

(21) Application No: **0408742.5**
 (22) Date of Filing: **20.04.2004**

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(51) INT CL⁷:
G02F 1/1347 // G02F 1/139

(52) UK CL (Edition X):
G2F FCD F23E F25F

(56) Documents Cited:
EP 0918247 A **EP 0802684 A**
US 5877829 A **US 5831698 A**

(58) Field of Search:
 UK CL (Edition W) **G2F**
 INT CL⁷ **G02F**
 Other: **ONLINE DATABASE: EPODOC, JAPIO, WPI**

(54) Abstract Title: **Display**

(57) A display comprises a conventional display device, such as a TFT LCD panel (1), which provides image display in the conventional way. In addition, a liquid crystal device (4) is provided in association with the display device (1) so as to allow switching between wide and narrow viewing angle ranges. The liquid crystal device (4) has a layer of liquid crystal molecules which are switchable between two states providing the different viewing angle ranges. Thus, a narrow range (8) may be used for private viewing whereas a wide range (7) may be used to allow several users to see the same image.

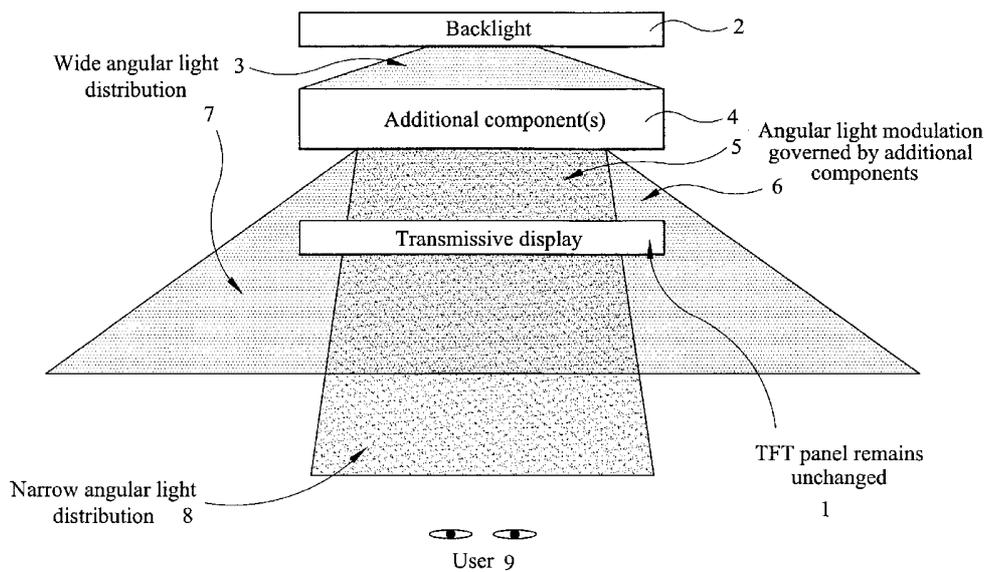


FIG 1^(a)

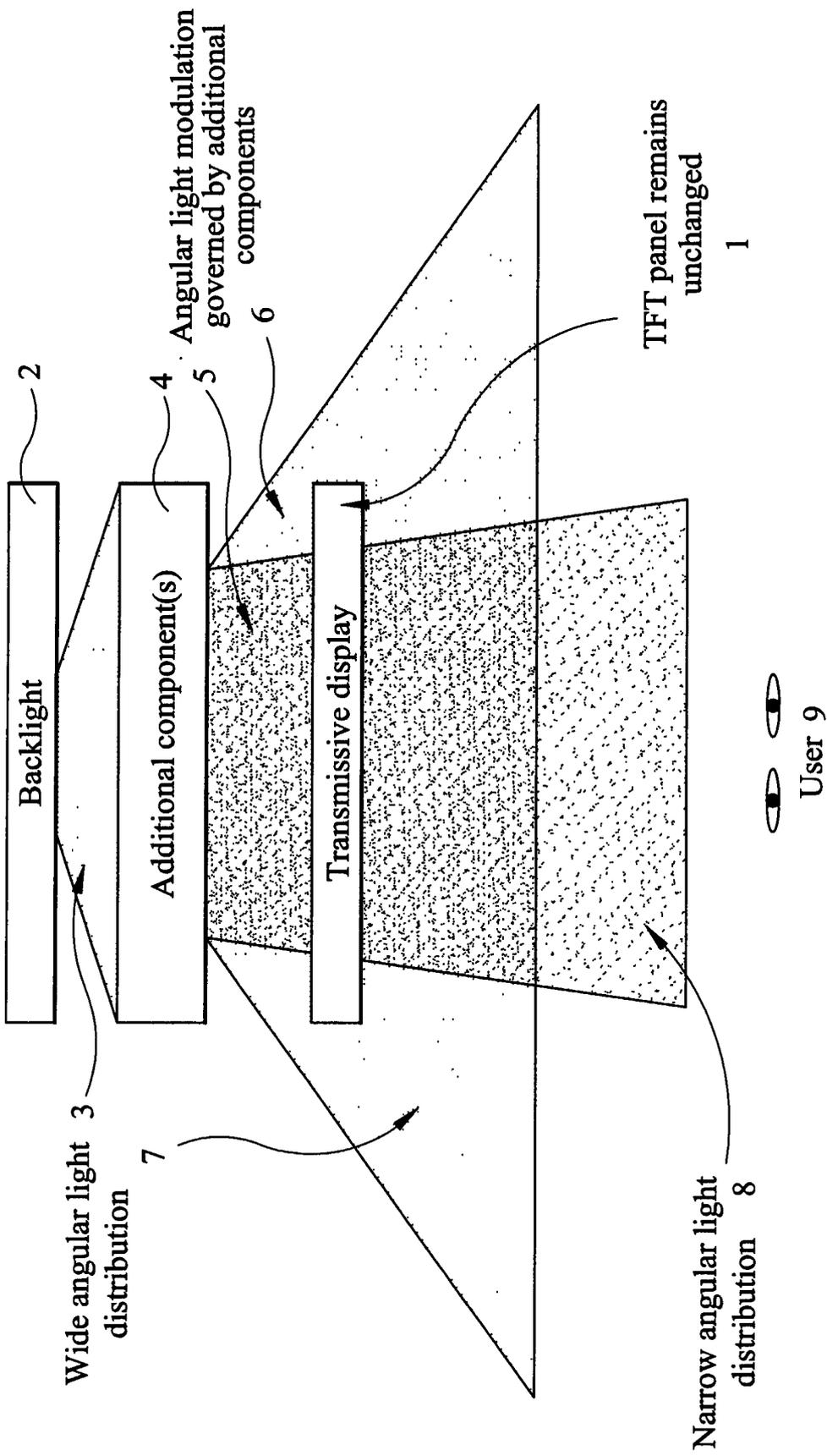
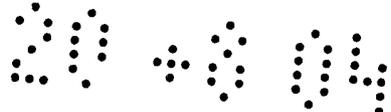


FIG 1(a)

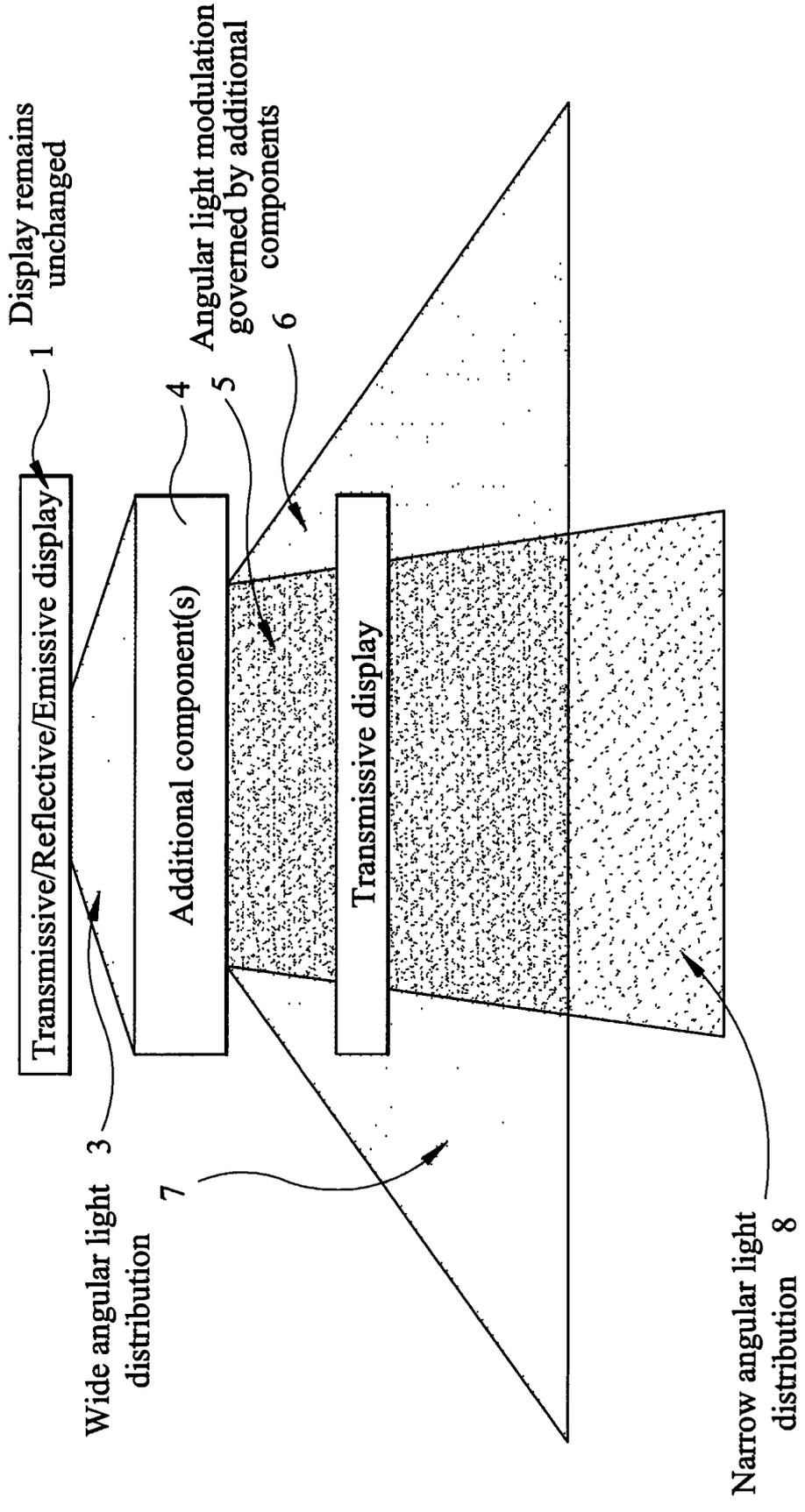
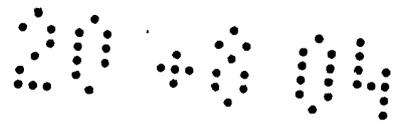


FIG 1(b)

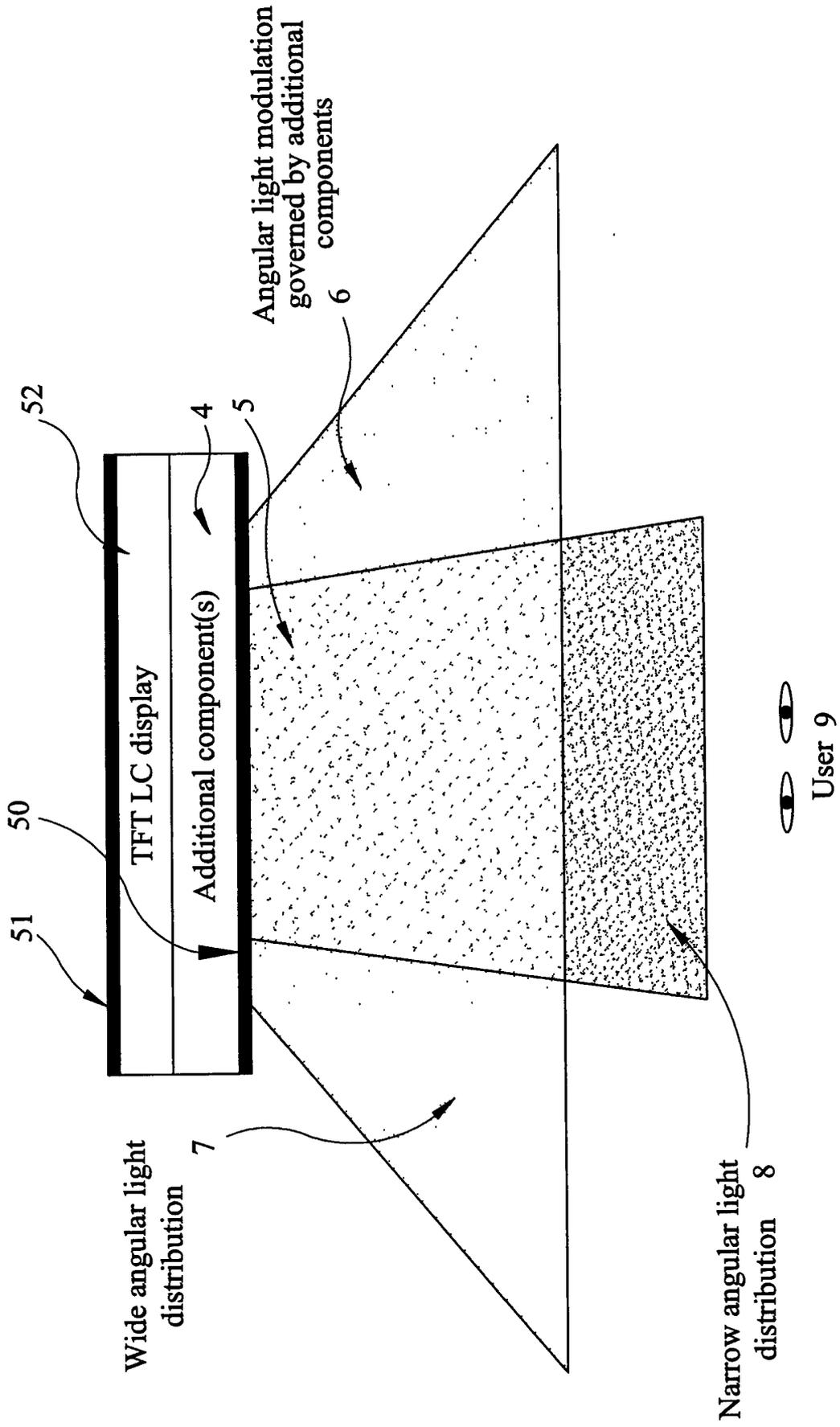
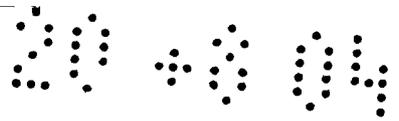


FIG 1(c)

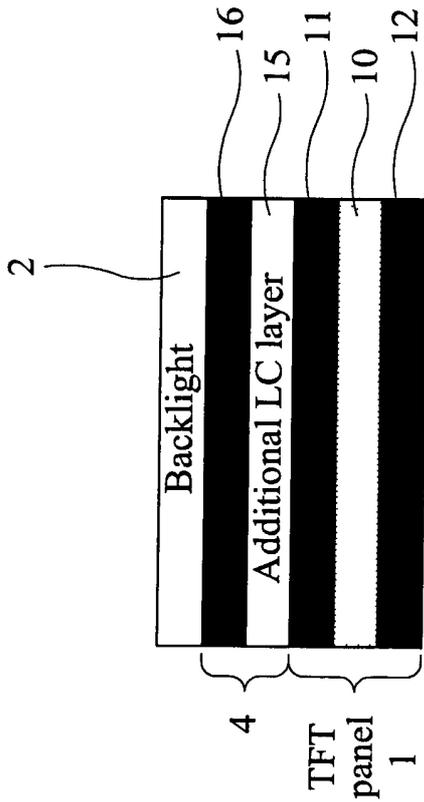
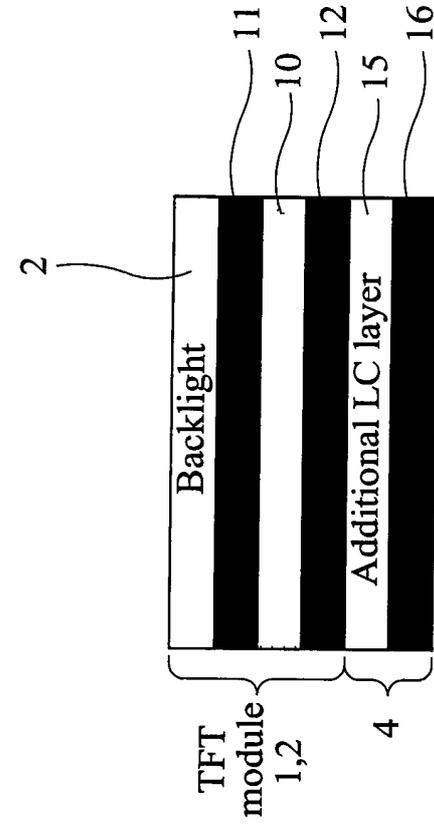
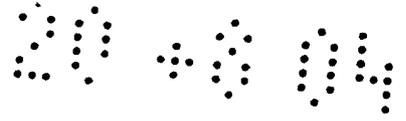


FIG 2(b)

FIG 2(a)



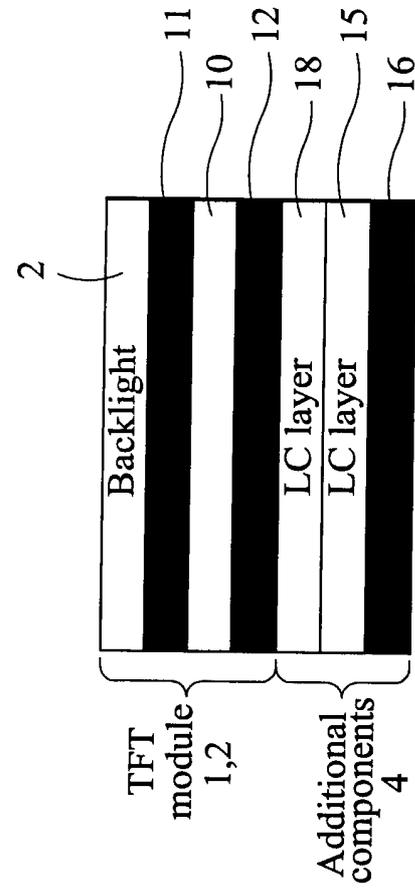


FIG 3(b)

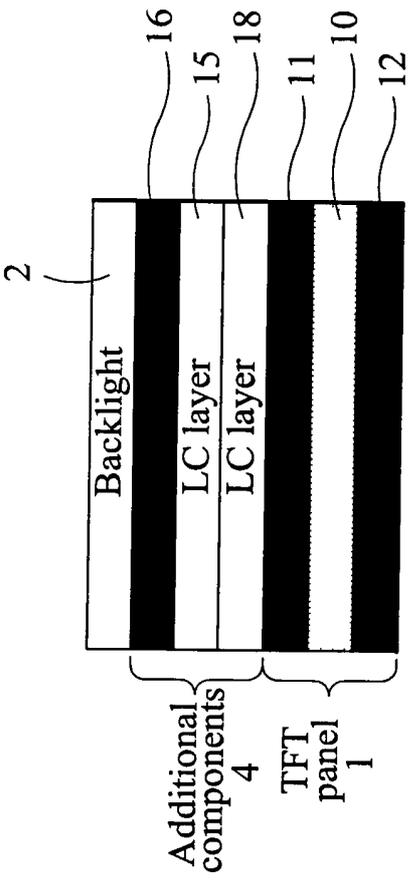


FIG 3(a)

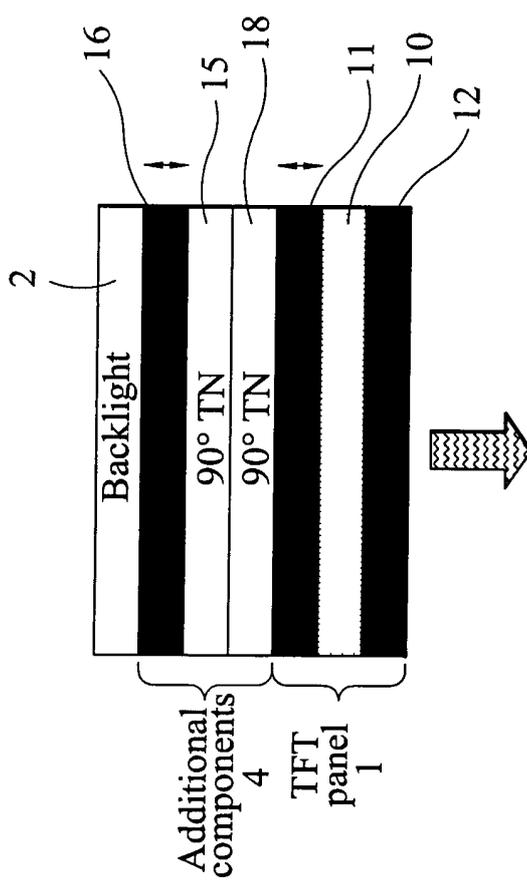
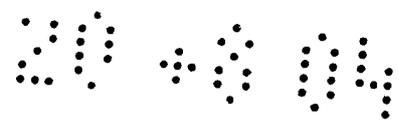
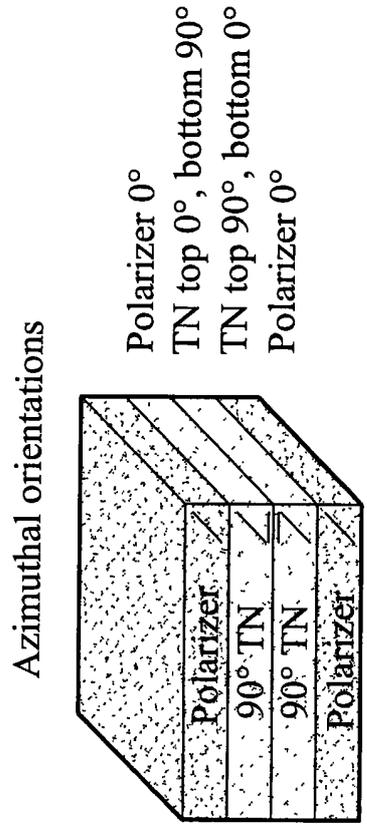


FIG 3(c)



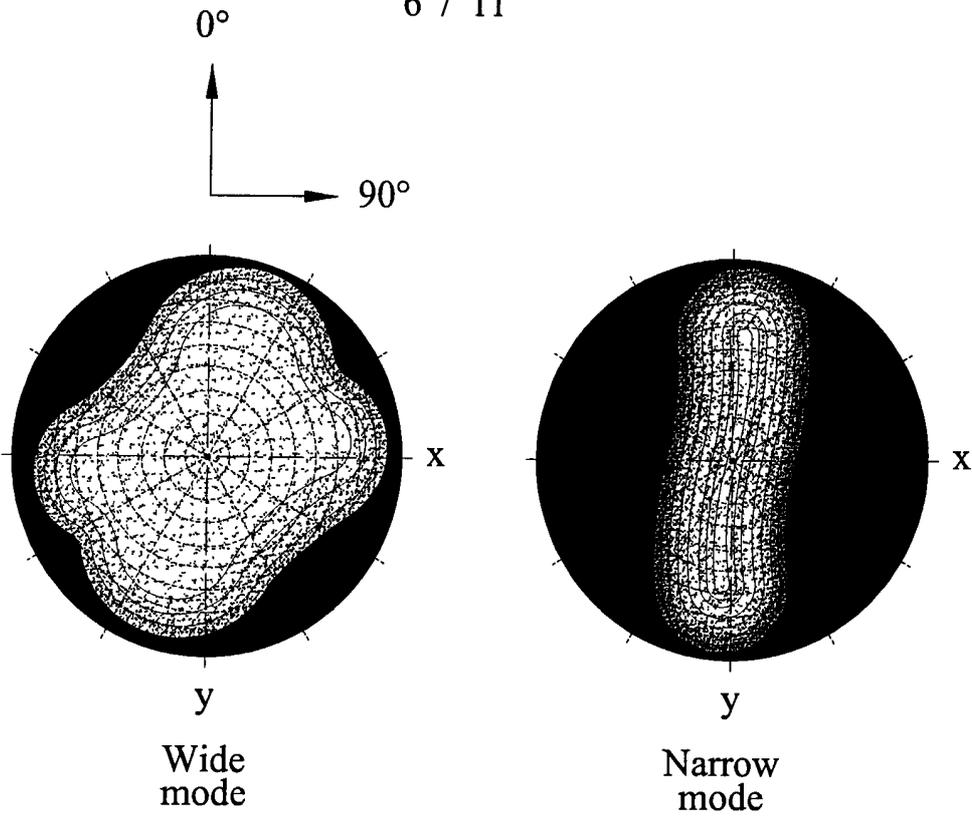


FIG 4^(a)

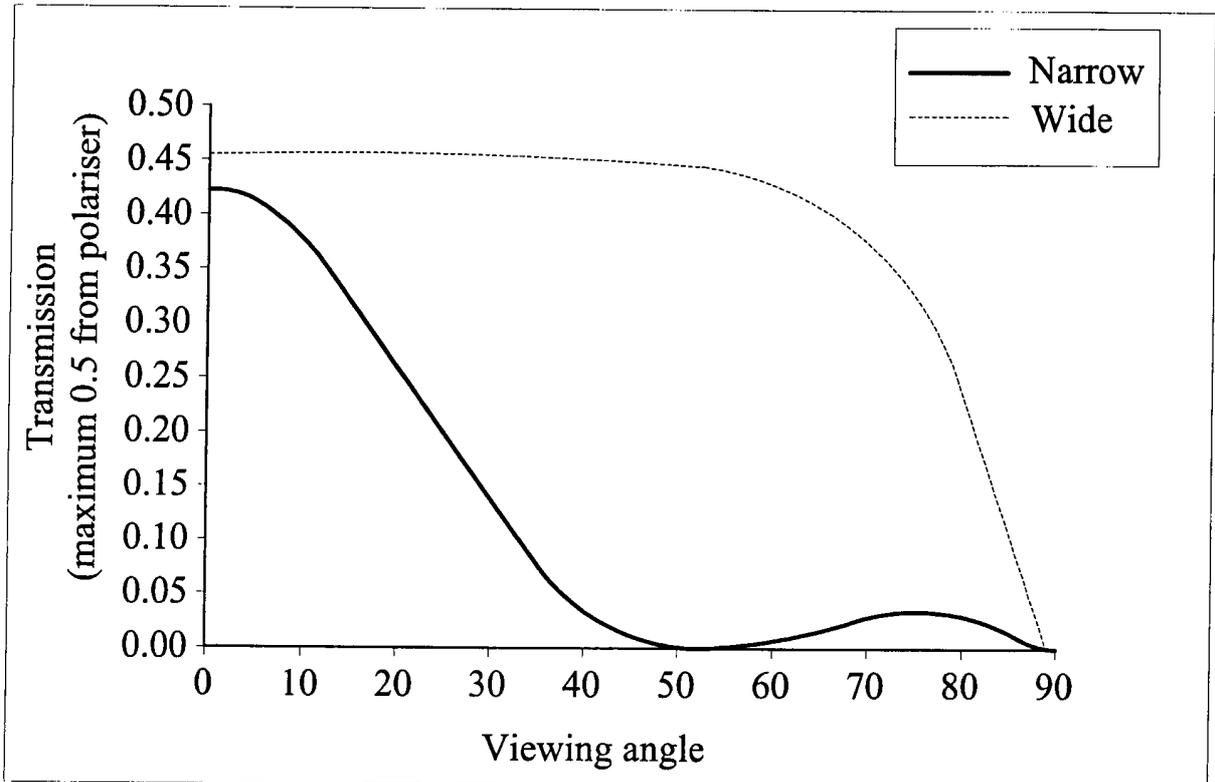


FIG 4^(b)

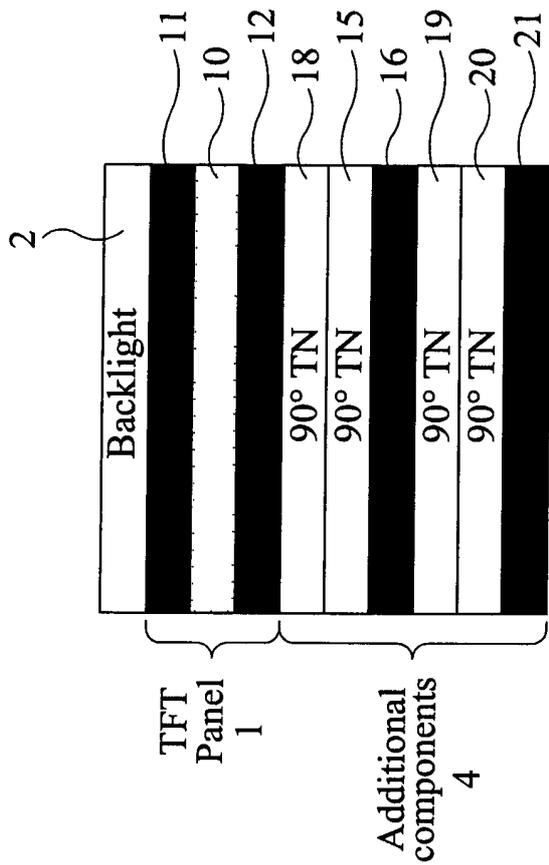


FIG 5(a)

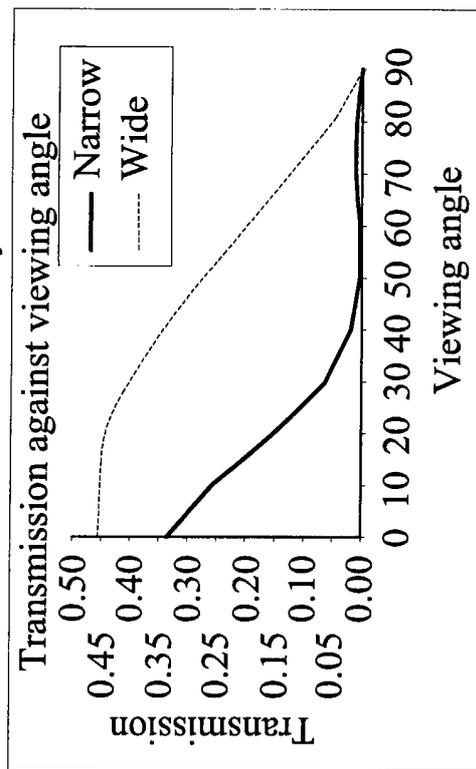
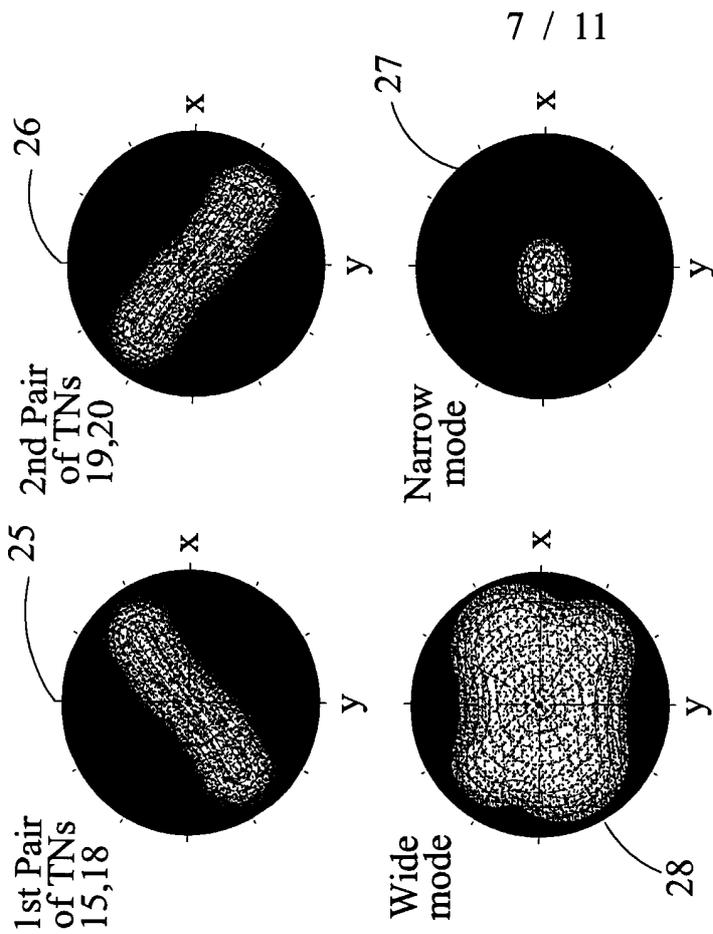
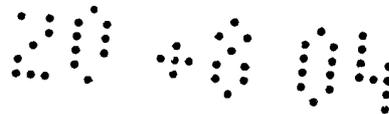


FIG 5(b)



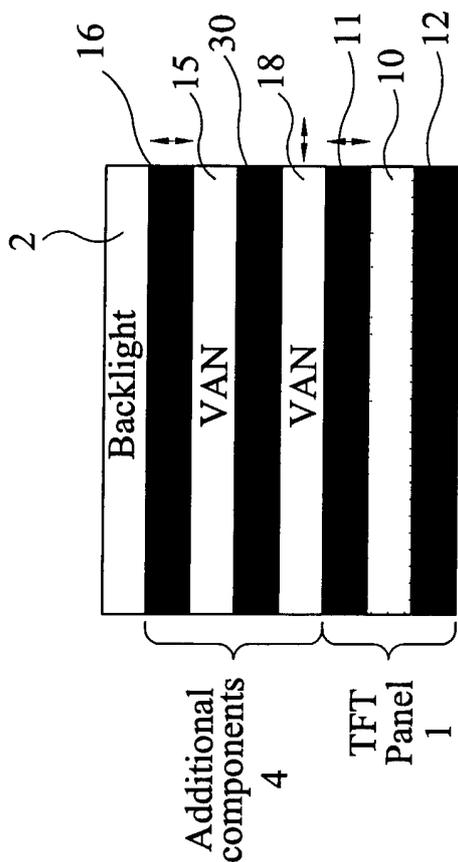
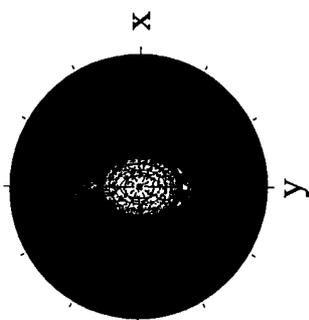
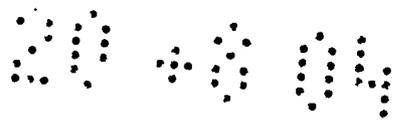


FIG 6(a)

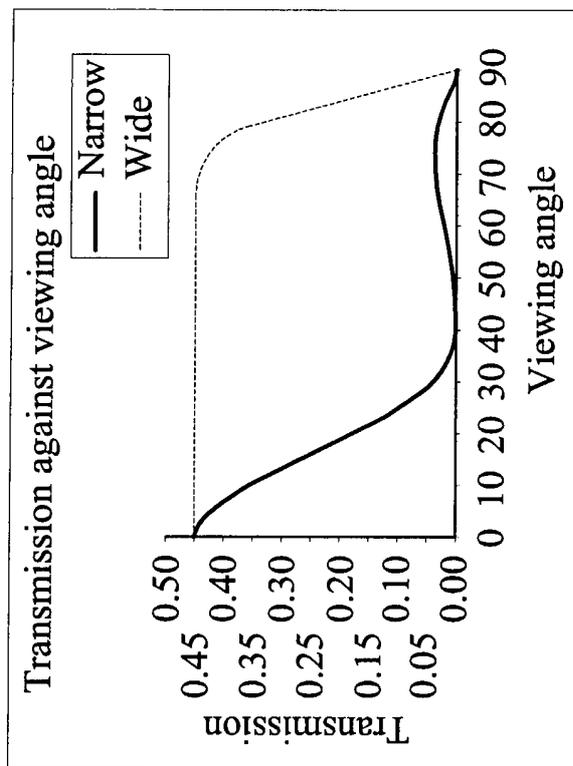


FIG 6(b)

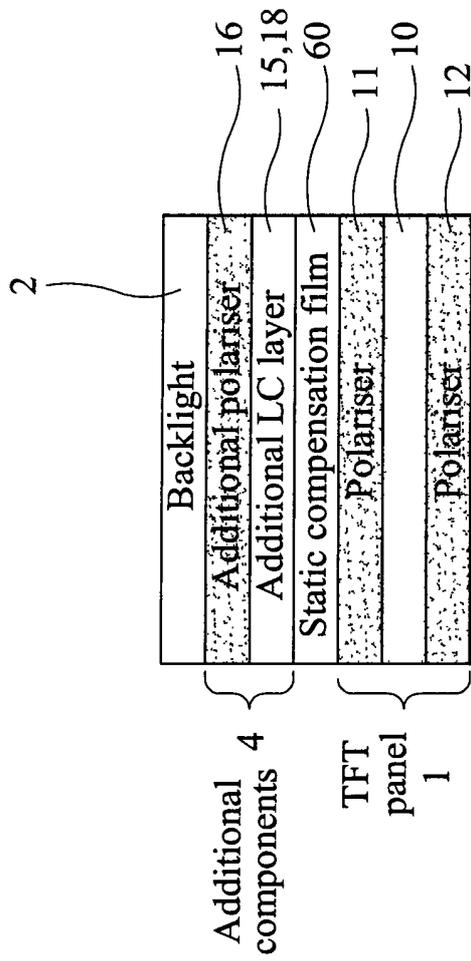
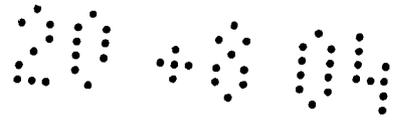
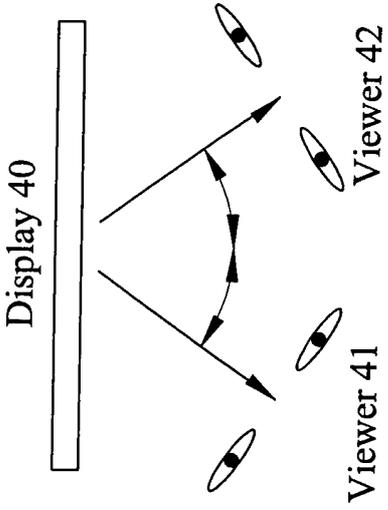


FIG 8





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FIG 9(a)

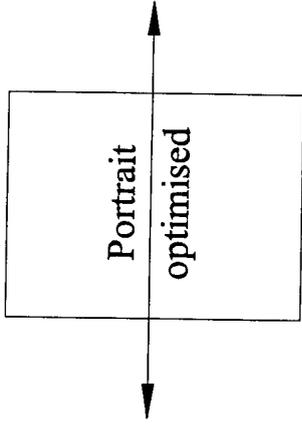


FIG 9(d)

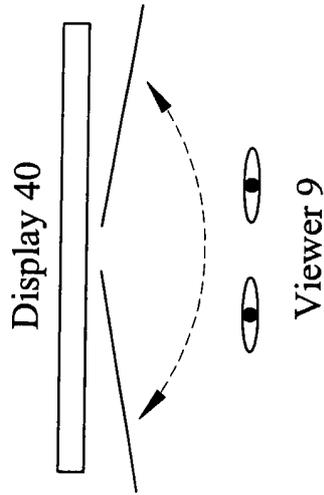


FIG 9(b)

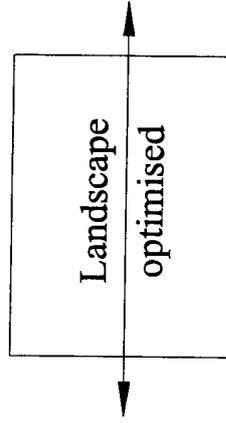
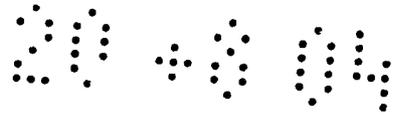


FIG 9(c)



Display

The present invention relates to a display.

5 Electronic display devices, such as monitors used with computers and screens built in to telephones and portable information devices, are usually designed to have a viewing angle as wide as possible so that they can be read from any viewing position. However, there are some situations where a display which is visible from only a narrow range of angles is useful. For example, one might wish to read a private document using a
10 portable computer while on a crowded train.

A number of devices are known which restrict the range of angles or positions from which a display can be viewed.

15 US6552850 discloses a technique for the display of private information on a cash-dispensing machine. Light emitted by the machine display has a fixed polarisation state and the machine and its user are surrounded by a large screen of sheet polariser which absorbs light of that polarisation state but transmits the orthogonal state. Passers by can see the user and the machine but cannot see information displayed on the screen.

20 Another known technique for controlling the direction of light is a 'louvred' film. The film consists of alternating transparent and opaque layers in an arrangement similar to a Venetian blind. Like a Venetian blind, it allows light to pass through it when the light is travelling in a direction nearly parallel to the layers but absorbs light travelling at large
25 angles to the plane of the layers. These layers may be perpendicular to the surface of the film or at some other angle.

Louvred films may be manufactured by stacking many alternating sheets of transparent and opaque material and then cutting slices of the resulting block perpendicular to the
30 layers. This method has been known for many years. For example, it is disclosed in US2053173, US2689387 and US3031351.

A process where a louvred film is cut continuously from a cylindrical billet of stacked layers is disclosed in USRE27617. US4766023 shows how the optical quality and mechanical robustness of the resulting film can be improved by coating with a UV-curable monomer and then exposing the film to UV radiation. US4764410 discloses a similar process where the UV-curable material is used to bond the louvre sheet to a covering film.

Other methods exist for making films with similar properties to the louvred film. For example, US05147716 discloses a light-control film which contains many elongate particles which are aligned in the direction perpendicular to the plane of the film. Light rays which make large angles to this direction are therefore strongly absorbed.

Another example of a light-control film is disclosed in US05528319. Embedded in the transparent body of the film are two or more layers parallel to the plane of the film, each layer having opaque and transparent sections. The opaque sections block the transmission of light through the film in certain directions while allowing the transmission of light in other directions.

The films described above may be placed either in front of a display panel or between a transmissive display panel and its backlight to restrict the range of angles from which the display can be viewed. In other words, they make a display 'private'. However none of them can easily be switched off to allow viewing from a wide range of angles.

US 2002/0158967 shows how a light control film can be mounted on a display so that the light control film can be moved over the front of the display to give a private mode or mechanically retracted into a holder behind or beside the display to give a public mode. This method has the disadvantages that it contains moving parts which may fail or be damaged and which add bulk to the display.

Another known technique for switching between public and private mode with no moving parts is to mount a light control film behind a display panel and to place a diffuser which can be electronically switched on and off between the light control film and the panel. When the diffuser is inactive, the light control film restricts the range of

viewing angles and the display is in private mode. When the diffuser is switched on, it causes light travelling at a wide range of angles to pass through the panel and the display is in public mode. It is also possible to mount the light control film in front of the panel and place the switchable diffuser in front of the light control film to achieve
5 the same effect. Switchable privacy devices of such type are described in US5831698, US6211930 and US05877829. They share the disadvantage that the light control film always absorbs a significant fraction of the light incident upon it, whether the display is in public or private mode. The display is therefore inefficient in its use of light. Since the diffuser spreads light through a wide range of angles in the public mode, these
10 displays are also dimmer in public than in private mode unless the backlight is made brighter to compensate.

A third known technique for providing a switchable public/private display is disclosed in US5825436. The light control device in this patent is similar in structure to the
15 louvred film described earlier. However, each opaque element in the louvred film is replaced by a liquid crystal cell which can be electronically switched from an opaque state to a transparent state. The light control device is placed in front of or behind a display panel. When the cells are opaque, the display is in its private mode; when the cells are transparent, the display is in its public mode.

20 A first disadvantage of this method is difficulty and expense of manufacturing liquid crystal cells with an appropriate shape. A second disadvantage is that in the private mode, a ray of light may enter at an angle such that it passes first through the transparent material and then through part of a liquid crystal cell. Such a ray will not be
25 completely absorbed by the liquid crystal cell and this may reduce the privacy of the device.

JP2003-233074 discloses a liquid crystal display which provides a conventional display of images from normal viewing angles. However, for relatively large viewing angles
30 away from the normal to the display, a fixed image is displayed and this may be used to hide or "scramble" the normal image so as to provide a privacy mode of operation. The fixed image is achieved by having display regions with different alignment directions

from each other, although all pixels operate in the same mode. A lower than normal drive voltage is used.

5 Although such an arrangement may be used to provide a privacy mode, it is not switchable. In particular, the relatively narrow range of viewing angles throughout which the non-fixed image can be seen cannot be changed if non-private operation is desired.

10 According to the invention, there is provided a display comprising a display device which is controllable to provide image display and a first liquid crystal device having at least one liquid crystal region whose molecules are switchable between a first state providing a first viewing angle range and a second state providing a second viewing angle range which is smaller than the first range.

15 The display device may be a second liquid crystal device.

The display device may be transmissive and the first liquid crystal device may be disposed between the display device and a backlight. As an alternative, the first liquid crystal device may be disposed in front of the display device.

20 The first liquid crystal device may comprise at least one liquid crystal layer and at least one linear polariser. The or each liquid crystal layer may comprise nematic liquid crystal. The or each liquid crystal layer may be arranged to operate in one of untwisted nematic, twisted nematic, super twisted nematic, vertically aligned nematic and hybrid
25 aligned nematic modes.

The or each liquid crystal layer may be bistable.

30 The first liquid crystal device may comprise a plurality of layers arranged to operate in the same mode. The display may comprise first and second twisted nematic liquid crystal layers of opposite twist directions disposed between first and second linear polarisers. The display may comprise third and fourth twisted nematic liquid crystal

layers of opposite twist directions disposed between the second and a third linear polarisers.

5 The display may comprise first, second and third linear polarisers and first and second vertically aligned nematic liquid crystal layers, the first layer being disposed between the first and second polarisers, the second layer being disposed between the second and third polarisers, the second polariser having a polarising direction perpendicular to those of the first and third polarisers, and the first and second states being a pinwheel alignment and a substantially uniform in-plane alignment, respectively.

10

It is thus possible to provide a display whose viewing angle may be switched, for example between a wide view mode and a narrow or private view mode. The first liquid crystal device may be used with a display device which can be of any suitable type and whose operation need not be changed in order to provide the wide and narrow view modes.

15

Such a display may be used, for example, in desktop monitors, mobile telephones and personal digital assistants (PDA's). Such an arrangement is simple to implement and may be manufactured by well-known and established manufacturing techniques. The first liquid crystal device does not require any electrode patterning or internal structure, for example to define pixels. If the first liquid crystal device has a single liquid crystal region for switching the viewing angle range across the whole of the display device, a very simple electrode pattern may be used and is easy to manufacture. Although the display may be switched between the first and second viewing angle ranges, the viewing angle may be varied continuously or in steps by, for example, applying the appropriate drive voltages to the first liquid crystal device.

20

25

Such displays may be used in applications requiring a "public" mode with a wide viewing angle for general use and a "private" mode with a narrow viewing angle so that, for example, private information may be read in public places.

30

Another application for such a display is in a vehicle dashboard. For example, the viewing angle of the display may be controlled so that the passengers or the driver is

unable to view the display. Alternatively, the viewing angle may be controlled in order to reduce reflection of the display in windscreens and windows, especially at night time or in low light conditions. In order to provide automatic control, a brightness sensor and a backlight brightness control may be provided.

5

In yet another application, the first liquid crystal device acts as a switchable compensation film. Liquid crystal displays are usually laminated with static compensation films to improve the viewing angle characteristics. Such known arrangements are generally arranged to give the best results in one direction, usually horizontally. For a display which can be rotated and viewed in landscape or portrait modes, it is advantageous to be able to switch a compensation film so as to give improved results depending on the display content.

Such displays may also be used in applications where two or more images are spatially multiplexed and displayed by the display device. For example, such a display may have a first mode in which one image is displayed across the display and a second mode in which two or more different images are displayed across the display in a spatially multiplexed manner. In the second mode, the displayed images may be stereoscopically related to provide an autostereoscopic display or may be entirely independent of each other to provide different views to different viewers. The different modes may require different optical compensation and a switchable compensator may be used to achieve this.

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

Figures 1a, 1b and 1c are diagrams schematically illustrating displays constituting embodiments of the invention;

Figures 2a and 2b are diagrammatic cross-sectional views of displays constituting embodiments of the invention and having a single additional liquid crystal layer as compared with a conventional display;

Figures 3a and 3b are diagrammatic cross-sectional views of displays constituting embodiments of the invention and having two additional liquid crystal layers as compared with conventional displays;

- 5 Figure 3c shows a diagrammatic cross-sectional view and a view illustrating azimuthal orientations of an example of the display of Figure 3a;

Figures 4a and 4b are light intensity plots illustrating wide and narrow modes of operation of the display illustrated in Figure 3c;

10

Figure 5a is a diagrammatic cross-sectional view of a display constituting an embodiment of the invention and having four additional liquid crystal layers as compared with conventional displays;

- 15 Figure 5b shows light intensity plots illustrating operation of the display of Figure 5a;

Figure 6a is a diagrammatic cross-sectional view of a display constituting an embodiment of the invention having two additional liquid crystal layers as compared with conventional displays;

20

Figure 6b shows light intensity plots for the display of Figure 6a;

Figures 7a and 7b illustrate liquid crystal configurations for wide and narrow view modes of the additional liquid crystal layers shown in Figure 6a;

25

Figure 8 is a diagrammatic cross-sectional view of a display constituting an embodiment of the invention and having a single additional liquid crystal layer and a static compensation film layer as compared with a conventional display

- 30 Figures 9a to 9d illustrate diagrammatically the use of a display constituting an embodiment of the invention for providing two independent views to different viewers.

Like reference numerals refer to like parts throughout the drawings.

Figure 1a illustrates a display comprising a transmissive display device 1, which may be of conventional type and which does not require any change in order to provide a display having wide view and narrow view modes. For example, the display device 1
5 may be a thin film transistor (TFT) liquid crystal panel providing a pixellated full colour or monochrome display in response to image data supplied to the display.

The display also comprises a backlight 2 which emits light with reasonable uniformity of intensity throughout a relatively wide angular distribution range as shown at 3. The
10 backlight 2 may also be of conventional type as used in known displays.

The display comprises one or more additional components 4 disposed in the light path from the backlight 2 to the display device 1. The or each additional component comprises a liquid crystal device having one or more liquid crystal layers and one or
15 more polarisers. The or each device 4 provides angular light modulation, for example between narrow and wide viewing modes as shown at 5 and 6, in accordance with an electric field applied to the or each liquid crystal layer. The applied field may be switched between two values to give the two angular distributions or may be varied continuously or in discrete steps to give more than two angular viewing ranges.

20 In the arrangement illustrated in Figure 1a, the additional component or components 4 have little effect on the angular light distribution 3 from the backlight 2 as illustrated at 7. However, when the display operates in the narrow mode, the or each component 4 is controlled so as to restrict the angular light distribution to a narrow range as illustrated
25 at 8 so that a user 9 may only view the image or sequence of images displayed by the display device 1 in a relatively narrow angular viewing range. This may be used, for example, to provide private viewing by a single user 9 and to prevent others outside the narrow angular viewing range from being able to see the displayed image. When the display is in the wide viewing mode, users such as 9 located anywhere within a
30 relatively wide viewing angle may all see the displayed image.

Figure 1b illustrates a display which differs from that shown in Figure 1a in that the or each additional component 4 is located in front of the display device 1. The display

device 1 is not, therefore, limited to being of the transmissive type as illustrated in Figure 1a but, instead, may be of any suitable type such as transmissive, reflective or emissive. The display device 1 provides a relatively wide angular light distribution as shown at 3 and the or each additional component 4 modulates the angular light distribution between wide and narrow modes as illustrated at 7 and 8.

Figure 1c illustrates a display which differs from that shown in Figures 1a or 1b in that the display is a thin film transistor (TFT) liquid crystal display 50. The or each additional component 4 is disposed between polarisers 51 and 52, in front of the TFT liquid crystal display. This arrangement of the or each additional component 4 and display, affecting the structure of the display itself, is only applicable to TFT liquid crystal displays. The display of Figure 1c still operates in wide and narrow modes illustrated at 7 and 8.

Figures 2a and 2b illustrate examples of the displays shown in Figures 1a and 1b, respectively, for thin film transistor panels 1 of the transmissive liquid crystal type. Both displays thus have the backlight 2 and may be substantially identical except for the order in which the individual devices within the display are arranged. The liquid crystal display (LCD) panel 1 comprises a liquid crystal layer 10 disposed between input and output polarisers 11 and 12. Other components, such as substrates, alignment layers, electrode arrangements and filtering arrangements, have been omitted for clarity.

The additional components 4 comprise an additional liquid crystal layer 15 and an additional polariser 16. Again, elements such as substrates, alignment layers and electrode arrangements have been omitted for the sake of clarity. In the display of Figure 2a, the additional components 4 are disposed between the LCD panel 1 and the backlight 2 so that the additional liquid crystal (LC) layer 15 cooperates with the polarisers 11 and 16. In the display of Figure 2b, the additional components 4 are disposed in front of the LCD panel and the backlight 2 (forming a TFT module 1, 2) so that the additional LC layer 15 cooperates with the polarisers 12 and 16.

The LCD panels 1 are controlled so as to provide conventional image display of an image or a sequence of images in monochrome or in colour. Although the electrode

arrangement of the additional LC layer 15 could be divided into several regions so that the viewing angle of the display may be different for different regions of the display, a single uniform electrode may be provided so that the viewing angle of the whole display is controlled between wide and narrow modes, possibly with a discrete or continuous
5 range of intermediate viewing angle values. For example, the wide and narrow modes may be obtained by applying and removing, respectively, an electric field across the layer 15.

The additional liquid crystal layer 15 may be arranged to operate in any suitable liquid
10 crystal mode. Examples of such modes include untwisted nematic, twisted nematic (TN), super-twisted nematic (STN), vertically aligned nematic (VAN) and hybrid aligned nematic (HAN) modes. However, liquid crystal materials other than nematic materials may also be used. Further, the liquid crystal layer 15 may be bistable so as to allow both the wide and narrow angle modes to be low power modes.

15

Figures 3a and 3b illustrate displays which differ from those shown in Figures 2a and 2b, respectively, in that the additional components 4 comprise a second liquid crystal layer 18. Figure 3c illustrates a specific example of the display shown in Figure 3a, in which the polarisers 11 and 16 have parallel transmission axes whose azimuthal
20 orientation defines a reference or 0° direction. Each of the layers 15 and 18 comprises a 90° twisted nematic (TN) liquid crystal layer. The alignment direction and hence the director azimuth orientation at the upper surface of the layer 15 is at 0° to the reference direction whereas the director azimuthal orientation at the lower surface of the layer 15 is at 90° to the reference direction. For the layer 18, the upper and lower director
25 azimuthal orientations are at 90° and 0° , respectively, to the reference direction. The layers 15 and 18 are each of two micrometre thickness. In the wide mode, no voltage is applied across the layers 15 and 18 whereas, in the narrow mode, a field of two volts is applied across each of the layers 15 and 18.

30 Figure 4a shows light intensity plots for a 360° range of azimuth angles and a 90° range of polar angles for the wide and narrow modes. In the narrow mode, the TN liquid crystal layers 15 and 18 cooperate with the polarisers 11 and 16 to restrict the light intensity, and hence the viewing angle, in a horizontal plane. This is illustrated

graphically in Figure 4b, which shows light intensity against polar angle at 90° azimuth with 0° being normal to the display surface.

As mentioned hereinbefore, a continuous or discrete range of voltages may be applied to the layers 15 and 18. Also, the voltages applied to the layers 15 and 18 need not be the same. Further, although only one additional polariser 16 is shown, depending on the liquid crystal mode of the layers 15 and 18, it may be necessary or desirable to have a further additional polariser, for example disposed between the layers 15 and 18.

The display shown in Figure 3c allows a relatively narrow viewing angle to be achieved in a plane with an azimuth angle of 90° . In order to provide a narrow viewing angle perpendicularly to this also, a display as shown in Figure 5a may be provided.

The display shown in Figure 5a differs from that shown in Figure 3c in that another pair of liquid crystal layers 19 and 20 and another linear polariser 21 are provided and the display is of the type illustrated in Figure 3b with the panel 1 between the backlight 2 and the additional components 4. The orientations of the liquid crystal layers 19 and 20 and the further linear polariser 21 are the same as those of the liquid crystal layers 15 and 18 and the polariser 16, but the surface pretilt angles are different between the two sets of layers. The different surface pretilt angles give opposing twists between the two sets of layers.

Figure 5b shows light intensity plots at 25 and 26 with only the layers 15 and 18 or only the layers 19 and 20 in the narrow view mode. The narrow view mode of the whole display is illustrated at 27 and the wide mode of the whole display is illustrated at 28.

The display shown in Figure 6a is of a similar type to that shown in Figure 3c but differs in that the layers 15 and 18 operate in the vertically aligned nematic (VAN) mode and are separated by a further polariser 30. The transmission axes of the polarisers 11 and 16 are parallel to each other and perpendicular to the transmission axis of the polariser 30.

In this case, the liquid crystal layers 15 and 18 are disposed between electrodes, one of which may be plane and the other of which is patterned so as to be able to switch each liquid crystal layer between the appropriate configurations of the liquid crystal directors. In the absence of any applied field, each of the layers is vertically aligned as illustrated at 31 and 32 in Figures 7a and 7b. In the wide viewing angle mode illustrated in Figure 7a, an electric field is applied to each of the liquid crystal layers 15 and 18 so as to produce a continuous pinwheel alignment (CPA) as illustrated at 33. This is achieved by applying an electric field substantially perpendicular to the substrates with a suitable electrode structure and a cell surface of non-uniform flatness. This mode of operation provides a very wide angular distribution of light and thus gives a good wide-angle mode.

In the narrow mode, an electric field is applied using the electrode structure so as to introduce an in-plane field as well as a field perpendicular to the cell surfaces as illustrated at 35. In this mode, the liquid crystal molecules align in the same direction which is generally in-plane, as illustrated at 36. By arranging the layers 15 and 18 such that the in-plane alignment directions in this mode are perpendicular to each other, a good narrow mode of operation may be obtained as illustrated by the light intensity plots in Figure 6b.

The additional layers 4 may be used in combination with a static compensation film or films 60, as illustrated in Figure 8. Such a combination allows the two different viewing angle modes to be achieved by switching the or each liquid crystal layer 15, 18 with an electric field. For example, in one of the modes, the liquid crystal layer or layers 15, 18 may counteract the optical effect of the static layer 60. In the other mode, the or each liquid crystal layer 15, 18 may be switched such that its optical effect combines with that of the static layer 60 to change the viewing angle characteristics.

An example of the embodiment described in Figure 8 involves the static compensation film 60 being a short pitch cholesteric liquid crystal layer, acting as a static positive c-plate retarder. The pitch of the liquid crystal layer 15, 18 is less than the wavelength of the light passed through it and, when unswitched, acts as a negative c-plate retarder. When switched with an electric field, the twist is "unwound", the liquid crystal layer 15,

18 aligns vertically and acts as a positive c-plate retarder. When the liquid crystal layer 15, 18 in the unswitched state is combined with the static compensation film 60, the unswitched state is fully compensated, giving a wide view mode of operation. Conversely, when the liquid crystal layer 15, 18 in the switched state is combined with
5 the static compensation film 60, the retardation of both layers is added to give a narrow view mode of operation.

Figure 9a illustrates the use of a display 40 in accordance with any of the embodiments described hereinbefore arranged to display different images which are visible to two or
10 more viewers 41 and 42 in different directions. In the example illustrated in Figure 9a, the display 40 is optimised for viewing at viewing angles of $\pm 30^\circ$ with respect to the display normal 43.

The display 40 also has a single view mode where a single image is to be viewable by a
15 viewer 9 anywhere within the field of view of the display 40, as indicated by the broken double-headed arrow. The viewing angle requirements for these different modes of operation may be different and the arrangements described hereinbefore with the additional components 4 may be used to adjust the viewing angle range to the different requirements. The additional components 4 may be used to optimise the viewing angle
20 characteristics for each mode.

The display as described hereinbefore may also be used such that the additional components 4 act as a switchable compensation film to allow the display to be viewed in landscape or portrait configurations, illustrated in Figures 9c and 9d, respectively.
25 The additional components 4 may be selected and operated in order to provide the appropriate viewing angle ranges in both display orientations, optimising the viewing angle characteristics for each mode.

CLAIMS:

1. A display comprising a display device which is controllable to provide image display and a first liquid crystal device having at least one liquid crystal region whose
5 molecules are switchable between a first state providing a first viewing angle range and a second state providing a second viewing angle range which is smaller than the first range.
2. A display as claimed in claim 1, in which the display device is a second liquid
10 crystal device.
3. A display as claimed in claim 1 or 2, in which the display device is transmissive and the first liquid crystal device is disposed between the display device and a
15 backlight.
4. A display as claimed in claim 1 or 2, in which the first liquid crystal device is disposed in front of the display device.
5. A display as claimed in any one of the preceding claims, in which the first liquid
20 crystal device comprises at least one liquid crystal layer and at least one linear polariser.
6. A display as claimed in claim 5, in which the or each liquid crystal layer comprises nematic liquid crystal.
- 25 7. A display as claimed in claim 6, in which the or each liquid crystal layer is arranged to operate in one of untwisted nematic, twisted nematic, supertwisted nematic, vertically aligned nematic and hybrid aligned nematic modes.
8. A display as claimed in any one of claims 5 to 7, in which the or each liquid
30 crystal layer is bistable.
9. A display as claimed in any one of claims 5 to 8, in which the first liquid crystal device comprises a plurality of layers arranged to operate in the same mode.

10. A display as claimed in claim 9, comprising first and second twisted nematic liquid crystal layers of opposite twist directions disposed between first and second linear polarisers.
- 5 11. A display as claimed in claim 10, comprising third and fourth twisted nematic liquid crystal layers of opposite twist directions disposed between the second and a third linear polarisers.
- 10 12. A display as claimed in claim 9, comprising first, second and third linear polarisers and first and second vertically aligned nematic liquid crystal layers, the first layer being disposed between the first and second polarisers, the second layer being disposed between the second and third polarisers, the second polariser having a polarising direction perpendicular to those of the first and third polarisers, and the first and second states being a pinwheel alignment and a substantially uniform in-plane
15 alignment, respectively.



INVESTOR IN PEOPLE

Application No: GB0408742.5

16

Examiner: Helen Edwards

Claims searched: All

Date of search: 16 July 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular reference
X	1, 2, 3, 4	US5877829 A (SHARP KK) See figures 10 and 13 and columns 10-14
X	1, 2, 3, 4	US5831698 A (IBM) See figures 2 and 4 and column 5 lines 7-13
A	-	EP0918247 A (NCR INT INC)
A	-	EP0802684 A (NCR INT INC)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W :

G2F

Worldwide search of patent documents classified in the following areas of the IPC⁰⁷

G02F

The following online and other databases have been used in the preparation of this search report

EPODOC, JAPIO, WPI