A display device

Field of technology

[001] This description relates to a display device, particularly a color display device, and a display panel incorporating the display device.

Background

[002] Liquid Crystal Displays (LCDs) operate in one of three illumination modes: backlit, reflective, and transflective which is a combination of backlit and reflective illumination modes. Reflective and transflective illumination modes involve the use of reflective liquid crystals to reflect ambient light in order to display an image, without the use of a backlight. Advantageously, the displayed image can be viewed easily under bright conditions, while power consumption is significantly lower than backlit display devices.

[003] Color image projection currently presents some challenges for reflective and transflective illumination modes. A patterned color matrix comprising a repeating array of red, green and blue color pixels are typically used to provide a color display. However, as light passes through the color matrix layers and the electrodes associated with each layer, degradation of light quality and parallax issues may result. Ongoing research and development is focused on providing a patterned color matrix capable of providing acceptable image quality.

[004] A need therefore exists for color reflective displays that have high ambient brightness that can be inexpensively manufactured and can display good quality images.

Summary of invention

[005] In one aspect, a display device comprises a liquid crystal assembly including active display elements for displaying an image, a patterned color layer including at least one color pixel array, a reflector for reflecting ambient incident light,

and a light absorbing layer, wherein the color pixel array comprises a first pixel group including at least three contiguously arranged pixels capable of transmitting a first color, and a second pixel group including at least three contiguously arranged pixels capable of transmitting a second color. In other aspects, a vehicle instrument panel comprising the display device is provided.

[006] These and other aspects are described in the detailed description below. In no event should the above summary be construed as a limitation on the claimed subject matter, which is defined solely by the claims as set forth herein.

Brief Description of the Drawings

[007] Throughout the specification, reference is made to the appended drawings, where like reference numerals designate like elements, wherein:

[008] FIG. 1 is a cross-sectional view of an embodiment of a display device.

[009] FIG. 2 is a cross-sectional view of another embodiment of the display device.

[010] FIG. 3 is a cross-sectional view of another embodiment of the display device.

[011] FIG. 4, 5 and 6 are a plane views of various embodiments of the color pixel array.

[012] FIG. 7 is a vehicle instrument panel incorporating the display device.

[013] The figures are not necessarily to scale. However, it will be understood that the use of a numeral to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

Detailed Description

[014] Certain displays, such as those for motorcycle or car instrument panels, require color, but the portions requiring color are located at specific areas of the display, and the image graphics may be simple. Images to be projected include numbers, alphabets, symbols, or simple graphical gauges. For example, in the case of a motorcycle or a car, the velocity and Revolutions Per Minute (RPM) display may be represented by white color for normal RPM ranges, and red color for excessive RPM. Black may be displayed if the white and/or the red ranges have a null value, e.g. when the vehicle is stationary. Other portions such as warning indicators, fuel gauges and the like, may likewise be indicated in white when normal, in red to indicate caution.

[015] The inventors have found that a color display panel with excellent sunlight readability having areas of high brightness can be provided by incorporating a patterned color layer as described herein. For example, this invention can reduce the center of gravity of motor vehicles and improve stability

[016] A cross sectional view of one embodiment is shown in FIG. 1. In this embodiment, the patterned color layer is interposed between the reflective polarizer and liquid crystal. The patterned color layer transmits a first color and a second color; black is displayed if the liquid crystal molecules are arranged to block the transmission of the reflected light. For example, light ray 10 of the first color is polarized by the absorbing polarizer, rotated by the liquid crystal layer, filtered by the color layer, reflected by the reflective polarizer, and emitted by the display as ray 12. Light ray 14 of the second color follows the same path, but is emitted by the display as ray 16, and is of the second color. Ray 18 is not rotated by the liquid crystal, and is transmitted by the reflective polarizer and at least partially absorbed by the absorbing layer.

[017] The order of the components in the liquid crystal module may be changed. For example, the patterned color layer may be located between the absorbing polarizer and the liquid crystal layer. The color layer similarly transmits a first color and a second color; black is displayed if incident light is absorbed by the absorbing layer. As shown in FIG. 2, light ray 10 of the first color is transmitted by the color layer, and subsequently filtered by the color layer in which the first color is transmitted. Subsequently, ray 10 is rotated by the liquid crystal layer, reflected by the reflective

polarizer, and emitted by the display as ray 12. Light ray 14 of the second color follows the same path, but is emitted by the display as ray 16, and is of the second color. Ray 18 is not rotated by the liquid crystal, and is transmitted by the reflective polarizer and at least partially absorbed by the absorbing layer, resulting in black being displayed.

[018] Alternatively, as shown in FIG. 3, the patterned color layer may be located above the absorbing polarizer. The color layer similarly transmits a first color and a second color. For example, light ray 10 of the first color is transmitted by the color layer, and subsequently polarized by the absorbing polarizer, rotated by the liquid crystal layer, reflected by the reflective polarizer, and emitted by the display as ray 12. Light ray 14 of the second color follows the same path, but is emitted by the display as ray 16, and is of the second color. Ray 18 is not rotated by the liquid crystal, and is transmitted by the reflective polarizer and at least partially absorbed by the absorbing layer.

[019] Each color pixel array comprises a first pixel group including at least three contiguously arranged pixels capable of transmitting a first color, and a second pixel group including at least three contiguously arranged pixels capable of transmitting a second color.

[020] FIG. 4 shows the various embodiments of a color pixel array wherein each pixel group contains three pixels. The first example shows three green and three red pixel groups, the second example shows three blue and three red pixel groups and the third example shows three green and three blue pixel groups. A white pixel group may also be used. As seen from the figures, the three pixels of each pixel group are arranged contiguous to each other, or in other words, they are immediately adjacent to each other. In one embodiment, the pixels in each pixel group are arranged in an L-shaped format. In the context of this invention, diagonally adjacent pixels are not considered to be arranged contiguous to each other.

[021] The pixels within each pixel group are of substantially the same color. They preferably differ from each other by less than 0.2 units under the CIE 1931 standard, or more preferably less than 0.05 or less than 0.025 units.

[022] FIG. 5 shows an embodiment in which the color pixel array comprises three different color pixel groups. The third pixel group comprises one or more pixels of a third color. FIG. 6 shows other embodiments in which two pixel groups are present, each pixel group having four pixels.

[023] The viewing range of the display can be improved by having one or more of the components scatter light. The adhesive layer may have a non-depolarizing, low back-scatter diffusing component, such as spherical acrylic particles with a diameter between about 200 and 20,000 nm, and having a refractive index difference between the particle and the matrix of about 0.005 to about 0.030.

[024] A suitable adhesive for attaching the layers together is described in US 6,288,172. If the diffusing adhesive is located above the absorbing polarizer, the adhesive may depolarize light, but should still have a low back scatter. Alternatively, one or more of the surfaces from the upper surface of the reflective polarizer to the outermost surface of the display may diffuse light through one or a combination of surface roughness or coatings. If the scattering function is between the absorbing polarizer and the reflective polarizer, optionally, the scattering is accompanied with little depolarization. Also optionally, the depolarization from the coating or surface structure results in less than about 20% transmission when placed between crossed polarizer.

[025] FIG. 7 shows a vehicle instrument panel displaying two different colors of red and orange, while numerals and bars and other indicators are displayed in the typical LCD black/grey. This is a fixed pattern graphic on a fixed pattern LCD. A fixed pattern graphic may be placed on a TFT LCD, allowing the display to have the cost and brightness of the fixed pattern LCD, but give a more dynamic display. The dynamic display can offer different information depending on the operation of the motorcycle. For example, the speedometer can indicate speed when the motor is running, and diagnostics such as service intervals, performance metrics such as average fuel consumption, and the like. In general, the liquid crystal assembly may comprise a standard TFT module, or a Pixel Qi reflective display with no pixelated color filter in reflective mode, or a Pixel Qi reflective display with no pixelated color

filter in either reflective and transmissive modes. By using a TFT LCD, the LCD can be easily modified to work with new graphics, allowing variation within product lines and between customers, without requiring new LCD inventory.

[026] The back absorbing layer can also emit light, and the adhesive, color absorbing layer, or the first surface of the reflective polarizer may diffusely scatter light.

[027] An additional aspect of this invention is that the front portion of the panel may be covered with a solar reflective film as part of the outermost portion of an opaque graphic overlay to protect the display from overheating in direct sunlight. The solar reflective film can protect the display from overheating in direct sunlight. Overheating may cause the display to exceed the clearing temperature of the LCD, and make the display illegible until temperature is reduced. Overheating may also degrade the optical films use in the display, particularly the polarizer and adhesive components.

[028] A method of forming the display device will be described in the following. The front graphic is preferably made by the following steps:

1. Coating the first side of solar reflecting film, available from 3M company, with an antiglare scratch resistant material. Suitable coatings are well known in the display industry.
2. Coating the second side of the solar reflective film with a graphic. The graphic may include a combination of transparent and colorless areas, transparent colored areas, and opaque graphics.
3. Laminating the second side of the printed solar reflecting film with an optically clear adhesive (OCA), available from 3M company.
4. Preparing the LCD with an absorbing polarizer on one side, an LC without a color matrix, and a reflective display film (RDF, available from 3M company) on the backside of the display.
5. Laminating the printed graphic onto the LCD.

[029] Variations on this method of assembly include applying the graphics to the first side of the reflective polarizer, or any other surface between the first side of the reflective polarizer and the front side of the display. The color filter array in the LCM

may also be patterned with the color and clear graphics. The pattern may also be split between different surfaces. Graphics may also be applied to the back side of the display, i.e., behind the reflective polarizer.

[030] The back reflector may be a reflective polarizer with a black or colored coating on the second surface (RDF-B, available from 3M company), a non-inverting or inverting transflective film (including TDF, available from 3M company), or a partially reflective coating on the back surface of an absorbing polarizer.

[031] Transflective displays may be back lit with a light source, including electroluminescent lights, organic LED light sources, LEDs, and other light sources. Either reflective or transflective displays may also be illuminated from the front of the display, using for example, off-set light sources such as LEDs, or light guides designed for front illumination. The transflective display may also be a reflective display for certain colors (for example blue and green light) and transflective for other colors (for example red light).

[032] The display may be partially or fully covered with a solar reflective film. Suitable solar reflective films include SRF, available from 3M company. Preferably, the solar reflective film is at least 90% transparent average luminous response for 6500 K sunlight, and reflects at least 70% of IR light on average from 850 to at least 950 nm, both measured at normal angles to the film surface.

[033] Although the present invention has been described with particular reference to preferred embodiments illustrated herein, it will be understood by those skilled in the art that variations and modifications thereof can be effected and will fall within the scope of this invention as defined by the claims thereto now set forth hereinbelow.

What is claimed is:

1. A display device comprising:

a liquid crystal assembly including active display elements for displaying an image,
a patterned color layer including at least one color pixel array,
a reflector for reflecting ambient incident light, and
a light absorbing layer,

wherein

the color pixel array comprises a first pixel group including at least three contiguously arranged pixels capable of transmitting a first color, and a second pixel group including at least three contiguously arranged pixels capable of transmitting a second color.

2. The display device of Claim 1, wherein the color pixel array further comprises a third pixel group including at least one pixel capable of transmitting a third color.

3. The display device of any of Claims 1 to 3, wherein the at least three contiguously arranged pixels of the first, second and/or third pixel group are arranged in an L-shape.

4. The display device of any of Claims 1 to 3, wherein the first pixel group includes four contiguously arranged pixels, and the second pixel group includes four contiguously arranged pixels.

5. The display device of any of Claims 1 to 4, wherein each color pixel array includes nine individual pixels arranged in a 3-rows-by-3-columns arrangement.

6. The display device of any of Claims 1 to 5, wherein the patterned color layer is disposed on the liquid crystal assembly

7. The display device of any of Claims 1 to 5, wherein the liquid crystal assembly comprises an external-facing absorbing polarizer layer, and an internal-facing liquid crystal layer.

8. The display device of Claim 7, wherein the patterned color layer is disposed between the absorbing polarizer layer and the liquid crystal layer.

9. The display device of Claim 7, wherein the patterned color layer is disposed between the liquid crystal assembly and the reflector.

10. The display device of any of Claims 1 to 9, wherein the reflector is selected from a reflective polarizer or a transflector.

11. The display device of any of Claims 1 to 10, wherein the liquid crystal assembly is a Thin Film Transistor (TFT) array liquid crystal module.

12. A vehicle instrument panel comprising the display device of any of Claims 1 to 11.

13. The vehicle instrument panel of Claim 12, further comprising an opaque graphic layer.