76.3^\circ\text{C}$
viscosity $\eta = 30 \text{ mm}^2 \text{ s}^{-1} (20^\circ\text{C})$
optical anisotropy $\Delta n = 0.130 (20^\circ\text{C}, 589 \text{ nm})$
5 dielectric anisotropy $\Delta\epsilon = 13 (20^\circ\text{C}, 1 \text{ kHz})$

b) The electrooptical liquid crystal system which is prepared by the process described in Example 1b) is distinguished by a good preparation capability, a wide working temperature range, favourable values
10 for the electrooptical parameters and their temperature dependence, a good contrast and high angular dependence [sic] of the contrast.

Example 83

a) An electrooptical liquid crystal system, containing
15 a liquid crystal mixture which consists of the following compounds

25% 2-(4-cyanophenyl)-5-propylpyridine
25% 2-(4-cyanophenyl)-5-butylpyridine
25% 2-(4-cyanophenyl)-5-pentylpyridine
20 25% 2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine

and has the following physical characteristics:

clear point $T_c = 85^\circ\text{C}$
viscosity $\eta = 70 \text{ mm}^2/\text{s}$
25 optical anisotropy $\Delta n = 0.269 (20^\circ\text{C}, 589 \text{ nm})$
dielectric anisotropy $\Delta\epsilon = 24.1 (20^\circ\text{C}, 1 \text{ kHz})$
ordinary refractive
index $n_o = 1.529 (20^\circ\text{C}, 589 \text{ nm})$

b) The electrooptical system is prepared by the processes described in Example 1b), 1.1, 1.2, 1.3 and
30 2, but in which in the process analogous to 1.1 a ratio of liquid crystal to NOA 65 of 1:1 is selected

and spacers of 10 μm were [sic] used.

5 In Fig. 1, the relative transmission for the electrooptical system prepared by the process described in Example 1b), 1.1 is [lacuna] as a function of the applied voltage (sinusoidal alternating voltage (effective values), frequency 100 Hz). This system is distinguished, in particular, by a good contrast and a low threshold voltage.

Example 84

10 a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

	15%	p-trans-4-propylcyclohexylbenzonitrile
	15%	p-trans-4-butylcyclohexylbenzonitrile
15	20%	p-trans-4-pentylcyclohexylbenzonitrile
	10%	2-(4-cyanophenyl)-5-pentylpyridine
	15%	2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine
	7.5%	4-ethoxy-4'-fluorotolan
20	7.5%	4-butoxy-4'-fluorotolan

b) The electrooptical system which is prepared by the processes described in Example 1 b) is distinguished by a wide working temperature range, a good preparation capability, favourable values for the electrooptical parameters, a low threshold voltage and in particular a high stability.

25

Example 85

a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

30

17.5%	4-propyl-4'-cyanobiphenyl
17.5%	4-butyl-4'-cyanobiphenyl
17.5%	4-pentyl-4'-cyanobiphenyl

- | | | |
|---|-------|---|
| | 17.5% | 2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine |
| | 15.0% | 4-(trans-4-propylcyclohexyl)-4'-trifluoromethoxytolan |
| 5 | 15.0% | 4-propyl-4'-trifluoromethoxytolan |
- b) The electrooptical system which is prepared by the processes described in Example 1 b) is distinguished by a wide working temperature range, a good preparation capability, favourable values for the electrooptical parameters, a low threshold voltage and in particular a high stability.

Example 86

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:
- | | | |
|----|-----|--|
| | 15% | p-trans-4-propylcyclohexylbenzonitrile |
| | 15% | p-trans-4-butylcyclohexylbenzonitrile [sic] |
| | 15% | p-trans-4-pentylcyclohexylbenzonitrile |
| 20 | 15% | p-trans-4-heptylcyclohexylbenzonitrile |
| | 10% | 2-(3,4-difluorophenyl)-5-propylpyrimidine |
| | 10% | 2-(4-fluorophenyl)-5-pentylpyrimidine |
| | 10% | 1-[4-(4-propylphenyl)phenyl]-2-(4-cyanophenyl)ethane |
| 25 | 10% | 1-[4-(4-pentylphenyl)phenyl]-2-(4-cyanophenyl)ethane |
- b) The electrooptical system which is prepared by the processes described in Example 1 b) is distinguished by a wide working temperature range, a good preparation capability, favourable values for the electrooptical parameters, a low threshold voltage and in particular a high stability.

Example 87

- a) An electrooptical liquid crystal system, containing

a liquid crystal mixture which consists of the following compounds:

	15%	p-trans-4-propylcyclohexylbenzonitrile
	15%	p-trans-4-butylcyclohexylbenzonitrile
5	15%	p-trans-4-pentylcyclohexylbenzonitrile
	15%	p-trans-4-heptylcyclohexylbenzonitrile
	10%	1-(5-propylpyridin-2-yl)-2-(4-cyano-phenyl)ethane
	10%	1-(5-pentylpyridin-2-yl)-2-(4-cyano-phenyl)ethane
10	8%	4-fluorophenyl trans-4-(trans-4-propyl-cyclohexyl)cyclohexylcarboxylate
	8%	4-fluorophenyl trans-4-(trans-4-pentyl-cyclohexyl)cyclohexylcarboxylate
15	4%	3,4-difluorophenyl trans-4-(trans-4-pentylcyclohexyl)cyclohexylcarboxylate

- b) The electrooptical system which is prepared by the processes described in Example 1 b) is distinguished by a wide working temperature range, a good preparation capability, favourable values for the electrooptical parameters, a low threshold voltage and in particular a high stability.

Example 88

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

	17.5%	2-(4-cyanophenyl)-5-propylpyridine
	17.5%	2-(4-cyanophenyl)-5-butylpyridine
	17.5%	2-(4-cyanophenyl)-5-pentylpyridine
30	17.5%	2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine
	15.0%	1-[4-(4-propylphenyl)phenyl]-2-(4-cyano-phenyl)ethane
35	15.0%	1-[4-(4-pentylphenyl)phenyl]-2-(4-cyano-phenyl)ethane

and has the following physical characteristics:

clear point $T_c = 94^\circ\text{C}$
optical anisotropy $\Delta n = 0.2722$ (20°C, 589 nm)
dielectric anisotropy $\Delta\epsilon = 25.6$ (20°C, 1 kHz)

- 5 b) The electrooptical system which is prepared by the processes described in Example 1 b) is distinguished by a wide working temperature range, a good preparation capability, favourable values for the electrooptical parameters and in particular by a low
10 threshold voltage.

Example 89

- a) An electrooptical liquid crystal system, containing a liquid crystal mixture which consists of the following compounds:

15	20.0%	2-(4-cyanophenyl)-5-propylpyridine
	20.0%	2-(4-cyanophenyl)-5-butylpyridine
	20.0%	2-(4-cyanophenyl)-5-pentylpyridine
	20.0%	2-(4-cyanophenyl)-5-(4-pentylphenyl)-pyridine
20	10.0%	4-(trans-4-propylcyclohexyl)-3',4'-difluorobiphenyl
	10.0%	4-(trans-4-pentylcyclohexyl)-3',4'-difluorobiphenyl

and has the following physical characteristics:

25 clear point $T_c = 86^\circ\text{C}$
optical anisotropy $\Delta n = 0.2436$ (20°C, 589 nm)
ordinary refractive index $n_o = 1.5259$ (20°C, 589 nm)
dielectric anisotropy $\Delta\epsilon = 21.8$ (1 kHz, 20°C)

- 30 b) The electrooptical system is prepared by the processes described in Example 1b), 1.1, 1.2, 1.3 and 2, but where in the process analogous to 1.1 a

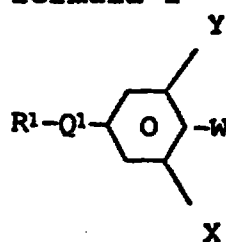
ratio of liquid crystal to NOA 65 of 1 : 1 is selected and spacers of 10 μm were [sic] used.

5 In Fig. 2 the relative transmission for the electro-optical system prepared by the process described in Example 1b), 1.1 is shown as a function of the applied voltage (sinusoidal alternating voltage (effective value), frequency 100 Hz).

10 This system is distinguished in particular by a low threshold voltage, an advantageous value for the slope of the electrooptical characteristic curve and by a high UV stability.

Patent claims

1. Electrooptical liquid crystal system
- which contains a dielectrically positive liquid crystal mixture and a further optically transparent medium between 2 electrodes which are optionally applied to substrate sheets, where the liquid crystal mixture is embedded in the optically transparent medium in the form of compartments which are separated to a greater or lesser extent from one another or forms a more or less coherent, continuous phase in the optically transparent medium,
 - whose liquid crystal molecules in the switched-off state have an irregular orientation,
 - in which one of the refractive indices of the liquid crystal mixture essentially agrees with the refractive index of the matrix n_m and/or in which the quotient of the mass of the liquid crystal mixture and of the mass of the optically transparent medium is 1.5 or more,
 - which, independently of the polarization of the incident light, has a reduced transmission in one of the two switch states compared to the other state, characterized in that the liquid crystal mixture contains one or more compounds of the formula I



I

in which

Q^1 is $-\text{A}^1-\text{Z}^1-(-\text{A}^2-\text{Z}^2-)_m-$

$-\text{A}^1-$ and $-\text{A}^2-$ are independently of one another

trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene and one of A^1 and, if present, A^2 , is also



diyl, tetrahydropyran-2,5-diyl or naphthalene-2,6-diyl,

Z^1 and Z^2 are independently of one another a single bond, $-CH_2CH_2-$, $-COO-$, $-OCO-$, $-C\equiv C-$, $-CH_2O-$ or any desired combinations of these bridge groups,

Y and X are independently of one another H or F, and one of X and Y is also Cl,

W is $-Cl$, $-F$, $-CF_3$, $-OCF_3$, $-OCHF_2$ or $-NCS$

R^1 is alkyl having 1-12 C atoms, in which one or 2 non-adjacent CH_2 groups can also be replaced by $-O-$ or $-HC=CH-$, and

m is 0, 1 or 2,

with the provisos that

(i) the mass content of compounds of the formula I in the liquid crystal mixture is at least 50%, and/or

(ii) the liquid crystal mixture contains no compound of the formula I where W is F or NCS, and/or

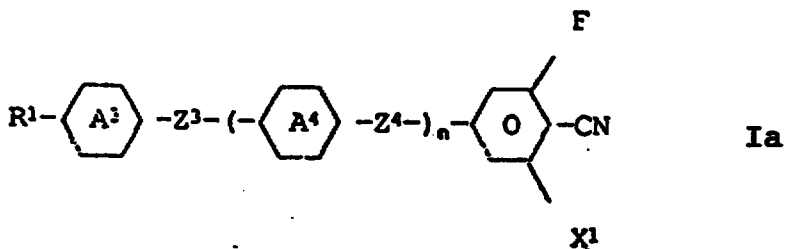
(iii) the liquid crystal mixture has no compound containing a nitrogen-containing heterocycle.

2. System according to Claim 1, characterized in that it is a PDLC system.

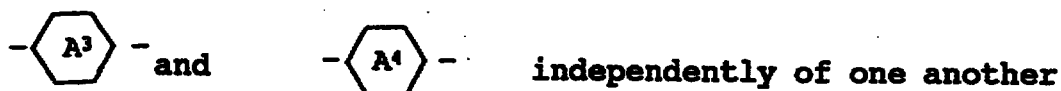
3. System according to Claim 1, characterized in that it is an NCAP system.

4. System according to Claim 1, characterized in that it is a PN system.

5. System according to one of Claims 1-4, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ia



in which





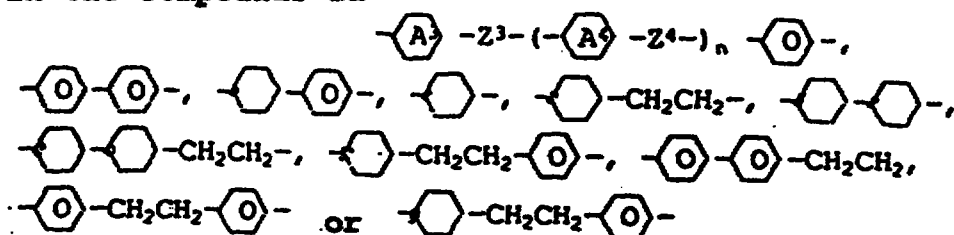
are 1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene and

X¹ is H or F

and the following combinations Nos. 1-5 apply to n, Z³ and Z⁴:

No.	n	Z ³	Z ⁴
1	0	single bond	-
2	0	-CH ₂ CH ₂ -	-
10 3	1	-CH ₂ CH ₂ -	single bond
4	1	single bond	-CH ₂ CH ₂ -
5	1	single bond	single bond

6. System according to Claim 5, characterized in that in the compounds Ia

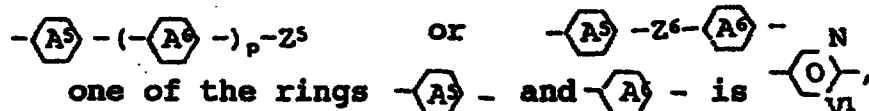


15 7. System according to one of Claims 1-6, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ib



in which

20 Q² is



in which V¹ is N or H, and the other, if present, is trans-1,4-cyclohexylene or 1,4-phenylene,

25 X² and Y²

p is

Z⁵ and Z⁶

independently of one another are H or F, 0 or 1, and

independently of one another are a single



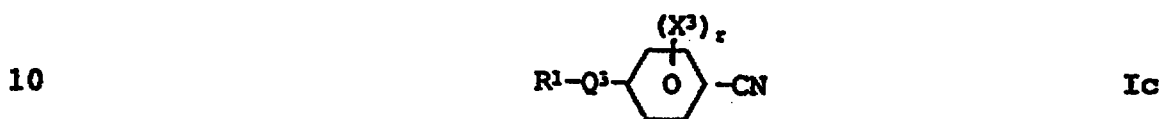
bond or CH_2CH_2

and R^1 has the meaning given in Claim 1.

8. System according to Claim 7, characterized in that at least one of X^2 and Y^2 is F.

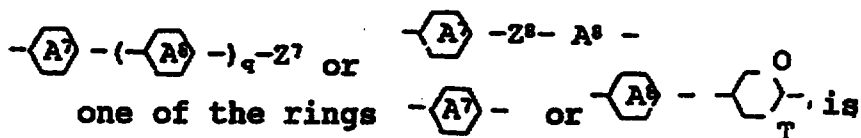
5 9. System according to Claim 7, characterized in that $\text{X}^2 = \text{Y}^2 = \text{H}$.

10. System according to one of Claims 1-9, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ic



in which

Q^3 is



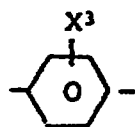
15 in which T is $-\text{CH}_2-$ or $-\text{O}-$, and the other, if present, is trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene

Z^7 and Z^8 independently of one another are a single bond, $-\text{COO}-$, $-\text{OCO}-$ or $-\text{CH}_2\text{CH}_2-$,

20 r and q independently of one another are 0 or 1, and

X^3 is

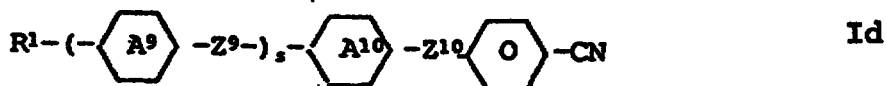
F or Cl, and



is 2-fluoro- or 2-chloro-1,4-phenylene or 3-fluoro- or 3-chloro-1,4-phenylene,

25 and the meaning of R^1 is given in Claim 1.

11. System according to one of Claims 1-10, characterized in that the liquid crystal mixture contains one or more compounds of the formula Id



30 in which



is 1,4-phenylene or trans-1,4-cyclohexylene



 is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene

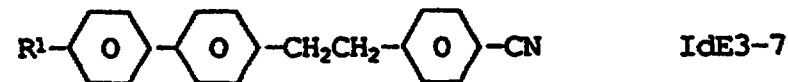
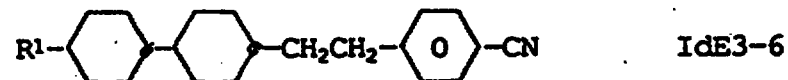
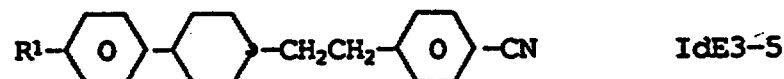
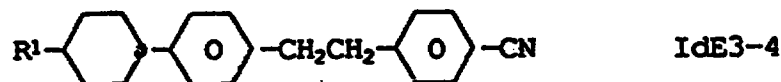
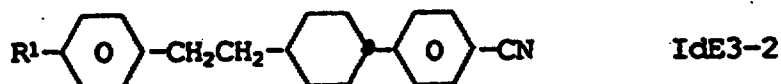
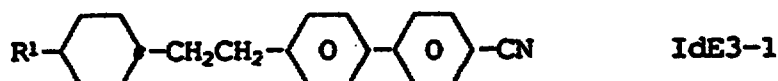
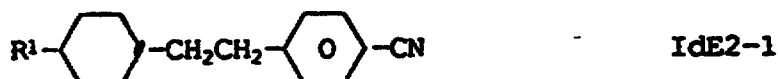
Z^9 is a single bond, -COO-, -OCO- or -CH₂CH₂-

5 Z^{10} is a single bond, -COO- or -CH₂CH₂-, and

s is 0 or 1

and the meaning of R¹ is given in Claim 1.

12. System according to Claim 11, characterized in that the liquid crystal mixture contains one or more
10 compounds selected from the compound classes of the formulae IdE2-1 and IdE3-1 to IdE3-8

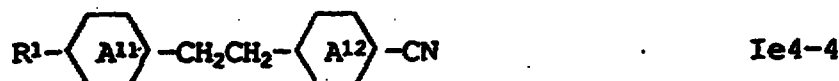
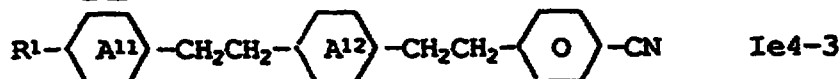
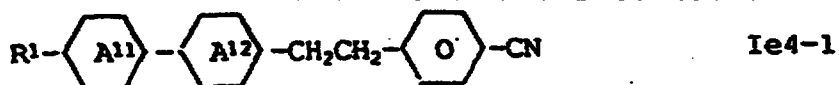


in which the meaning of R¹ is given in Claim 1.

13. System according to one of Claims 1-12, characterized in that the liquid crystal mixture [lacuna] one

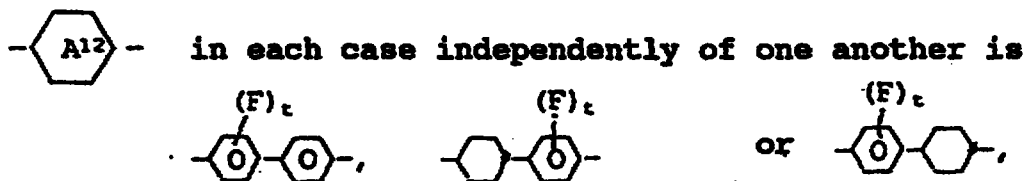


or more 4-ring compounds selected from the group of carbonitriles of the formulae Ie4-1 to Ie4-4



in which

5 A^{11} in each case independently of one another is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene [sic] or trans-1,4-cyclohexylene,



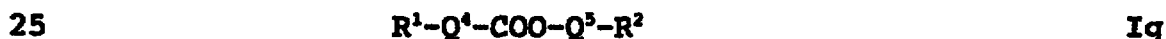
10 t is 0 or 1 and

A^{11} is 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene

and the meaning of R^1 is given in Claim 1.

14. System according to one of Claims 1-13, characterized in that the liquid crystal mixture contains, in addition to a dielectrically positive component A consisting of dielectrically positive compounds having $\Delta\epsilon \geq 2$, a dielectrically neutral component B consisting of compounds having $-2 \leq \Delta\epsilon \leq +2$, and optionally a dielectrically negative component C consisting of compounds having $\Delta\epsilon < -2$.

15. System according to one of Claims 1-14, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ig



in which

the radicals Q^4 and Q^5 in each case independently of one

another are , , , ,  or , and one of Q⁴ and Q⁵ is also -COO- or -COO-, and

5 R¹ and R² in each case independently of one another have the meaning given in Claim 1 for R¹.

16. System according to one of Claims 1-15, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ih

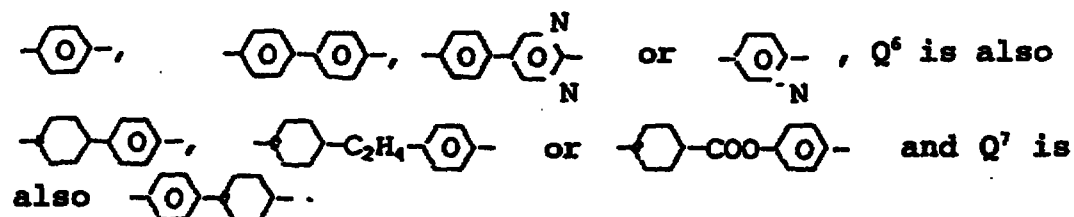


10 in which

at least one of the radicals R¹ and R² has the meaning given in Claim 1 for R¹,

one of the two radicals R¹ and R² is also F, Cl, OCF₃, OCHF₂, or CF₃, and

15 the radicals Q⁶ and Q⁷ independently of one another are



17. System according to one of Claims 1-16, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ii



in which

25 R¹ and R² in each case independently of one another have the meaning given in Claim 1 for R¹, and the radicals Q⁸ and Q⁹ in each case independently of one another are trans-1,4-cyclohexylene, 1,4-phenylene, 4,4'-biphenyl, 4,4'-cyclohexylphenyl or 4,4'-phenylcyclohexyl, where one of the 1,4-phenylene groups present in the molecule can also be substituted by fluorine or chlorine.

18. System according to one of Claims 1-17, characterized in that the liquid crystal mixture additionally contains one or more compounds selected from the group of compounds II-IV



T-W ¹ -Phe-Cn	II
R-W ¹ -Cyc-CN	III
T-V-Phe-CN	IV

in which

- 5 R in each case independently of one another is an alkyl group having 1-15 C atoms, in which one or two non-adjacent CH₂ groups can also be replaced by -O-, -CO- and/or -CH=CH,
- W¹ is Phe.(F)-Y¹ or Cyc-Y¹,
- 10 Y¹ is a single bond, -COO- or -OCO-,
- V is pyridine-2,5-diyl or pyrimidine-2,5-diyl,
- T is R, R-Phe.(F)-Y¹ or R-Cyc-Y¹ and Phe.(F) is 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene.
- 15 19. System according to one of Claims 1-18, characterized in that the liquid crystal mixture has a dielectric anisotropy $\Delta\epsilon > 3$.
20. System according to Claim 19, characterized in that the mass content of compounds which contain a terminal carbonitrile compound in the liquid crystal mixture is less than 15%.
- 20 21. System according to one of Claims 1-20, characterized in that the liquid crystal mixture is based on compounds which have a dielectric anisotropy
- 25 $3 \leq \Delta\epsilon \leq 15$.
22. System according to one of Claims 1-21, characterized in that the liquid crystal mixture contains a pleochroitic dye.
23. System according to one of Claims 1-22, characterized in that the liquid crystal mixture contains a
- 30 doping component.
24. Use of the electrooptical liquid crystal system according to one of Claims 1-23 for guest-host display systems, for active or passive matrix-controlled
- 35 displays, for projection systems and for switches for large-area display systems.
25. Use of the electrooptical liquid crystal system according to one of Claims 1-23 for architectural applications and for motor vehicles.



26. Electrooptical system, containing an electrooptical liquid crystal system according to one of Claims 1-23, which is controlled by an active matrix.

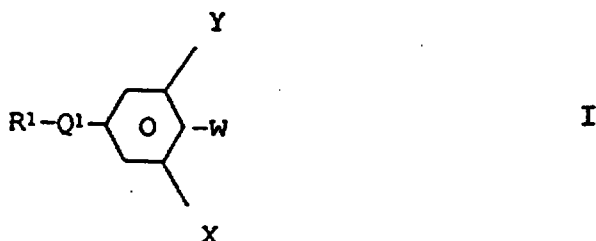


Claims [as printed]

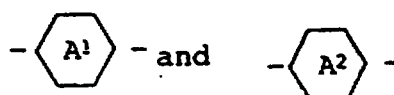
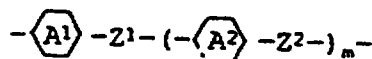
1. Electrooptical liquid crystal system

- which contains a dielectrically positive liquid crystal mixture and a further optically transparent medium between 2 electrodes which are optionally applied to substrate sheets, where the liquid crystal mixture is embedded in the optically transparent medium in the form of compartments which are separated to a greater or lesser extent from one another or forms a more or less coherent, continuous phase in the optically transparent medium,
- whose liquid crystal molecules in the switched-off state have an irregular orientation,
- in which one of the refractive indices of the liquid crystal mixture essentially agrees with the refractive index of the matrix n_M and/or in which the quotient of the mass of the liquid crystal mixture and of the mass of the optically transparent medium is 1.5 or more,
- which, independently of the polarization of the incident light, has a reduced transmission in one of the two switch states compared to the other state,

characterized in that the liquid crystal mixture contains one or more compounds of the formula I



in which
Q¹ is



are independently of one another trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene and one of A¹ and, if present, A², is also diyl, tetrahydropyran-2,5-diyl or naphthalene-2,6-diyl,

Z¹ and Z² are independently of one another a single bond, -CH₂CH₂-, -COO-, -OCO-, -C≡C-, -CH₂O- or any desired combinations of these bridge groups,

Y and X are independently of one another H or F, and one of X and Y is also Cl,

W is -Cl, -F, -CF₃, -OCF₃, -OCHF₂ or -NCS

R¹ is alkyl having 1-12 C atoms, in which one or 2 non-adjacent CH₂ groups can also be replaced by -O- or -HC=CH-, and

m is 0, 1 or 2,

with the provisos that

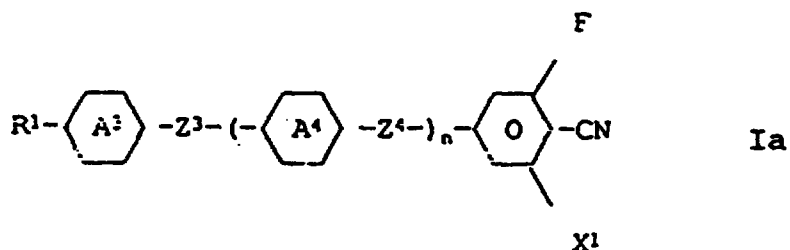
- (i) the mass content of compounds of the formula I in the liquid crystal mixture is at least 50%, and/or
- (ii) the liquid crystal mixture contains no compound of the formula I where W is F or NCS, and/or
- (iii) the liquid crystal mixture has no compound containing a nitrogen-containing heterocycle.

2. System according to Claim 1, characterized in that it is a PDLC system.

3. System according to Claim 1, characterized in that it is an NCAP system.



4. System according to Claim 1, characterized in that it is a PN system.
5. System according to one of Claims 1-4, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ia



in which



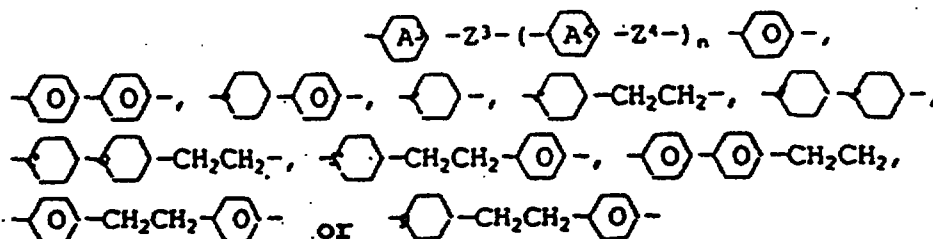
independently of one another are 1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene and

X¹ is H or F

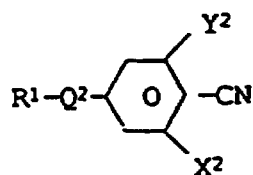
and the following combinations Nos. 1-5 apply to n, Z³ and Z⁴:

No.	n	Z ³	Z ⁴
1	0	single bond	-
2	0	-CH ₂ CH ₂ -	-
3	1	-CH ₂ CH ₂ -	single bond
4	1	single bond	-CH ₂ CH ₂ -
5	1	single bond	single bond

6. System according to Claim 5, characterized in that in the compounds Ia



7. System according to one of Claims 1-6, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ib

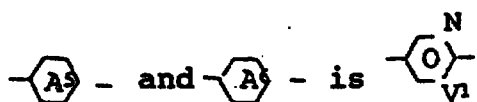


Ib

in which
Q² is

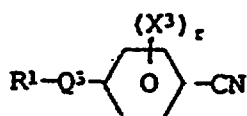


one of the rings



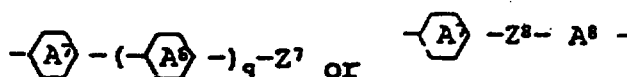
in which V¹ is N or H, and the other, if present, is trans-1,4-cyclohexylene or 1,4-phenylene,
X² and Y² independently of one another are H or F,
p is 0 or 1, and
Z⁵ and Z⁶ independently of one another are a single bond or CH₂CH₂
and R¹ has the meaning given in Claim 1.

8. System according to Claim 7, characterized in that at least one of X² and Y² is F.
9. System according to Claim 7, characterized in that X² = Y² = H.
10. System according to one of Claims 1-9, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ic

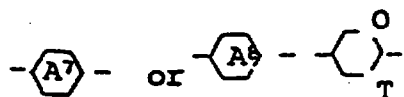


Ic

in which
Q³ is



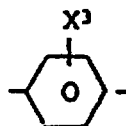
one of the rings



is in which T is -CH₂- or -O-, and the other, if present, is trans-1,4-cyclohexylene, 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene
Z⁷ and Z⁸ independently of one another are a single bond, -COO-, -OCO- or -CH₂CH₂-.

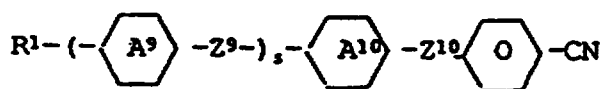


r and q independently of one another are 0 or 1, and
X³ is F or Cl, and



is 2-fluoro- or 2-chloro-1,4-phenylene or 3-fluoro- or 3-chloro-1,4-phenylene,
and the meaning of R¹ is given in Claim 1.

11. System according to one of Claims 1-10, characterized in that the liquid crystal mixture contains one or more compounds of the formula Id



Id

in which



is 1,4-phenylene or trans-1,4-cyclohexylene



is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene

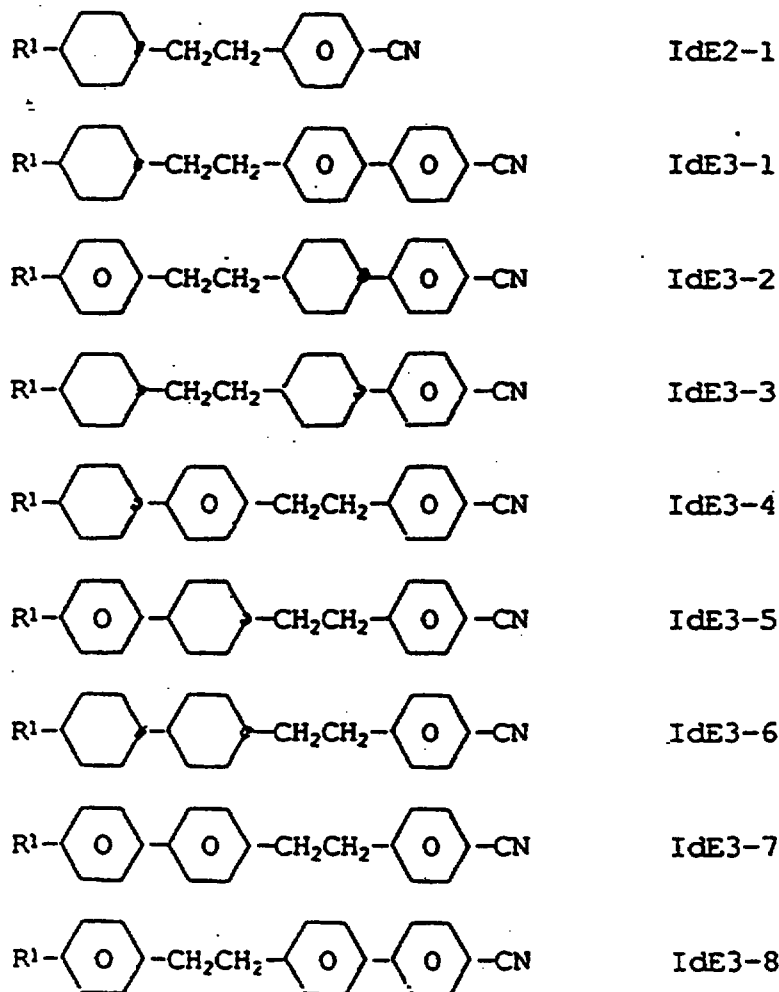
Z⁹ is a single bond, -COO-, -OCO- or -CH₂CH₂-

Z¹⁰ is a single bond, -COO- or -CH₂CH₂-, and

s is 0 or 1

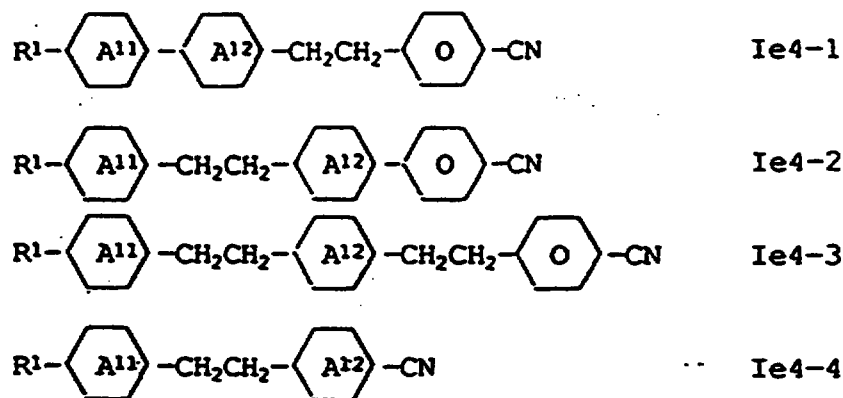
and the meaning of R¹ is given in Claim 1.

12. System according to Claim 11, characterized in that the liquid crystal mixture contains one or more compounds selected from the compound classes of the formulae IdE2-1 and IdE3-1 to IdE3-8



in which the meaning of R¹ is given in Claim 1.

13. System according to one of Claims 1-12, characterized in that the liquid crystal mixture contains one or more 4-ring compounds selected from the group of carbonitriles of the formulae Ie4-1 to Ie4-4



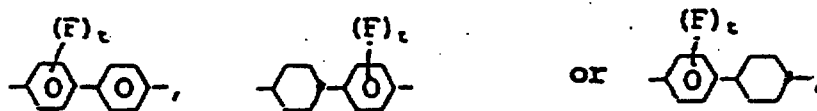
in which



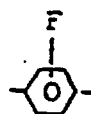
in each case independently of one another is 1,4-phenylene, 2-fluoro-1,4-phenylene, 3-fluoro-1,4-phenylene or trans-1,4-cyclohexylene,



in each case independently of one another is

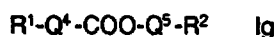


t is 0 or 1 and



is 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene
and the meaning of R¹ is given in Claim 1.

14. System according to one of Claims 1-13, characterized in that the liquid crystal mixture contains, in addition to a dielectrically positive component A consisting of dielectrically positive compounds having $\Delta\epsilon \geq 2$, a dielectrically neutral component B consisting of compounds having $-2 \leq \Delta\epsilon \leq +2$, and optionally a dielectrically negative component C consisting of compounds having $\Delta\epsilon < -2$.
15. System according to one of Claims 1-14, characterized in that the liquid crystal mixture contains one or more compounds of the formula Ig



in which
the radicals Q⁴ and Q⁵ in each case independently of one another are



and one of Q⁴ and Q⁵ is also



and
R¹ and R² in each case independently of one another have the meaning given in Claim 1 for R¹.

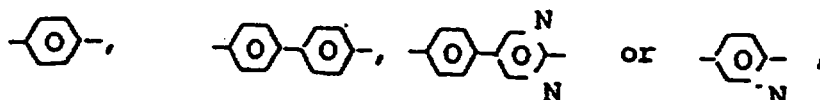


16. System according to one of Claims 1-15, characterized in that the liquid crystal mixture contains one or more compounds of the formula I_h

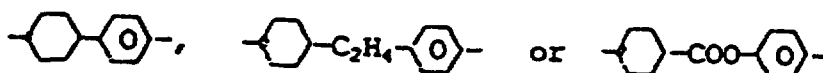


in which

at least one of the radicals R^1 and R^2 has the meaning given in Claim 1 for R^1 , one of the two radicals R^1 and R^2 is also F, Cl, OCF_3 , $OCHF_2$ or CF_3 , and the radicals Q^6 and Q^7 independently of one another are



Q^6 is also



and Q^7 is also



17. System according to one of Claims 1-16, characterized in that the liquid crystal mixture contains one or more compounds of the formula II



in which

R^1 and R^2 in each case independently of one another have the meaning given in Claim 1 for R^1 , and the radicals Q^8 and Q^9 in each case independently of one another are trans-1,4-cyclohexylene, 1,4-phenylene, 4,4'-biphenylene, 4,4'-cyclohexylphenyl or 4,4'-phenylcyclohexyl, where one of the 1,4-phenylene groups present in the molecule can also be substituted by fluorine or chlorine.

18. System according to one of Claims 1-17, characterized in that the liquid crystal mixture additionally contains one or more compounds selected from the group of compounds II-IV



in which

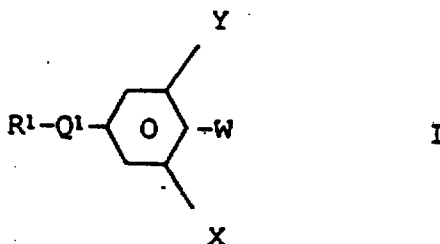
- R in each case independently of one another is an alkyl group having 1-15 C atoms, in which one or two non-adjacent CH_2 groups can also be replaced by $-O-$, $-CO-$ and/or $-CH=CH-$,
 W^1 is Phe.(F)-Y¹ or Cyc-Y¹,
 Y^1 is a single bond, $-COO-$ or $-OCO-$,
 V is pyridine-2,5-diyl or pyrimidine-2,5-diyl,
 T is R, R-Phe.(F)-Y¹ or R-Cyc-Y¹ and
Phe.(F) is 1,4-phenylene, 2-fluoro-1,4-phenylene or 3-fluoro-1,4-phenylene.



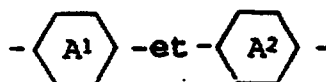
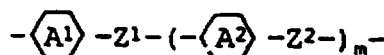
19. System according to one of Claims 1-18, characterized in that the liquid crystal mixture has a dielectric anisotropy $\Delta\epsilon > 3$.
20. System according to Claim 19, characterized in that the mass content of compounds which contain a terminal carbonitrile compound in the liquid crystal mixture is less than 15%.
21. System according to one of Claims 1-20, characterized in that the liquid crystal mixture is based on compounds which have a dielectric anisotropy
 $3 \leq \Delta\epsilon \leq 15$.
22. System according to one of Claims 1-21, characterized in that the liquid crystal mixture contains a pleochroitic dye.
23. System according to one of Claims 1-22, characterized in that the liquid crystal mixture contains a doping component.
24. Use of the electrooptical liquid crystal system according to one of Claims 1-23 for guest-host display systems, for active or passive matrix-controlled displays, for projection systems and for switches for large-area display systems.
25. Use of the electrooptical liquid crystal system according to one of Claims 1-23 for architectural applications and for motor vehicles.
26. Electrooptical system, containing an electrooptical liquid crystal system according to one of Claims 1-23, which is controlled by an active matrix.

Revendications [as printed]

1. Système mésomorphe électro-optique,
 - qui comprend entre deux électrodes, qui sont éventuellement disposées sur des plaques supports, un mélange de cristaux liquides positif du point de vue diélectrique et un autre milieu optiquement transparent, le mélange de cristaux liquides étant enrobé dans le milieu optiquement transparent sous la forme de compartiments plus ou moins séparés les uns des autres ou formant dans le milieu optiquement transparent une phase continue, plus ou moins cohérente,
 - dont les molécules de cristaux liquides présentent à l'état hors circuit une orientation irrégulière,
 - dans lequel l'un des indices de réfraction du mélange de cristaux liquides coïncide pratiquement avec l'indice de réfraction de la matrice n_m et/ou dans lequel le quotient de la masse du mélange de cristaux liquides et de la masse du milieu optiquement transparent vaut 1,5 ou plus,
 - qui présente dans l'un des deux états de commutation indépendamment de la polarisation de la lumière incidente une transmission réduite par rapport à l'autre état,
 caractérisé en ce que
 le mélange de cristaux liquides contient un ou plusieurs composés de formule I



où
Q¹ est



représentent, indépendamment l'un de l'autre, un groupe trans-1,4-cyclohexylène, 1,4-phénylène, 2-fluoro-1,4-phénylène, 3-fluoro-1,4-phénylène et l'un des groupes A¹ et, pour autant qu'il soit présent, A², également un groupe pyridine-2,5-diyle, pyrimidine-2,5-diyle, 1,3-dioxanne-2,5-diyle, tétrahydro-pyranne-2,5-diyle ou naphthalène-2,6-diyle,

Z¹ et Z² représentent, indépendamment l'un de l'autre, une simple liaison, -CH₂CH₂-, -COO-, -OCO-, -C≡C-, -CH₂O- ou des combinaisons quelconques de ces groupes de pontage,

Y et X désignent, indépendamment l'un de l'autre, H ou F, et l'un des radicaux X et Y également Cl,

W représente -Cl, -F, -CF₃, -OCF₃, OCHF₂ ou -NCS,

R¹ désigne un radical alkyle ayant 1-12 atomes de carbone, où également un ou deux groupes CH₂ non vicinaux peuvent être remplacés par -O- ou -HC=CH-, et

m est 0, 1 ou 2,

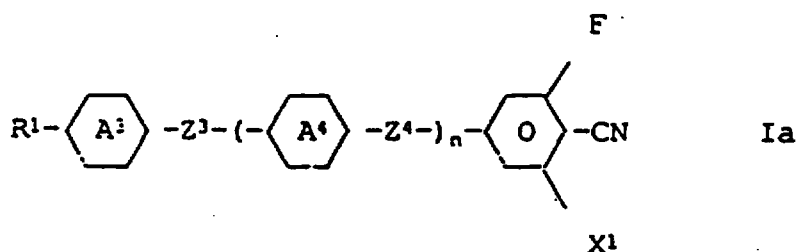
avec pour conditions que

(i) la proportion en masse des composés de formule I par rapport au mélange de cristaux liquides est d'au moins 50%, et/ou

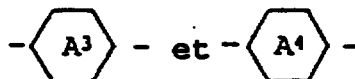
(ii) le mélange de cristaux liquides ne contient aucun composé de formule I ayant W = F ou NCS, et/ou

(iii) le mélange de cristaux liquides ne présente aucun composé comportant un hétérocycle contenant de l'azote.

2. Système selon la revendication 1, caractérisé en ce qu'il s'agit d'un système PDLC.
3. Système selon la revendication 1, caractérisé en ce qu'il s'agit d'un système NCAP.
4. Système selon la revendication 1, caractérisé en ce qu'il s'agit d'un système PN.
5. Système selon l'une quelconque des revendications 1 à 4, caractérisé en ce que le mélange de cristaux liquides contient un ou plusieurs composés de formule Ia



où



représentent, indépendamment l'un de l'autre, un groupe 1,4-cyclohexylène, 1,4-phénylène, 2-fluoro-1,4-phénylène ou 3-fluoro-1,4-phénylène, et

X¹ désigne H ou F,



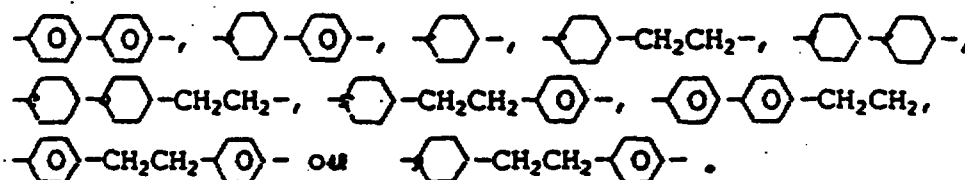
et pour n, Z³ et Z⁴ on a les combinaisons Nos.1-5 ci-après

No.	n	Z ³	Z ⁴
1	0	liaison simple	-
2	0	-CH ₂ CH ₂ -	-
3	1	-CH ₂ CH ₂ -	liaison simple
4	1	liaison simple	-CH ₂ CH ₂ -
5	1	liaison simple	liaison simple

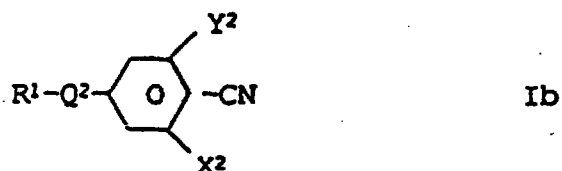
6. Système selon la revendication 5, caractérisé en ce que, dans les composés Ia,



représente



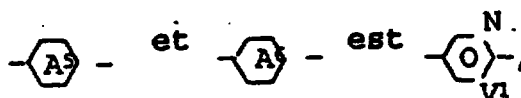
7. Système selon l'une quelconque des revendications 1 à 6, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés de formule Ib,



où
Q² désigne



l'un des cycles

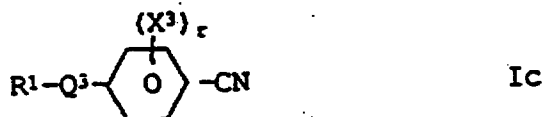


où V¹ est N ou H, et l'autre, s'il est présent, est un cycle trans-1,4-cyclohexylène ou 1,4-phénylène,
X² et Y² sont, indépendamment l'un de l'autre, H ou F,
p est 0 ou 1, et
Z⁵ et Z⁶ sont, indépendamment l'un de l'autre, une liaison simple ou -CH₂CH₂-.



et R³ a la signification indiquée dans la revendication 1.

8. Système selon la revendication 7, caractérisé en ce qu'au moins un des groupes X² et Y² est F.
9. Système selon la revendication 7, caractérisé en ce que X² = Y² = H.
10. Système selon l'une quelconque des revendications 1 à 9, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés de formule Ic,



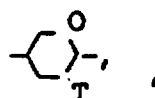
où
Q³ désigne



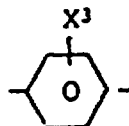
où l'un des cycles



représente

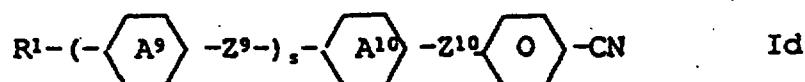


où T désigne -CH₂- ou -O-, et l'autre, dans la mesure où il est présent, désigne un groupe trans-1,4-cyclohexylène, 1,4-phénylène, 2-fluoro-1,4-phénylène ou 3-fluoro-1,4-phénylène,
Z⁷ et Z⁸ représentent, indépendamment l'un de l'autre, une liaison simple, -COO-, -OCO- ou -CH₂CH₂-,
r et q sont, indépendamment l'un de l'autre, 0 ou 1, et
X³ est F ou Cl, et



désigne un groupe 2-fluoro- ou 2-chloro-1,4-phénylène ou 3-fluoro- ou 3-chloro-1,4-phénylène,
et R¹ a la signification indiquée dans la revendication 1.

11. Système selon l'une quelconque des revendications 1 à 10, caractérisé en ce que le mélange mésomorphe contient l'un ou plusieurs des composés de formule Id





où



est un groupe 1,4-phénylène ou trans-1,4-cyclohexylène,



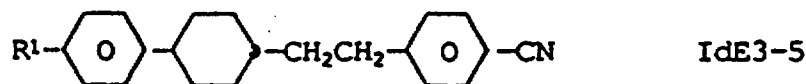
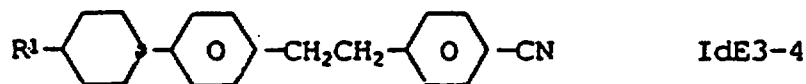
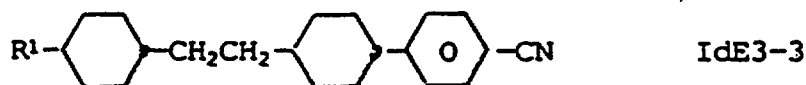
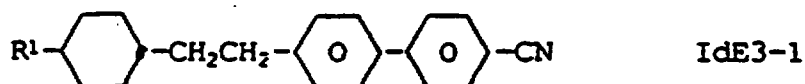
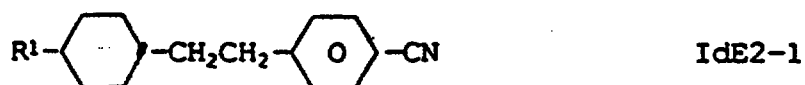
est un groupe 1,4-phénylène, 2-fluoro-1,4-phénylène, 3-fluoro-1,4-phénylène ou trans-1,4-cyclohexylène,

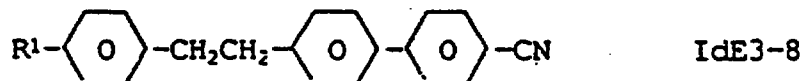
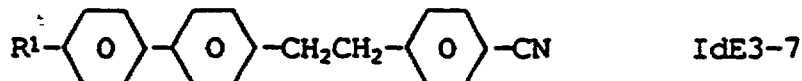
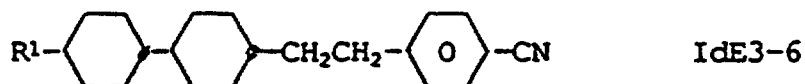
Z^9 représente une liaison simple, $-\text{COO}-$, $-\text{OCO}-$ ou $-\text{CH}_2\text{CH}_2-$,

Z^{10} représente une liaison simple, $-\text{COO}-$ ou $-\text{CH}_2\text{CH}_2-$ et s est 0 ou 1,

et R^1 a la signification indiquée dans la revendication 1.

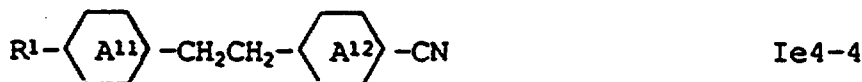
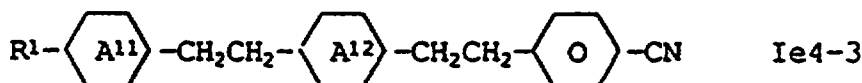
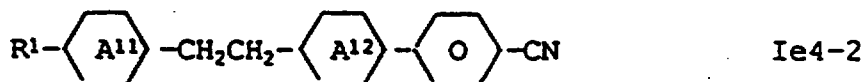
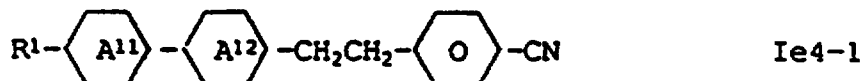
12. Système selon la revendication 11, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés choisis parmi les classes de composés de formules IdE2-1 et IdE3-1 à IdE3-8,





où R¹ a la signification indiquée dans la revendication 1.

13. Système selon l'une quelconque des revendications 1 à 12, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés à 4 cycles, choisis dans le groupe des carbonitriles de formules Ie4-1 à Ie4-4



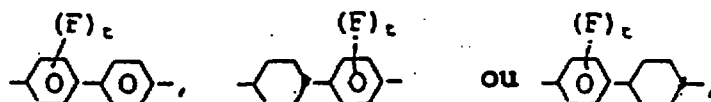
où



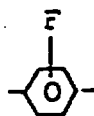
représente, dans chaque cas, indépendamment l'un de l'autre, un groupe 1,4-phénylène, 2-fluoro-1,4-phénylène, 3-fluoro-phénylène ou trans-1,4-cyclohexylène,



représente, dans chaque cas, indépendamment l'un de l'autre,



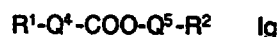
t est 0 ou 1, et



désigne un groupe 2-fluoro-1,4-phénylène ou 3-fluoro-1,4-phénylène, et R¹ a la signification indiquée dans la revendication 1.

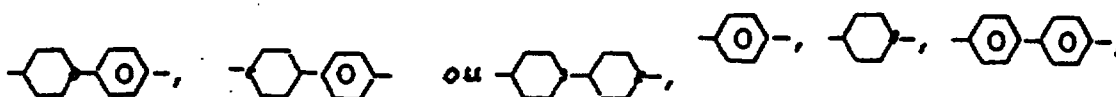
14. Système selon l'une quelconque des revendications 1 à 13, caractérisé en ce que le mélange mésomorphe contient, outre un composant A diélectriquement positif, consistant en des composés diélectriquement positifs ayant $\Delta\epsilon \geq 2$, un composant B diélectriquement neutre, consistant en des composés ayant $-2 \leq \Delta\epsilon \leq +2$, et éventuellement un composant C diélectriquement négatif, consistant en des composés ayant $\Delta\epsilon < -2$.

15. Système selon l'une quelconque des revendications 1 à 14, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés de formule Ig,



où

les restes Q⁴ et Q⁵ désignent, dans chaque cas, indépendamment l'un de l'autre, un radical



et l'un des groupes Q⁴ et Q⁵ désigne également un radical



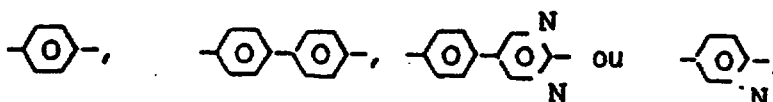
et R¹ et R² ont, chacun indépendamment l'un de l'autre, la signification indiquée dans la revendication 1 pour R¹.

16. Système selon l'une quelconque des revendications 1 à 15, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés de formule Ih,

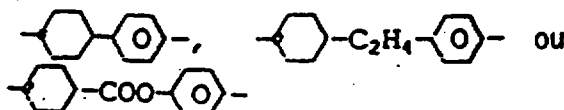


où

au moins l'un des restes R¹ et R² a la signification indiquée dans la revendication 1 pour R¹, l'un des deux restes R¹ et R² désigne également F, Cl, OCF₃, OCHF₂ ou CF₃, et les restes Q⁶ et Q⁷ désignent, indépendamment l'un de l'autre,



Q⁶ désigne également





et Q' représente également



17. Système selon l'une quelconque des revendications 1-16, caractérisé en ce que le mélange mésomorphe contient un ou plusieurs composés de formule II,



où

R¹ et R² ont, dans chaque cas, indépendamment l'un de l'autre, la signification indiquée dans la revendication 1 pour R¹, et les restes Q⁸ et Q⁹ désignent chacun, indépendamment l'un de l'autre, un groupe trans-1,4-cyclohexylène, 1,4-phénylène, 4,4'-biphénylyle, 4,4'-cyclohexylphényle ou 4,4'-phényl-cyclohexyle, tandis que l'un des groupes 1,4-phénylène présents dans la molécule peut également être substitué par un radical fluoro ou chloro.

18. Système selon l'une quelconque des revendications 1 à 17, caractérisé en ce que le mélange mésomorphe contient en outre un ou plusieurs composés, choisis dans le groupe des composés de formules II à IV,



où

- R représente dans chaque cas, indépendamment l'un de l'autre, un groupe alkyle ayant 1 à 15 atomes de carbone, dans lequel également un ou deux groupes -CH₂-non vicinaux peuvent être remplacés par des radicaux -O-, -CO- et/ou -CH=CH,
W¹ désigne Phe.(F)-Y¹ ou Cyc-Y¹,
Y¹ représente une double liaison, -COO- ou -OCO-,
V désigne un radical pyridine-2,5-diyle ou pyrimidine-2,5-diyle,
T désigne R, R-Phe.(F)-Y¹ ou R-Cyc-Y¹, et
Phe.(F) représente un groupe 1,4-phénylène, 2-fluoro-1,4-phénylène ou 3-fluoro-1,4-phénylène.

19. Système selon l'une quelconque des revendications 1 à 18, caractérisé en ce que le mélange mésomorphe a une anisotropie diélectrique $\Delta\epsilon > 3$.
20. Système selon la revendication 19, caractérisé en ce que la proportion en masse des composés présentant un groupement carbonitrile terminal par rapport au composé mésomorphe est inférieure à 15%.
21. Système selon l'une quelconque des revendications 1 à 20, caractérisé en ce que le composé mésomorphe est basé sur des composés présentant une anisotropie diélectrique $3 \leq \Delta\epsilon \leq 15$.
22. Système selon l'une quelconque des revendications 1 à 21, caractérisé en ce que le mélange mésomorphe contient un colorant pléochroïque.
23. Système selon l'une quelconque des revendications 1 à 22, caractérisé en ce que le mélange mésomorphe contient un composant dopé.
24. Utilisation du système mésomorphe électro-optique selon l'une quelconque des revendications 1 à 23 pour des systèmes d'affichage "hôte-hôte", pour des affichages commandés par une matrice active ou passive, pour des systèmes de projection et pour des commutateurs pour systèmes d'affichage de



grande surface.

25. Utilisation du système mésomorphe électro-optique selon l'une quelconque des revendications 1 à 23 pour des applications architectoniques et pour des véhicules automobiles.
26. Système électro-optique, contenant un système mésomorphe électro-optique selon l'une quelconque des revendications 1 à 23, qui est commandé par une matrice active.