

PATENT SPECIFICATION

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(54) A LIQUID CRYSTAL DISPLAY/

(71) We, BBC BROWN, BOVERI & COMPANY LIMITED, a body corporate organized and existing under the laws of Switzerland, of 5401, Baden, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention is concerned with a liquid crystal display, its manufacture, and its subsequent application. This display employs no separate reflector that is disposed on the outside of a cell-plate, and consists of a guest-host liquid crystal layer sandwiched between two cell plates and located between front and rear electrodes.

The nematic liquid crystal guest-host electro-optical effect is well-known (Applied Physics Letters, vol. 13, page 91, 1968) and has already been exploited in electro-optical display devices (see DT-OS 2,410,557). Another type of liquid crystal display is known from the Journal of Applied Physics, vol. 45, pp. 4718-4723, 1974. This display is operated in the reflection mode and employs pleochroic dyes (guest) in a cholesteric liquid crystal solvent (host). This type of display has an unusually bright appearance because it does not use external polarizers. This publication presents the basic operating principle of the cholesteric guest-host display effect (e.g. Figure 1) and also gives useful data on suitable liquid crystal mixtures and other experimental results.

Although liquid crystal displays employing a guest-host liquid crystal layer do not require the troublesome and expensive polarizers, this kind of display has not, until now, been able to compete with the proven technology of the conventional twisted nematic display. This is because noticeable parallax occurs which produces a double image in reflective guest-host displays made by placing a reflector behind the liquid crystal cell. This effect is particularly disturbing in relatively small displays where the width of the electrode segments is comparable to the thickness of the plates used for the cell. This unfavorable relationship is primarily found in displays that are designed for wrist watches and digital voltmeters.

It would then seem sensible to integrate the reflector into the interior of the cell. Unfortunately when this is done disturbing effects appear, particularly in alpha-numeric displays. The internal reflector, which is electrically conducting, takes over the function of a rear electrode in this case with the effect that not only the selected electrodes themselves become visible but also the conducting paths leading to these electrodes. Since these conducting paths can not for technological and electrical reasons be made arbitrarily narrow, this interfering effect hampers the practical application of this kind of display.

The purpose of the present invention is to create a display which does not have the aforementioned drawbacks and is easy to manufacture and which compared to the conventional twisted nematic display has a larger viewing angle.

According to the present invention, we provide a liquid crystal display comprising a guest-host liquid crystal layer located between the front and rear electrodes of two cell plates, and an internal reflector located inside the liquid crystal cells wherein at least the front electrode is composed of segments, and the said reflector has a surface conductivity of at most 10 μ s per square in the plane of the electrode surface and is composed of insulated metal

particles that are deposited on the inner surface of the rear cell plate and the rear electrode.

A display built according to this invention is cheap to manufacture and has outstanding optical properties, in particular a much greater viewing angle than the conventional twisted nematic display; furthermore, the conduction paths leading to the electrode segments do not become visible when an electrode segment is turned on.

The best way to produce the display according to this invention is to make the reflector by coating the rear electrode and the rear cell plate with metallic reflective particles.

Further details of this invention will become clear by referring to the accompanying drawings as well as the subsequent explanations.

Figure 1 shows a schematic illustration of a guest-host liquid crystal display with a type of reflector that is semi-transparent and suitable for either a transmissive or a reflective mode of operation; this is not a display in accordance with the invention, but it is described and illustrated to facilitate comprehension of the invention.

Figure 2 shows a preferred embodiment of the invention; it has a type of internal reflector that employs metal particles.

Figure 3 shows a schematic illustration of the fabrication process of the present (Figure 2) type of internal reflector after the silk-screening step.

Figure 4 shows a schematic illustration of the fabrication process of the present (Figure 2) type of internal reflector after the glass-sealing step.

Figure 5a illustrates the application of a guest-host liquid crystal cell with a digital display in an extra-thin wrist watch.

Figures 5b to 5d show further details of the construction of the wrist watch shown in Figure 5a.

Figure 6 shows a preferred embodiment of a semi-transparent reflector under a magnification indicated by the 10 μm scale bar.

Figure 7 shows a section of the reflector of Figure 6 taken under a higher magnification indicated by the 5 μm scale bar from a direction that makes a 60 degree angle with the plane of the cell plate.

The table set forth below gives the performance characteristics of the guest-host liquid crystal display of this invention as well as those of a conventional twisted nematic display having the same active area.

The corresponding components in all Figures of the accompanying drawings are designated with the same reference numbers.

The guest-host liquid crystal display illustrated in Figure 1, which, as stated above, is not a display in accordance with the present invention, is composed of a front cell plate 1 with a front electrode 2 on its inner surface and a rear cell plate 4 with a rear electrode 3 on its inner surface. A liquid crystal layer 5 is hermetically sealed between the two plates 1, 4 by means of a spacer element 6 which runs around the borders of the plate. The liquid crystal layer 5 has a light-absorbing, helicoidal structure 7 which can be transformed by the application of an electric field to a uniform structure 8 which is only slightly light absorbing, if at all. Such an electric field could be generated, for example, by connecting an a.c. voltage source 12 to the conduction paths 31 and 32 which lead to the electrodes 2 and 3, respectively.

In the reflective mode of operation the liquid crystal display is illuminated from the front side, as indicated here by the illumination source 10. The display is also viewed from this side, an observer's eye being shown at 11. Incident light falling upon the non-absorbing, uniform region 8 of the liquid crystal layer 5 is transmitted through to the rear cell plate 4 which is made from milk glass. This plate also serves as a reflector 9 which diffusely reflects this light through the transparent electrodes 3 and 2 and the transparent cell plate 1 back to the observer's eye 11.

If the illumination at the front (e.g. from source 10) is insufficient, it is possible to operate the liquid crystal display in the transmissive mode by turning on a substitute illumination source 10a that is located behind the rear cell plate 4.

The liquid crystal layer 5 is 10 μm thick and is composed of a nematic liquid crystal mixture with positive dielectric anisotropy to which has been added an optically active substance and a pleochroic dye. An example of such a liquid crystal mixture would be a 1:1:1 by weight nematic mixture of p-butoxy-, p-hexyloxy-, and p-octanoyloxy-benzylidene-p-aminobenzonitrile to which has been added 5-15% of an optically active material such as cholesteryl benzoate and about 0.2-1% of a pleochroic dye such as Indophenol Blue. This type of mixture is known from the literature (Journal of Applied Physics, vol. 45, pages 4718-4723, 1974) and can be replaced with any other mixture that has the same or similar physical properties.

The technology necessary for the fabrication of the cell itself is well-known and can be found in the literature dealing with the fabrication of twisted nematic cells.

Figure 2 illustrates a preferred embodiment of the invention. Only those elements in this figure and in the figures following that differ from those of Figure 1 will be specially

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mentioned. A rear cell plate 4 (Figure 2) made from ordinary glass is coated with a transparent SnO₂ electrode 3. The rear electrode 3 and the remaining uncoated portions of the inner surface of the rear cell plate 4 are both covered with insulated aluminum particles 20. A surface coated with these metal particles 20, which may comprise a coating having a thickness of 0.2 to 5 μ m, functions as a metallic reflector 9 and has a surface conductivity of less than 10 μ S per square.

The embodiment shown in Figure 2 requires capacitative coupling of the driving voltage with respect to the liquid crystal layer, which means that d.c. operation of the liquid crystal display is not possible.

The individual metal particles of aluminum pigment 20 (Figure 2) become covered with a 10-100 Å thick oxide layer in a normal atmosphere. This oxide coating acts as an insulator even though, as is shown in Figure 2, the metal particles are very tightly paced together; there is practically no conductivity in the plane of the electrode surface. There is nonetheless a very good capacitative coupling in the direction normal to the cell plate because the particles lie very close together, and this makes a.c. operation of the display possible.

In the following sections a description of the fabrication techniques employed will be given in order to permit a deeper understanding the invention.

In principle the proven materials such as SnO₂, In₂O₃, Al, Au, etc already employed in the manufacture of twisted nematic cells are also suitable for the electrodes 2 and 3 in all the variants of this invention.

The preferred embodiment of Figure 2 can be manufactured very cheaply. A glass cell plate 4 is coated with a preferably transparent electrode formed by evaporating SnO₂ or In₂O₃. The area of the cell plate 4 that will become the viewing area of the display cell, is then printed with an aluminum pigment paint in the subsequent silk-screening printing process. The aluminum pigment paint is composed of a binder (e.g. a 1:1 by weight mixture of nitrocellulose and amyl acetate) and aluminum pigment particles that have an average size of 2-10 μ m. A border of glass frit, which seals the cell and also acts as the cell spacer 6, can then be printed on the cell plate in the next production step. The optimum thickness of the aluminum pigment paint coating varies with the concentration of the aluminum pigment in the binder and also depends upon whether an ordinary reflector or a semi-transparent reflector is desired. In practice, a 2 to 20 μ m thick paint layer is applied, a 15-20 μ m thick aluminum pigment paint layer being particularly suitable. After putting the two cell plates 1 and 4 together and adjusting their relative positions with respect to the shape of the electrodes 2 and 3, the cell is then put into a glass-sealing oven of the same type that is employed for the glass-sealing process in twisted nematic cells. The cell plates are sealed together after about an hour at an oven temperature of 200-500°C, e.g. 400-500 °C. The binder is burned off during this process, leaving no residue, and the aluminum pigment packs together to form a 2 - 5 μ m thick coating. The abrasion resistance of the aluminum pigment paint and the aluminum pigment can be increased by mixing from 1 to 5% by weight glass frit powder having a particle size of from 0.1 to 5 μ m (e.g. 1 μ m) with the insulated metal particles.

Variants representing further developments in the cell technology of Figure 2 are illustrated in Figures 3 and 4. Non-conducting particles 29 are added to the wet aluminum pigment paint after it is printed onto the cell plate 4. The largest dimension of the particles is 12 μ m, corresponding to the nominal separation of the two cell plates 1 and 4. These non-conducting particles 29 function as cell spacers after glass-sealing process. This has the advantage of letting the glass frit serve its primary purpose of sealing the cell without requiring it to function as a cell spacer as well. Figure 4 shows how the non-conducting particles 29 are surrounded by the aluminum pigment, designated here by the metal particles 20. Because these particles 29 are present in only a very low concentration, a relatively small number of particles being required for each cell, and since they are non-conducting, there is no disturbance to the optical properties of the display. Particles 29 of CeO₂, MgO, Al₂O₃, SiO₂, SiO, TiO, TiO₂ or ZrO₂, or mixtures thereof, have proven to be suitable. The shape of the particles is not critical; 20 - 100 μ m long glass fibers have also proven to be suitable for this application.

In the preceding embodiment the front electrode 2 is made by evaporating SnO₂ or In₂O₃ onto the front cell plate 1. The two cell plates 1,4 are sealed together using glass frit, but a photopolymer, polymerized with subsequent hardening (see the German patent disclosure 2,322,616), or a thermoplastic cement could also be employed.

The outstanding properties of the guest-host liquid crystal displays produced using this invention are summarized in the table set forth below. The table shows that the guest-host liquid crystal displays of the invention could successfully replace the twisted nematic cells used presently by the watch industry. Furthermore, these guest-host liquid crystal displays make it possible to construct digital wrist watches that are considerably thinner than has previously been possible.

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Figure 5a shows that a digital wrist watch 50 fitted with a guest-host liquid crystal display cell 51 does not require a protective watch crystal; the liquid crystal cell 51 can be built directly into the watch case 52 and is relatively insensitive to scratches since the display does not require polarizers, half-wave retardation plates, etc. By this means it is possible to produce extremely flat, elegant, and competitively priced solid state watches. The higher operating voltage required for this display, as compared with the twisted nematic display, can be obtained from several conventional miniature watch batteries connected in series or from a voltage converter circuit. Construction details of the wrist watch 50 will be more specifically described in the following sections.

Figure 5b gives a cross sectional view (section parallel to the long dimension of the liquid crystal cell 51) of the liquid crystal cell 51 that is set into the watch case 52. Also shown in the figure is a circuit board 54 with an integrated circuit 55 mounted on it and a quartz oscillator crystal 56 with its trimming element 57. The watch case 52 is closed with a bottom cover 53.

Figure 5c shows a cross section of the wrist watch 50 that is at right angles to the cross section shown in Figure 5b. The additional elements that are visible here are the two rubber contact gaskets 59 and the two batteries 58. Details of the mounting and contacting of the liquid crystal cell 51 can be seen from the enlarged view shown in Figure 5d. The front cell plate 1 of the liquid crystal cell 51 is tightly cemented into a matching recess in the watch case 52. The rear cell plate 4 of the liquid crystal cell 51 is not as wide as the front cell plate 1, resulting in two offset regions running along the sides of the cell. Rubber contact gaskets 59 are then inserted in both of these offset regions. These rubber contact gaskets 59, which are commercially available, electrically connect the electrode contacts of the cell plates 1 and 4 with the corresponding terminals of the integrated circuit 55 which are brought out onto the circuit board 54.

It is clear that the mounting technique described above can just as well be applied to analog liquid crystal displays. In order not to clutter up the figure with unnecessary details, only a simple, one-function display has been illustrated and the setting buttons, etc. have been omitted. The wrist watch shown in Figure 5a is 29 mm in diameter and less than 8 mm thick.

An internal reflector variant that is especially suitable for application in wrist watches has a semi-transparent reflective layer composed of aluminum pigment. A picture of this reflector is given in Figure 6. This is a scanning electron micrograph and a 10 μ m length has been included for size comparisons. The uncoated regions of the cell plate 4 are visible in Figure 6 as well as in the corresponding Figure 7; also shown is the aluminum pigment 20 that is sticking to the plate. The same particles are designated by the same numbers 20a, 20b, 20c and 20d in these two figures.

The photomicrograph of Figure 6 was taken under perpendicular observation, whereas the photomicrograph of Figure 7 was taken with an inclined orientation of the cell plate 4. The arrow in Figure 7 designated by AR, indicates the direction from which the electron micrograph was taken; it forms an angle of about 60° with the plane of the cell plate 4. This technique enhances the contrast of the electron micrograph.

According to the invention, this type of internal semi-transparent reflector can be fabricated either by a silk-screen printing process or by a spraying technique. This kind of reflector is especially suitable for night-time illumination of the liquid crystal cell by means of an illumination source located behind the cell plate 4.

In the silk-screening technique, insulated metal particles 20 in the form of a viscous aluminum pigment paint having a 3 - 5% by weight fraction of aluminum pigment in a binder, corresponding to 1:32½ to 1:19 ratio of pigment to binder, are coated onto the cell plate 4. The degree of transmission of the reflective layer can be varied over a wide range (approximately between 5 - 50%) by choosing the thickness of the aluminum pigment paint coating. 2 - 12 μ m aluminum pigment particles in a 0.2-5 μ m thick coating have been found to be especially suitable.

The silk-screen printing technique is especially useful for mass production methods. Screens with more than 100 threads per cm are suitable for this application; the prototypes of this invention were made using a screen with 200 threads per cm (Estalmono 200 from the Swiss Silk-Screen Factory, St. Gallen).

Another production process is the spray technique. In this process, 2-12 μ m aluminum pigment particles are mixed with a low-viscosity, nonflammable solvent such as difluorodichloromethane (Freon TF [Registered Trade Mark] from du Pont) in a high-speed mixer or by means of an ultrasonic bath. From 1 - 20 % by weight of the aluminum pigment is mixed with the solvent, with careful attention being given to obtain a uniform mixture without noticeable agglomeration of the pigment particles.

According to this invention, such a mixture is then sprayed onto the pre-cleaned cell plates 4 using a spray gun with a very fine nozzle under a pressure of 4 - 6 atmospheres. The thickness of the coating is chosen to give the desired degree of reflection. Using this technique it is found that the solvent vaporizes before it hits the cell plate and that a substantially

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homogeneous reflector structure is achieved.

In principle these reflectors could already be used in liquid crystal cells, but at this stage they are sensitive to scratching and wiping. A subsequent heat treatment at a temperature of 200-500°C, e.g. 400 - 500°C, for about two hours is therefore recommended to thermally stabilize the reflector and make the cell plate 4 substantially abrasion-proof.

The electron micrographs of Figures 6 and 7 show a reflector produced by the silk-screen printing technique. The scale- or flake-like shapes of the aluminum pigment particles are easily seen in these pictures. The uncoated, transparent regions of the glass cell plate 4 show up as dark regions without structure.

Table

of the properties of the guest-host liquid crystal displays of this invention and twisted nematic displays having the same display surface area.

twisted nematic display		cholesteric guest-host liquid crystal display	
Cost	more expensive - requires polarizers and a liquid crystal orienting layer on the cell plates	considerably cheaper in spite of the extra costs for the dye	
Operating Voltage	3 V	6 - 12 V	
(4 digits driven at 3 V)	0.2 μA	Current consumption 0.4 - 1 μA	
Total of rise and decay times	350m sec	< 350 m sec	
Capability for multiplexing	N ≈ 3 digits	N > 3 digits	
Display type	"on" : black "off": white "on" : white "off": black	"on" : white (i.e. "off": black (i.e. dark or coloured)	
Brightness	25%	> 25% for various contrast ratios	
Contrast ratio	12:1	> 12 : 1	
Angle dependence	adequate	very good	

Denotation list for figures

1	=	front cell plate	
2	=	front electrode	
3	=	rear electrode	
4	=	rear cell plate	
5	=	liquid crystal layer	
6	=	spacer	
7	=	light-absorbing helicoidal structure	
8	=	non-absorbing uniform structure	
9	=	reflector	
10	=	illumination source	
10a	=	switchable, substitute light source	
11	=	observer	
12	=	a.c. voltage source	
20	=	insulated metal particles	
28	=	binder	
29	=	non-conductive spacer particles	
31	=	conduction path to electrode 2	
32	=	conduction path to electrode 3	
50	=	digital wrist watch	
51	=	guest-host liquid crystal cell	
52	=	watch case	
53	=	bottom cover to watch case	
54	=	circuit board	
55	=	integrated circuit	
56	=	quartz oscillator crystal	
57	=	frequency trimming element	
58	=	battery	
59	=	rubber contact gasket	
20a, b, c, d	=	aluminum pigment particles	
AR	=	viewing direction of the electron microscope	

WHAT WE CLAIM IS:-

1. A liquid crystal display comprising a guest-host liquid crystal layer located between the front and rear electrodes of two cell plates, and an internal reflector located inside the liquid crystal cell, wherein at least the front electrode is composed of segments, and said reflector has a surface conductivity of at most $10 \mu\text{S}$ per square in the plane of the electrode surface and is composed of insulated metal particles that are deposited on the inner surface of the rear cell plate and the rear electrode.
2. A liquid crystal display according to claim 1, wherein said insulated metal particles are aluminium pigment particles which form a coating that is from 0.2 to $5 \mu\text{m}$ thick.
3. A liquid crystal display according to claim 2, wherein said reflector is semi-transparent, and wherein said insulated metal particles are from 2 to $12 \mu\text{m}$ aluminium pigment particles.
4. A liquid crystal display according to any of claims 1 to 3, wherein from 1 to 5% by weight glass frit powder having a particle size of from 0.1 to $5 \mu\text{m}$ is mixed with the insulated metal particles.
5. A liquid crystal display according to any of claims 1 to 3, wherein non-conducting particles are mixed with the insulated metal particles, and the largest dimension of said non-conducting particles corresponds at least approximately to the nominal cell spacing.
6. A liquid crystal display according to claim 5, wherein said non-conducting particles are particles of CeO_2 , MgO , Al_2O_3 , SiO_2 , SiO , TiO , TiO_2 , or ZrO_2 , or mixtures thereof.
7. A liquid crystal display according to any of claims 1 to 6, wherein 20 to $100 \mu\text{m}$ long glass fibers whose diameters correspond to the nominal spacing of the cell plates are mixed with the insulated metal particles.
8. A process for the manufacture of a liquid crystal display device according to claim 1, wherein the reflector is created by coating the rear electrode and rear cell plate with metallic reflective particles.
9. A process according to claim 8, wherein the rear electrode and the rear cell plate are coated with a 2 to $20 \mu\text{m}$ thick layer of a mixture consisting of metal particles in a binder, the

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Denotation list for figures

1	=	front cell plate	
2	=	front electrode	
5 3	=	rear electrode	5
4	=	rear cell plate	
5	=	liquid crystal layer	
6	=	spacer	
10 7	=	light-absorbing helicoidal structure	10
8	=	non-absorbing uniform structure	
9	=	reflector	
10	=	illumination source	
15 10a	=	switchable, substitute light source	15
11	=	observer	
12	=	a.c. voltage source	
20	=	insulated metal particles	
20 28	=	binder	20
29	=	non-conductive spacer particles	
31	=	conduction path to electrode 2	
32	=	conduction path to electrode 3	
50	=	digital wrist watch	
25 51	=	guest-host liquid crystal cell	25
52	=	watch case	
53	=	bottom cover to watch case	
54	=	circuit board	
30 55	=	integrated circuit	30
56	=	quartz oscillator crystal	
57	=	frequency trimming element	
58	=	battery	
35 59	=	rubber contact gasket	35
20a, b, c, d	=	aluminum pigment particles	
AR	=	viewing direction of the electron microscope	

WHAT WE CLAIM IS:-

- 40 1. A liquid crystal display comprising a guest-host liquid crystal layer located between the front and rear electrodes of two cell plates, and an internal reflector located inside the liquid crystal cell, wherein at least the front electrode is composed of segments, and said reflector has a surface conductivity of at most $10 \mu\text{S}$ per square in the plane of the electrode surface and is composed of insulated metal particles that are deposited on the inner surface of the rear cell plate and the rear electrode.
- 45 2. A liquid crystal display according to claim 1, wherein said insulated metal particles are aluminium pigment particles which form a coating that is from 0.2 to $5 \mu\text{m}$ thick.
3. A liquid crystal display according to claim 2, wherein said reflector is semi-transparent, and wherein said insulated metal particles are from 2 to $12 \mu\text{m}$ aluminium pigment particles.
- 50 4. A liquid crystal display according to any of claims 1 to 3, wherein from 1 to 5% by weight glass frit powder having a particle size of from 0.1 to $5 \mu\text{m}$ is mixed with the insulated metal particles.
5. A liquid crystal display according to any of claims 1 to 3, wherein non-conducting particles are mixed with the insulated metal particles, and the largest dimension of said non-conducting particles corresponds at least approximately to the nominal cell spacing.
- 55 6. A liquid crystal display according to claim 5, wherein said non-conducting particles are particles of CeO_2 , MgO , Al_2O_3 , SiO_2 , SiO , TiO , TiO_2 , or ZrO_2 , or mixtures thereof.
7. A liquid crystal display according to any of claims 1 to 6, wherein 20 to $100 \mu\text{m}$ long glass fibers whose diameters correspond to the nominal spacing of the cell plates are mixed with the insulated metal particles.
- 60 8. A process for the manufacture of a liquid crystal display device according to claim 1, wherein the reflector is created by coating the rear electrode and rear cell plate with metallic reflective particles.
9. A process according to claim 8, wherein the rear electrode and the rear cell plate are coated with a 2 to $20 \mu\text{m}$ thick layer of a mixture consisting of metal particles in a binder, the
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binder being dried up or burned off in a subsequent heat treatment at temperatures from 200 to 500°C.

10. A process according to claim 8 or 9, wherein the rear electrode and the rear cell plate are coated using a silk-screen printing technique.

11. A process according to claim 8, 9 or 10, wherein spacer elements are added to the coating mixture or to the wet coating after it has been laid down upon the rear electrode and the rear cell plate.

12. A process according to claim 8 with a semi-transparent reflector, wherein the rear electrode and the rear cell plate are coated with a mixture which is composed of a binder and 2 to 12 μm aluminium pigment particles in an aluminium pigment to binder weight ratio from 1:32 to 1:19.

13. A process according to claim 12, wherein the rear cell plate is coated by means of a silk-screen printing technique using a fine-mesh screen that has more than 100 threads per cm.

14. A process according to claim 12 or 13, wherein the aluminium pigment is uniformly mixed with a low viscosity binder and sprayed onto the rear cell plate under a pressure of 4 to 6 atmospheres until a thickness is reached at which the rear cell plate has the desired degree of transmission or reflection.

15. A process according to claim 14, wherein the rear cell plate is heat-treated for at least one minute at a temperature from 400 to 500°C subsequent to the spraying process.

16. Usage of the liquid crystal display as recited in claim 1 as a display device in a time-measuring instrument.

17. Usage of the liquid crystal display as recited in claim 16 in a wrist watch.

18. Usage of the liquid crystal display as recited in claim 17 in a digital wrist watch where the display cell is mounted directly in the watch case and the front cell plate serves as the watch crystal.

19. A liquid crystal display according to claim 1 substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

20. A process according to claim 8 substantially as hereinbefore described with reference to the accompanying drawings.

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