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Declaration under Rule 4.17:

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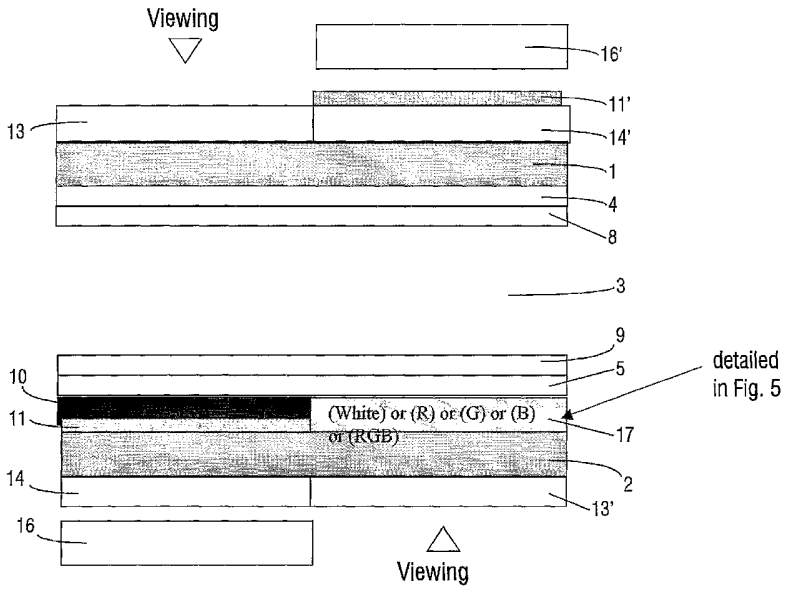
[Continued on next page]

(54) Title: TWO-SIDED READABLE DISPLAY DEVICE



(57) Abstract: A flat dual display device is provided comprising a first display section displaying in a first direction and a second display section displaying in a second direction, essentially opposite to said first direction and having certain elements in common, wherein at least one of said first display section and said second display section is a non-monochromatic colour display. Preferably, one of the common elements is a liquid crystal cell comprising a first and a second substrate and twisted nematic liquid crystal material inbetween. Also provided is an apparatus, including a flip phone, a lap-top computer, and an "organizer" comprising such a flat dual display device, wherein at least one of said first display and said second display is a non-monochromatic colour display.

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EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Two-sided readable display device

This invention generally relates to a flat dual display device comprising a first display section displaying in a first direction and a second display section displaying in a second direction, essentially opposite to said first direction and having certain elements in common. The invention further relates to an apparatus comprising such a dual display device, in particular a so-called flip phone, and a method of making the same.

Flip phones generally consist of two parts. One part contains the display, the other part contains the rest of the phone (keyboard etc.). The two parts are usually interconnected via hinges. During usage the phone is opened and the display is readable; after usage the two parts are folded on top of each other. A general problem with these phones is that the display is not readable in folded condition.

One way to solve this problem is to make use of two displays. However, the electrical and mechanical integration of two displays into one device is rather complicated and especially the electrical connections need some special attention. Therefore, this solution is not very cost effective.

Earlier this problem was solved for black and white or monochromatic colour displays by introducing a two-side readable display. For example, a display with 80 lines may be chosen, in which one part of the display (e.g. 16 lines) is used in folded state and the other part (64 lines) is used in opened state. Two back-lighting systems are required for the two display areas. Also the transflector is complementary positioned on two different sides. Figure 3 illustrates this principle.

The same principle is known and/or can be used not only in flip phones, but also in apparatus such as laptop computers, "organizers", and the like.

Dual view LCD assemblies are well-documented in the prior art. For example, EP-A-0881617 discloses a display arrangement comprising one cell which is readable from two different, essentially opposite directions.

Other background art includes GB 2,305,532, WO 00/36578, and JP-A-2000-193956. As far as the inventors are aware, all cited references and two-sided readable display devices relate only to black and white or monochromatic liquid crystal dual display devices.

Currently, there is an increasing demand for mobile phones with colour displays, in addition to laptops and organizers that already have colour displays for some time. However, dual displays in which at least the "main" screen is in colour involves some complications because an RGB array of colours has to be added. In principle the same solution can be applied as with black and white dual displays: pattern the transflector on two different glass plates and keep the colour filter on one glass plate.

However, a problem arises in that two glass plates would have to be patterned which is more complicated and, therefore, rather expensive. Moreover, when using an aluminium/silver reflector an additional overcoat is required with, e.g., indiumtinoxide (ITO) deposited on top to make the electrodes on the non-colour filter containing glass plate. This solution is too complicated and expensive.

The present invention provides a solution for these problems.

SUMMARY OF THE INVENTION

According to one aspect of the present invention a flat dual display device is provided comprising a first display section displaying in a first direction and a second display section displaying in a second direction, essentially opposite to said first direction and having certain elements in common, wherein at least one of said first display section and said second display section is a non-monochromatic colour display. In a prefereed embodiment said flat dual display device further comprises a common liquid crystal cell comprising a first and a second substrate and twisted nematic liquid crystal material inbetween.

According to another aspect of the present invention said dual display device comprises a liquid crystal cell comprising a first and second substrate and twisted nematic liquid crystal material inbetween, two viewing areas, the first viewing area comprising a first display section, which comprises a RGB layer and a first transflector layer, wherein said RGB layer and said first transflector layer are positoned to the cell wall of one substrate inside said cell, said first transflector layer being arranged between said cell wall and said RGB layer, and the second viewing area comprising a second display section, which comprises a second transflector layer, wherein said second transflector layer is positioned to the cell wall of the other substrate outside said cell.

According to a further aspect of the invention said first display section is composed of a colour supertwisted nematic ("CSTN") part and said second display system is composed of a "black and white" part, said CSTN part comprising said RGB layer and said

black and white part comprising a layer of transparent lacquer or a monochromatic layer of coloured pixels or another RGB layer, which is preferably unit-driven.

According to still another aspect of the invention a mirror reflective electrode layer is provided in said black and white part being positioned to the cell wall of said first substrate inside said cell.

In another aspect of the invention an apparatus is provided, for example a flip phone, a lap-top computer, an "organizer", and the like, comprising such a flat dual display device, wherein at least one of said first display section and said second display section is a non-monochromatic colour display.

These and other embodiments of the present invention will be explained in more detail in the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic cross-sectional view of a typical CSTN LCD which is suitable for use in the present invention, showing substantially all essential layers and further features of the structure.

Fig. 2 is a diagrammatic cross-sectional view in simplified form of both a typical CSTN LCD (left-hand side; as in Figure 1) and a commonly used prior art B&W LCD (right-hand side).

Fig. 3 is a diagrammatic cross-sectional view of a hybrid, two side readable, state of the art black and white display device.

Fig. 4 is a diagrammatic cross-sectional view of essentially three embodiments of the present invention showing a hybrid, two side readable display device wherein a black and white or monochromatic or CSTN panel (right-hand side) is integrated into a main CSTN panel (left-hand side).

Figs. 5a-c are detailed views of an essential feature of the present invention showing the surface of the layer indicated in Fig. 4. The upper parts of Figs. 5 a-c, referred to as the CSTN part in each Figure, corresponds to the RGB/transflector layers in the main CSTN panel of Fig. 4 (i.e. left-hand side), whereas the lower parts of Figs. 5a-c, referred to as the B&W part in each Figure, corresponds to the black and white or monochromatic or RGB layer, respectively, of the right-hand side panel of Fig. 4.

Fig. 6 is a diagrammatic cross-sectional view of an embodiment of the present invention showing a hybrid, two side readable display device with two CSTN panels (similar

to one of the embodiments of Fig. 4 but upside down), specifying the construction of the mirror and ITO electrode layers.

Fig. 7a and 7b are detailed views of two embodiments of the mirror and ITO electrode layers of Fig. 6. The lower part of both figures correspond to the two layers of the left-hand panel, and the upper part of both figures correspond to the two layers of the right-hand panel.

DETAILED DESCRIPTION OF THE INVENTION

It is to be noted that the same reference numbers are used in the various figures for the same or similar layers or functions. Where the same reference numbers are used within one figure, distinction is made by adding an apostrophe (') to one of them in order to avoid confusion.

Fig. 1 shows in a schematic cross-section substantially all layers of a typical known flat colour device which may now form part of a flat dual display of the present invention. A twisted nematic liquid crystal material 3 is positioned between two protective substrates 1 and 2, usually made of glass or a transparent polymer, which are provided with electrode layers, e.g. ITO (segment) 4 and ITO (commons) 5, a TC layer 7 and two PI layers 8 and 9. As used herein, "ITO" means indium tin oxide, a transparent conductor; "TC" stands for top code, an insulating layer to avoid disruptive discharge; "PI" means polyimide, an orientation or alignment layer. A colour filter 10 and a transflector 11 (e.g. made of aluminium-neodynium (AlNd), having typically a reflection in the range of 20-80%; however, other values including 0 are also possible), together with an overcoat layer 12 are positioned at the inner side of the second substrate 2, i.e. away from the viewing direction (see arrow). The device further comprises a front polar stack 13 and a back polar stack 14. As shown, the front polar stack 13 comprises an optional antireflection layer (a), usually of LR ("low refelction") or AR ("antireflection"), a glare layer (b) (HC ("hard coat") or AG ("antiglare")), a polarizer (c), one or more retarder layers (d), and a front scattering adhesive (e). As shown, the rear polar stack 14 comprises one or more retarder layers (f), a polarizer (g), and, optionally, a reflective polar layer (e.g. of DBEF ("Dual Brightness Enhancement Film")). The substrate layers 1 and 2 with the liquid crystal material 3 and other layers in between are sealed with a conductive seal 6. A flexible interconnection 15 is made through an IC to the electrode layer 4.

Fig. 2 shows in a simplified schematic cross-section the similarities and differences between a typical CSTN LCD (left-hand side, substantially as in Figure 1) and a

B&W LCD (right-hand side). Both LCDs comprise liquid crystal material 3 positioned between two substrates 1 and 2, respectively, which are each provided with electrode layers at their inner areas, i.e. the sides facing the LC material 3, the electrode layers being preferably the ITO layers 4 and 5, and the PI layers 8 and 9. A front polar stack 13 and back polar stack 14, as well as a LED/EL light source 16 is provided in both LCDs. In the CSTN LCD, a colour filter 10 and a transflector 11 is provided which are positioned at the inner side of the second substrate (as in Figure 1), whereas in the B&W LCD no colour filter is present and the transflector 11 is located outside the two substrate layers 1 and 2 at the opposite end of the viewing direction.

Fig. 3 shows in a schematic cross-section the principles of a known flat dual display device which can be used in apparatus such as flip phones, and the like. One display section is shown at the left-hand side with a view at the display from the top, and the other display section is shown at the right-hand side with a view at the display from the bottom. A twisted nematic liquid crystal material 3 is positioned between two substrates 1 and 2, usually made of glass or a transparent polymer, which are provided with electrode layers (ITO layers 4 and 5, and PI layers 8 and 9). The device comprises transflectors 11 and 11', front polar stacks 13 and 13', rear polar stacks 14 and 14', and light sources 16 and 16', respectively. The transflectors 11 and 11', usually a thin metal layer, e.g. aluminium, on plastic films are both situated at the outer sides of the substrates 2 and 1, respectively. The light sources 16 and 16' are electroluminescent films/backlight films or LED-based illumination systems for designing either a monochromatic colour, e.g. green or blue, or a white background.

In both display sections light from the surrounding area passes the transparant electrodes and reflects an image (depending on the voltage on the electrodes and directed through driving signals as is known to a person skilled in the art) which can be viewed as indicated in both sections.

Usually, but not necessarily, either of these first and second display sections is considered the main display section and is therefore larger in size than the other display section. A common and well-known display has, e.g., 80 lines of which the main display is using, e.g., 64 lines and the secondary display which is usually applied for low information density is using, e.g. 16 lines.

According to a preferred embodiment of the present invention the main display section is provided in colour. The construction of this embodiment in its essence is schematically illustrated in Fig. 4. The left-hand side of the device shows the first and main display section with incoming light on front polar stack 13 and reflected light leaving said

stack 13 (beams not drawn) whereas the right-hand side shows the secondary display section. In the first display section an RGB array 10 and a transflector 11 are positioned between the two substrates 1 and 2 adjacent to substrate 2. The presence of the transflector 11 at this position is considered necessary because otherwise the parallax causes incoming light beams and the reflected light beams passing different colour filters resulting in a strong decrease of brightness. When the secondary display section is not provided with colour capability the reflector 11' usually is a classical polar transflector as in Figure 3 and can be positioned outside the cell. The gap 17 which is formed by discontinuing the RGB array layer 9 to restrict said layer to the main display section needs to be filled to maintain the distance between the two substrates. According to one embodiment of the present invention this is suitably done by a transparant varnish, or the like. According to another embodiment of the invention the gap 17 may be filled by a monochromatic layer (green or blue or red pixels).

Thus, in a preferred embodiment of the flat dual display device according to the present invention, a first and main display section is realised in colour by including a RGB array of colours inside the LC cell together with the patronised mirror, whereas the second and secundary display section is realised in black and white or a monochromatic colour by arranging the patronised mirror outside the cell, as before.

In another embodiment of the invention gap 17 may be filled by a RGB filter layer which is driven as a unit of 3 pixels rather than as individual color pixels. This will result in a lower brightness of the colors in the right-hand side display section. Provisions may be made for correction of parallax for colour. This embodiment will result in a dual display device wherein both display sections are realised in full colour.

The differences between the three embodiments mentioned above concerning the layers 10, 11, and 17 are illustrated in Figs. 5a-c, respectively. The upper parts of Figs. 5a-c, referred to as the CSTN part in each figure, corresponds to the RGB/transflector layers 10 and 11 (very thin) in the main CSTN panel of Fig. 4 (i.e. left-hand side), whereas the lower parts of Figs. 5a-c, referred to as the B&W part in each figure, corresponds to the gap 17 of the right-hand side panel of Fig. 4 which is filled up to provide a black and white or monochromatic or RGB layer, respectively.

Fig. 6 and Fig. 7 illustrate further embodiments of a two-side readable CSTN display device of the present invention. Fig. 6 is similar to Fig. 4 except that it is upside down, that gap 17 is filled with a RGB array (see Fig. 5c) and that a mirror reflective electrode layer 18 has been included between the substrates 1 and 2, and is positioned at the inner side of the substrate 1, replacing the transflector 11' outside substrate 1. Fig. 7 shows

two possible variants of a surface view of the ITO layer 4 and mirror reflective electrode layer 18 which is usually made of silver or aluminium. The left-hand drawing illustrates an embodiment in which ITO transparent electrodes pass across the pixels, and the right-hand side drawing illustrates an embodiment where there is a small overlap between these components. It is noted that both the transflector layer 11 and the mirror reflective electrode layer are very thin, so that differences in thicknesses are relatively small.

A typical general example of how the present invention can be practised is illustrated by, but not limited to, the embodiment of Figure 4 illustrating schematically the most essential parts of the optical constructs of the first (CSTN) and second (FSTN) display sections in more detail. In the CSTN display on the left-hand side an incoming light beam (not shown) from the surrounding area passes sequentially a polar filter, a diffusor film layer, a retardation layer and enters the LC cell by passing the first substrate. The beam passes the colour filter and is then reflected by the mirror or reflector layer between the colour filter and the second substrate layer to pass the same layers in opposite direction and leave this display section. In the FSTN construct on the right-hand side an incoming light beam from the surrounding area passes sequentially a polar filter, a retardation layer, the LC cell (i.e. the first substrate, the LC layer, and the second substrate), another polar filter, a diffusor layer, and is reflected by the patterned mirror or reflector layer outside the cell, to pass the same layers in opposite direction and leave this display section.

It will be understood by those skilled in the art that the sequence of layers as shown in the display devices of Fig. 4 and 6 can be modified to some extent by adding or deleting one or more layers or change the sequential order. These modifications are all included within the scope of the present invention.

The present disclosure is to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency are intended to be embraced therein.

Claims:

1. A flat dual display device comprising a first display section displaying in a first direction and a second display section displaying in a second direction, essentially opposite to said first direction and having certain elements in common, characterised in that at least one of said first display section and said second display section is a non-monochromatic colour display.

2. A flat dual display device according to claim 1 further comprising a common liquid crystal cell comprising a first and a second substrate and twisted nematic liquid crystal material inbetween.

3. A flat dual display device according to claim 1 or 2 which comprises a liquid crystal cell comprising two substrates (1) and (2) and twisted nematic liquid crystal material (3) inbetween, two viewing areas, the first viewing area comprising a first display section, which comprises a RGB layer (10) and a first transflector layer (11), wherein said RGB layer (10) and said first transflector layer (11) are positoned to the cell wall of one substrate (2) inside said cell, said first transflector layer (11) being arranged between said cell wall (2) and said RGB layer (10), and the second viewing area comprising a second display section, which comprises a second transflector layer (11'), wherein said second transflector layer (11') is positioned to the cell wall of the other substrate (1) outside said cell.

4. A flat dual display according to any one of claims 1 to 3, wherein said first display section is composed of a colour supertwisted nematic (CSTN) part comprising said RGB layer (10) and said second display system comprising a layer of transparent lacquer (17) to provide a black and white display.

5. A flat dual display according to any one of claims 1 to 3, wherein said first display section is composed of a CSTN part comprising said RGB layer (10) and said second display system comprising a layer (17) of only one of the three pixels to provide a monochromatic display.

6. A flat dual display according to any one of claims 1 to 3, wherein said first display section is composed of a CSTN part comprising said RGB layer (10) and said second display system comprising another RGB layer (17).

7. A flat dual display according to claim 6, wherein said another RGB layer (17) is unit-driven as a black and white part.

8. A flat dual display according to claim 5 or 6, further comprising a mirror reflective electrode layer (18) in said black and white part being positioned to the cell wall of said substrate (1) inside said cell.

9. An apparatus, including a flip phone, a lap-top computer, and an "organizer" comprising a flat dual display device according to any one of claims 1 to 8.

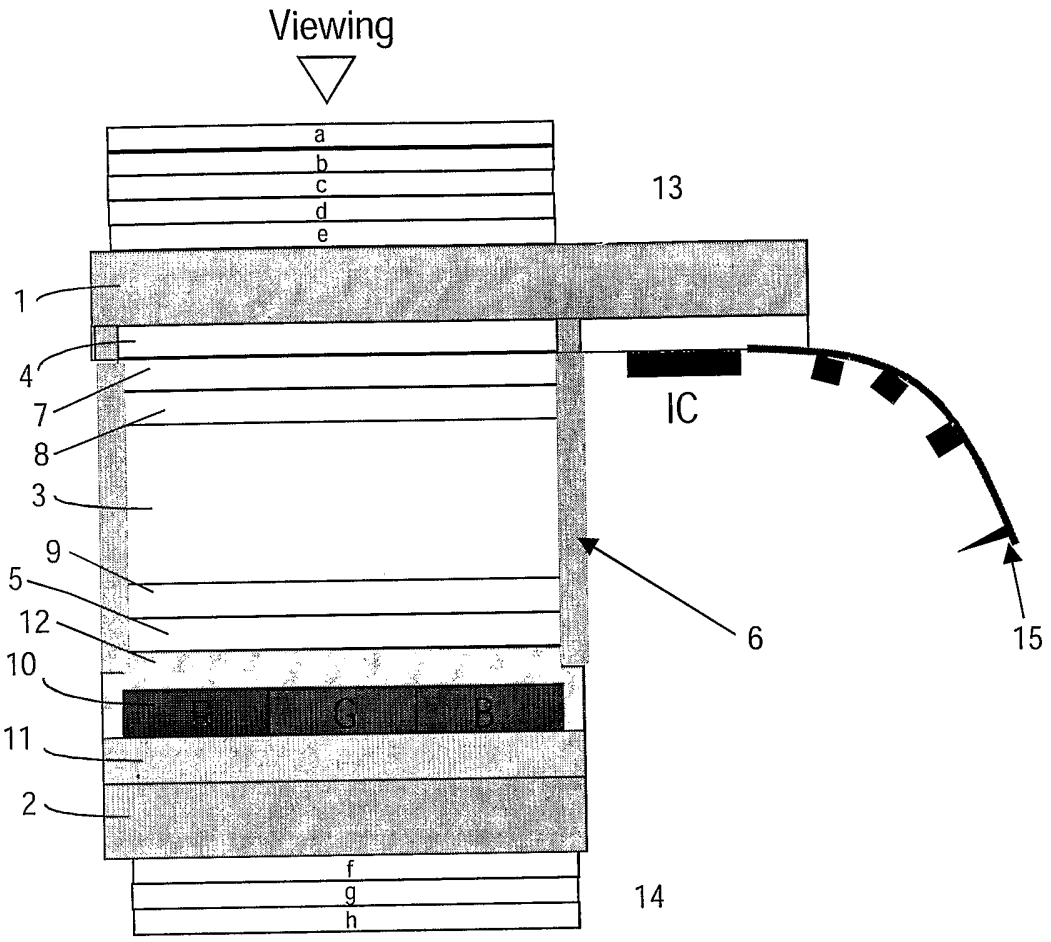
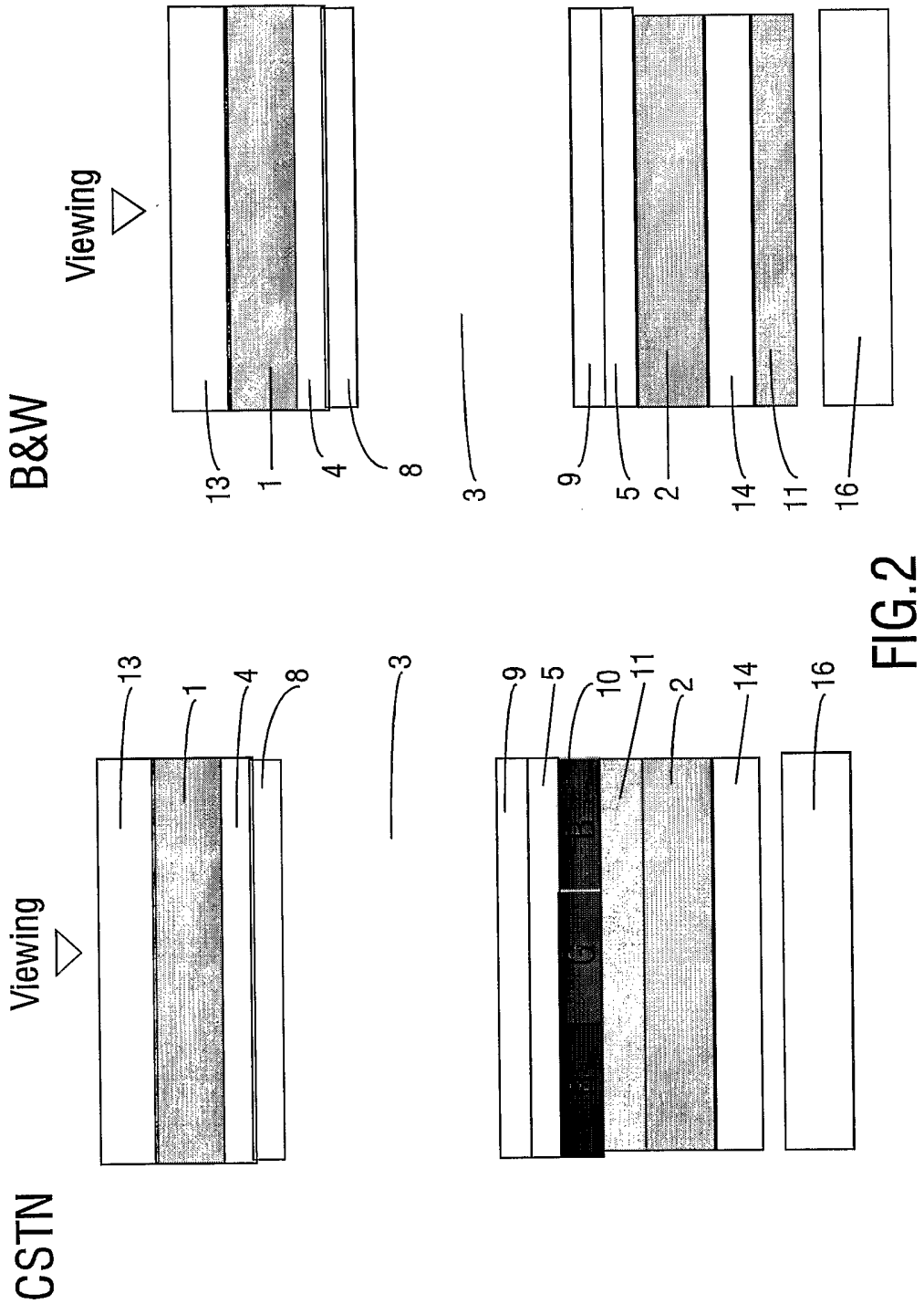


FIG.1


B&W
Viewing
13
1
4
8
3
9
5
2
14
11
16
CSTN
Viewing
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8
3
9
5
10
11
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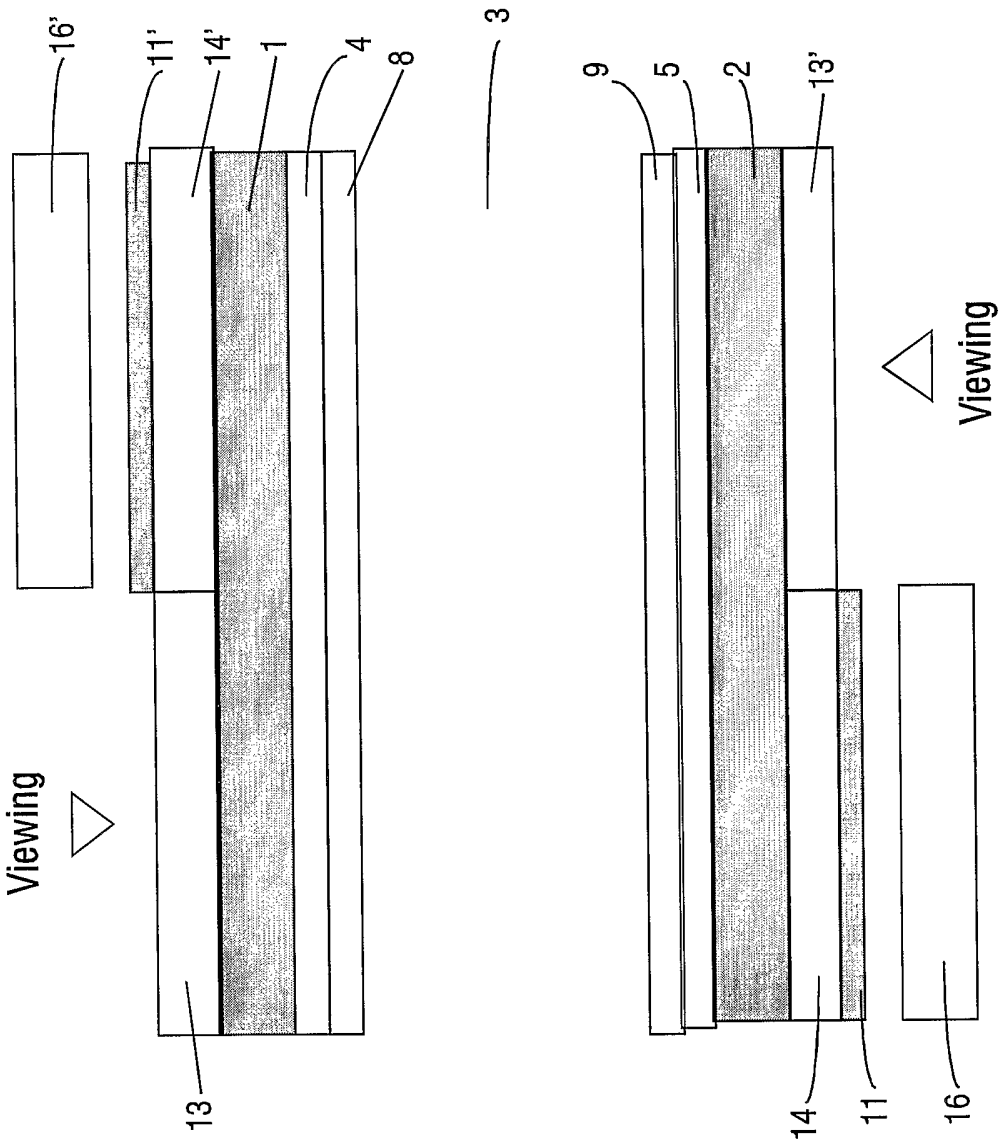
14
16

FIG.2

FIG.3



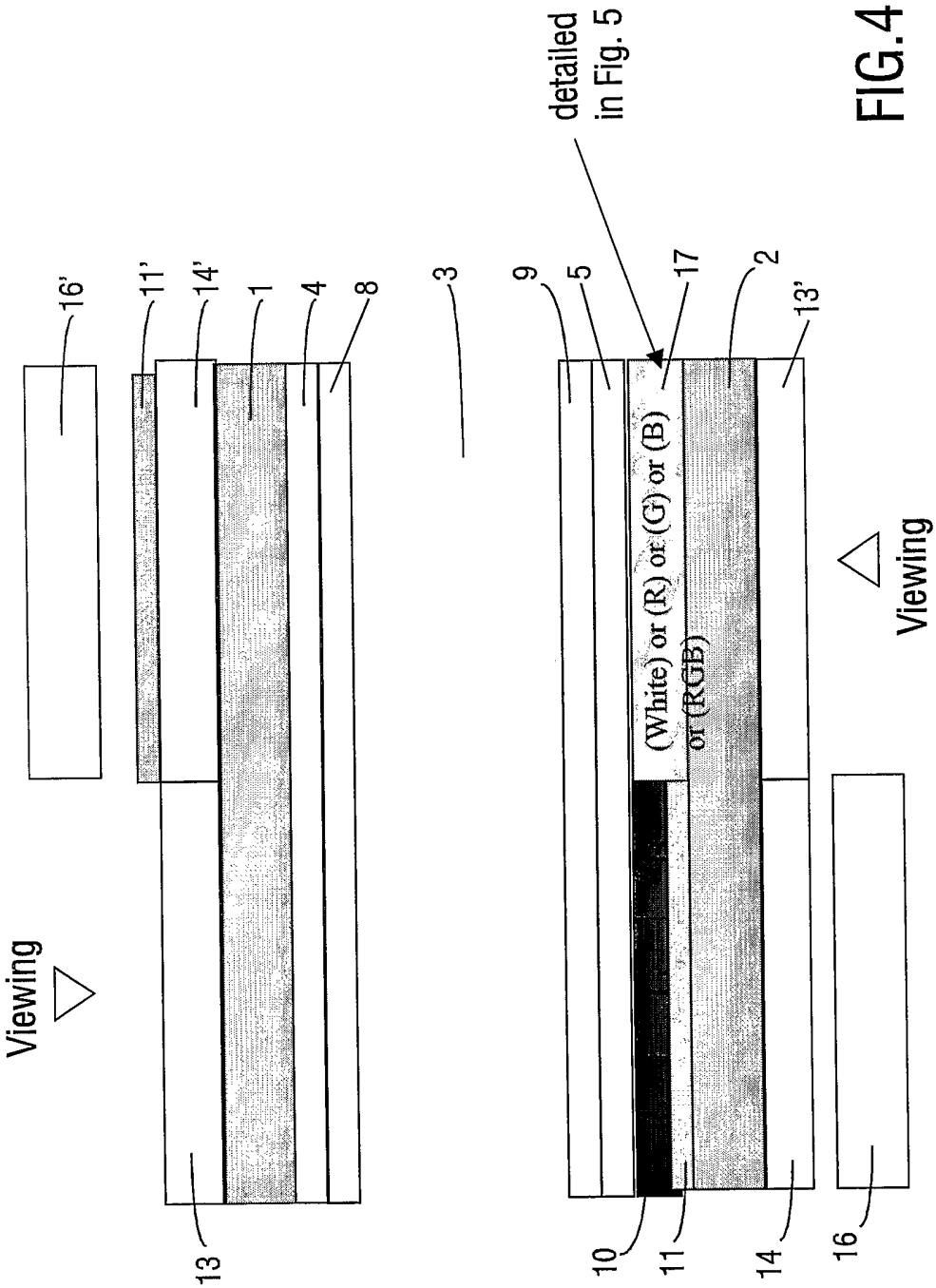

detailed in Fig. 5
16'
11'
14'
1
4
8
3
9
5
17
2
13'
(White) or (R) or (G) or (B) or (RGB)
Viewing
Viewing
13
10
11
14
16

FIG.4

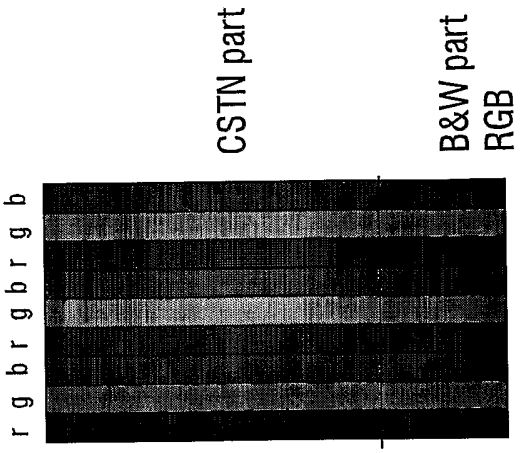


FIG.5c

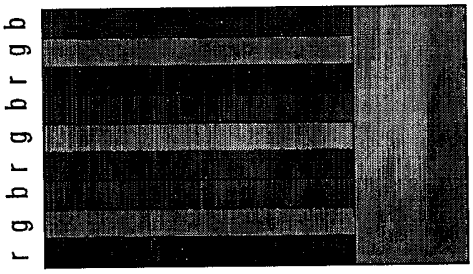


FIG.5b

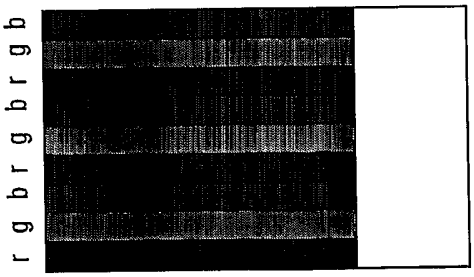
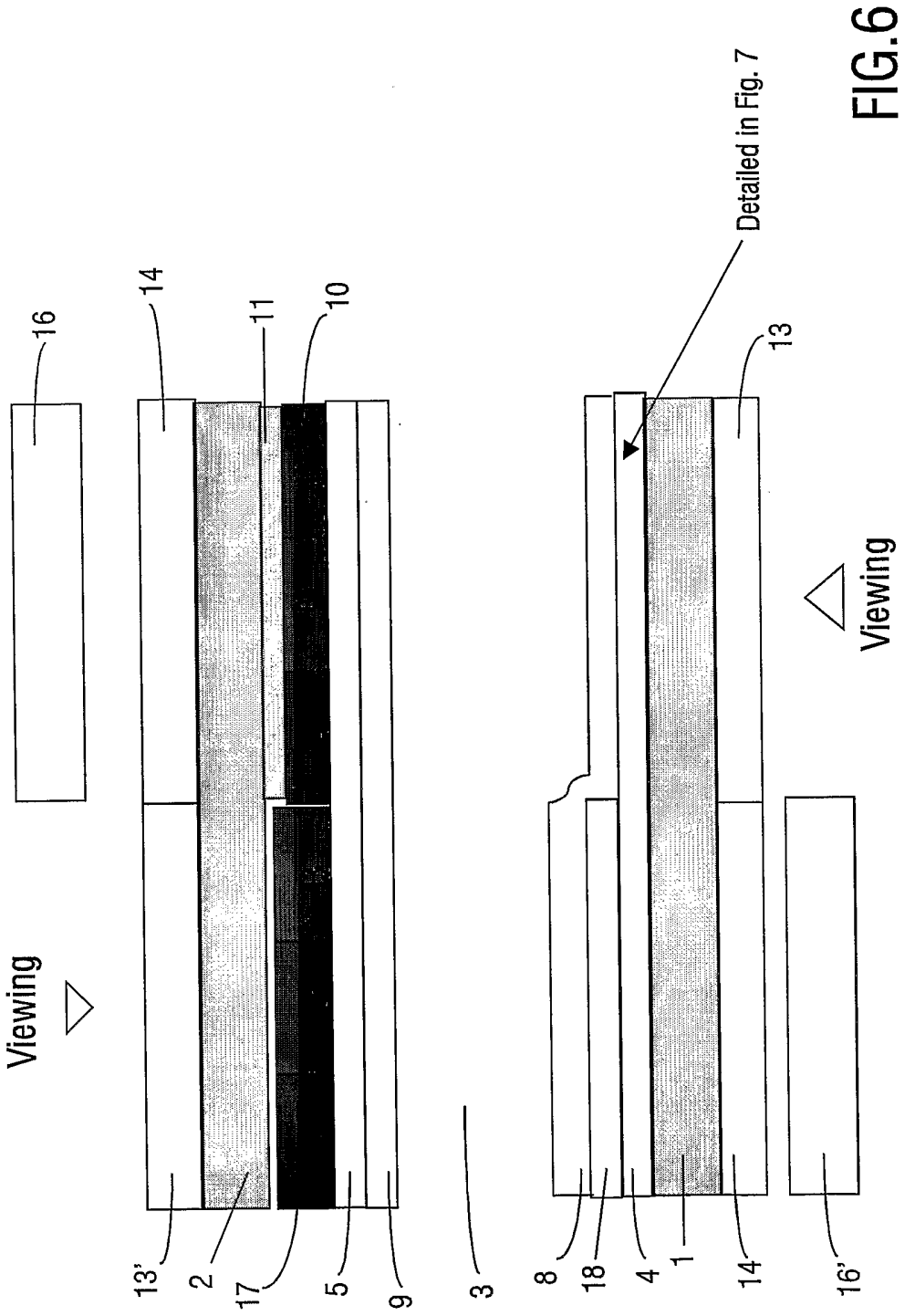


FIG.5a


Detailed in Fig. 7
16
14
11
10
13
Viewing
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2
17
5
9
3
8
18
4
1
14
16'

FIG.6

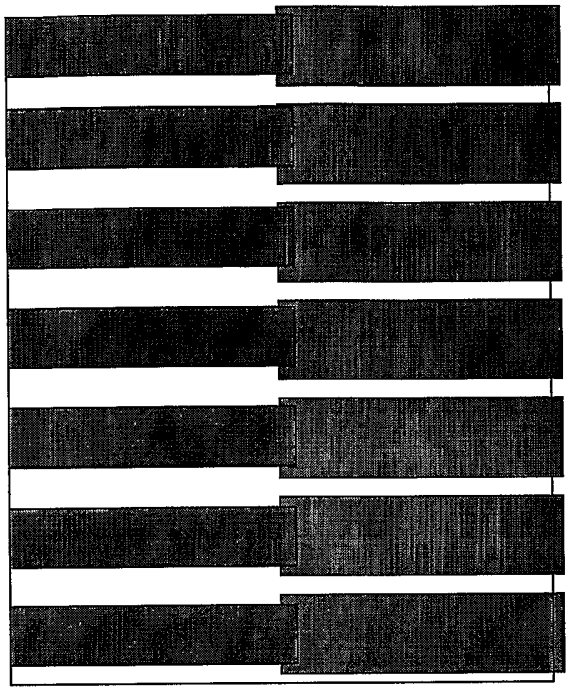

FIG.7b

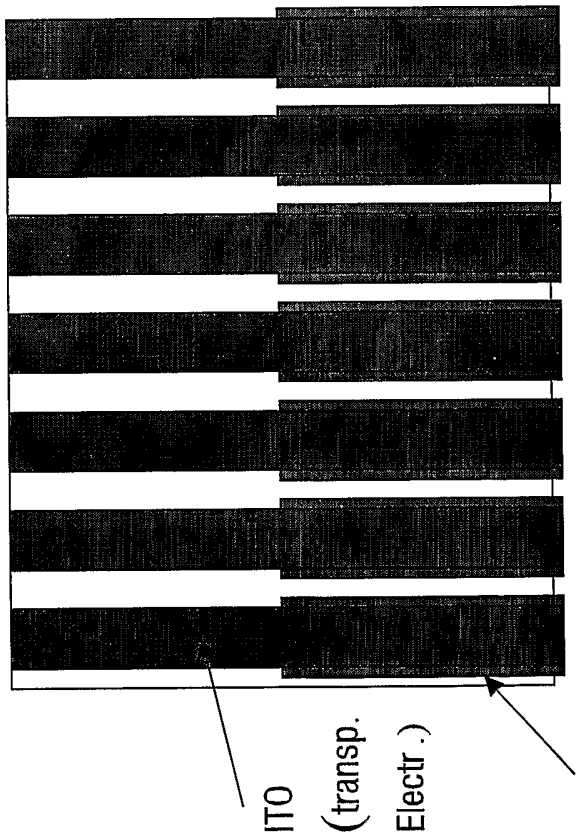

FIG.7a

INTERNATIONAL SEARCH REPORT

International Application No
/IB2004/050700

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02F1/1335

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, INSPEC, IBM-TDB, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 10, 17 November 2000 (2000-11-17) -& JP 2000 193946 A (SEIKO EPSON CORP), 14 July 2000 (2000-07-14)	1,2,4,5, 9
Y	abstract; figures 1-10	3,6-8
Y	US 2002/191135 A1 (KIM HONG JOO) 19 December 2002 (2002-12-19) paragraph '0039! - paragraph '0048!; figure 3	6-8
Y	EP 1 310 821 A (SEIKO EPSON CORP) 14 May 2003 (2003-05-14) paragraph '0053! - paragraph '0066!; figures 1-3,13	3

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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20 August 2004	03/09/2004

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 00/36578 A (QUALCOMM INC) 22 June 2000 (2000-06-22) cited in the application page 3, line 1 - page 10, line 28; figures 2-5	1-9

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