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(54) MULTI-COLOR LIQUID CRYSTAL DISPLAY

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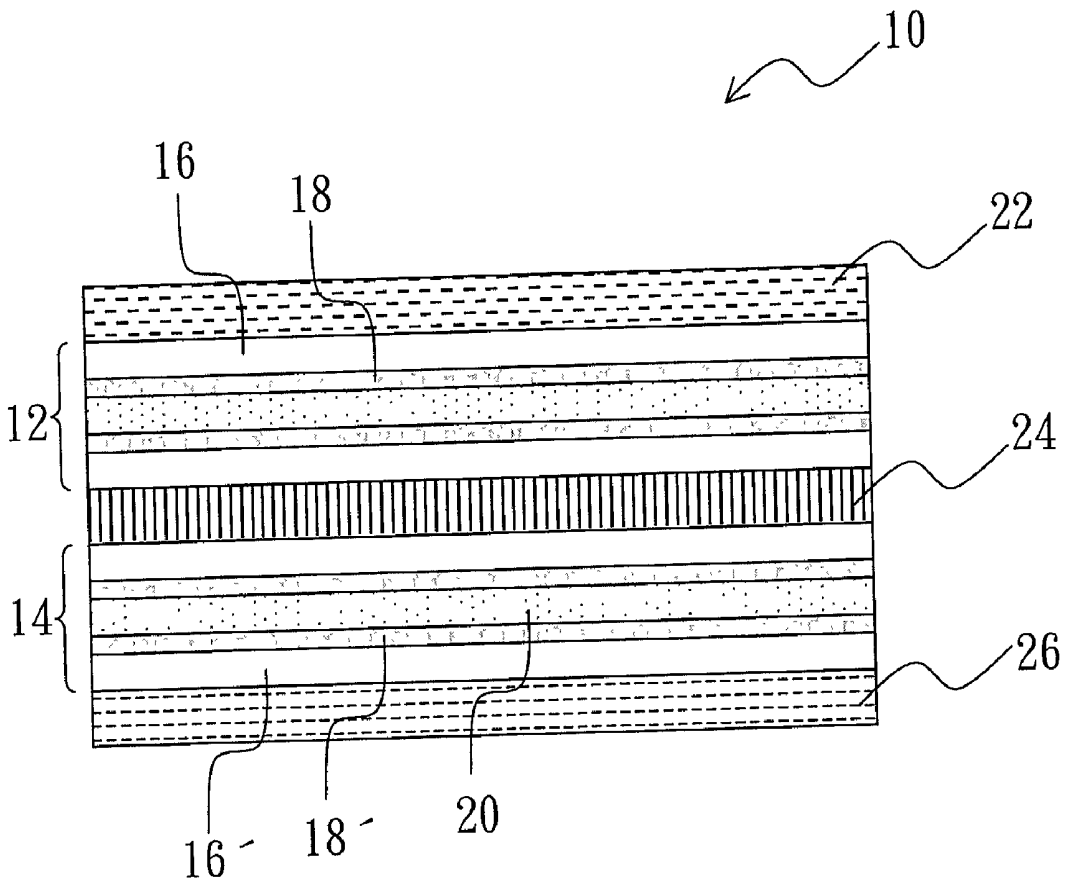
(57) **ABSTRACT**

The present invention provides a multi-color liquid crystal display, wherein polarizing plates are disposed above, below, and between at least two liquid crystal displaying modules stacked up and down. The polarizing plates can be combinations of polarizing plates absorbing monochromatic light and general uncolored polarizing plates. Various kinds of colors can be achieved according to whether a voltage is applied onto the liquid crystal displaying modules. The present invention has a low price to apply to some portable products requiring less number of colors.



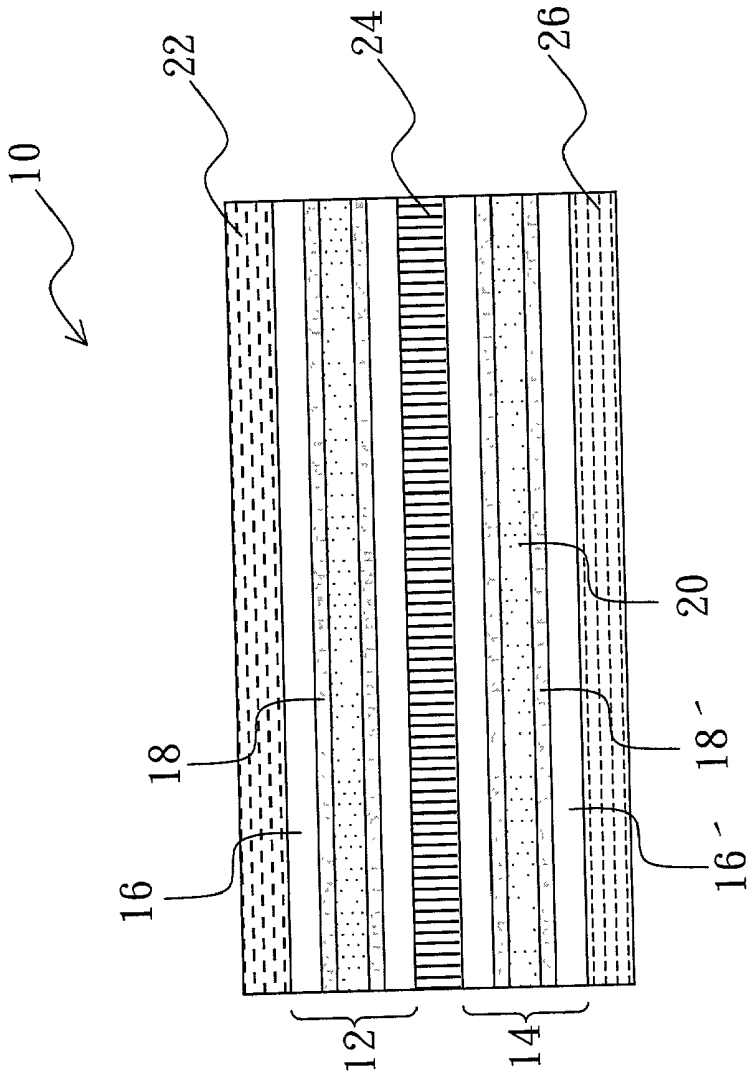


Fig. 1

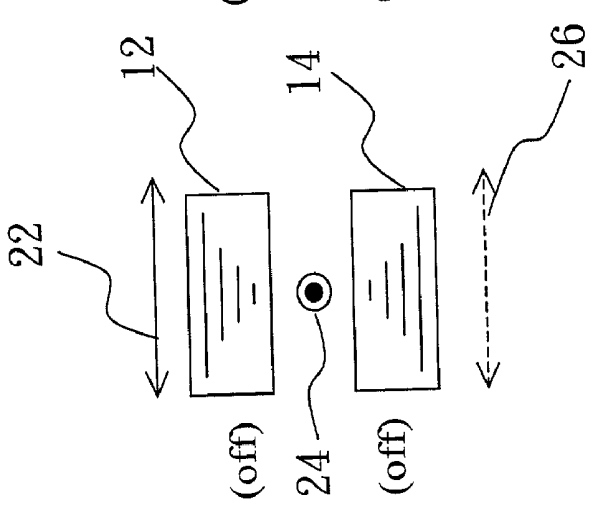


Fig. 2a

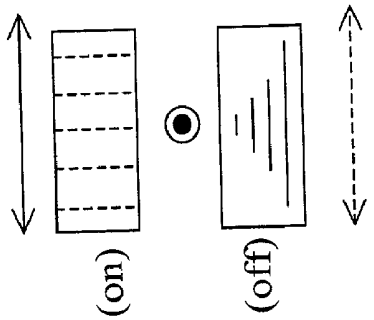


Fig. 2b

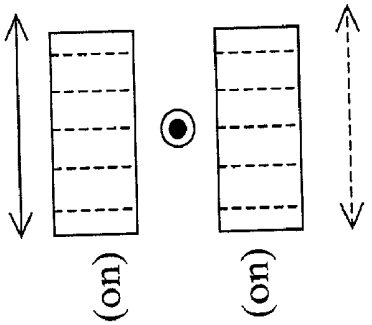


Fig. 2c

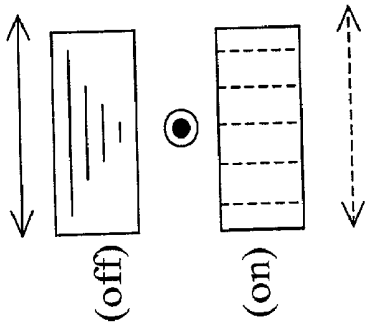


Fig. 2d

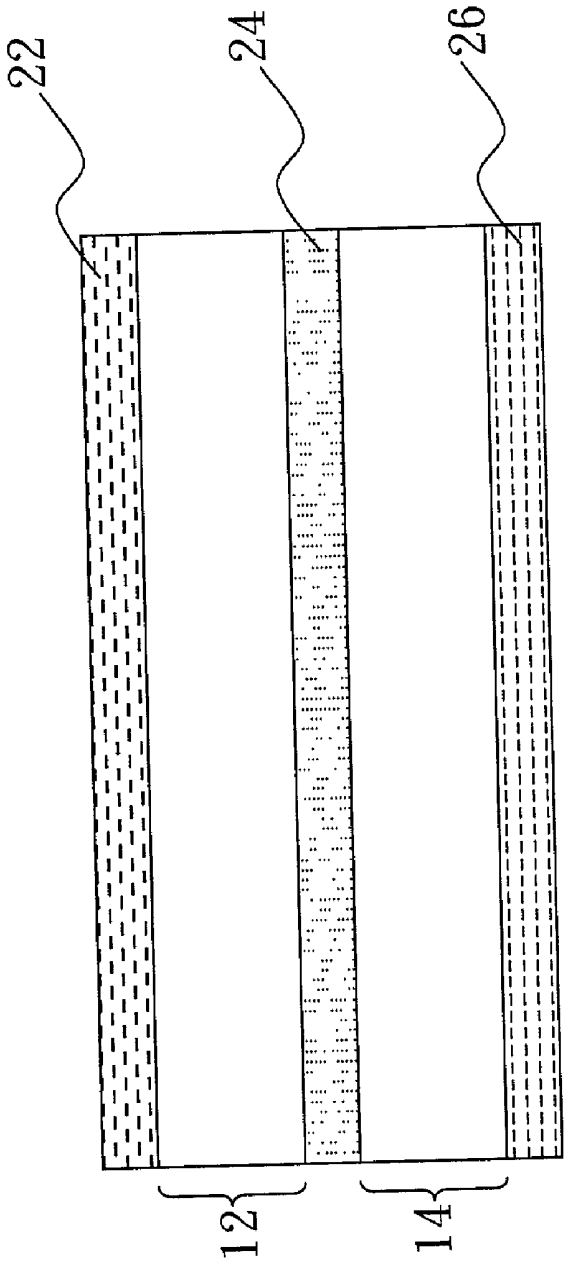


Fig. 3

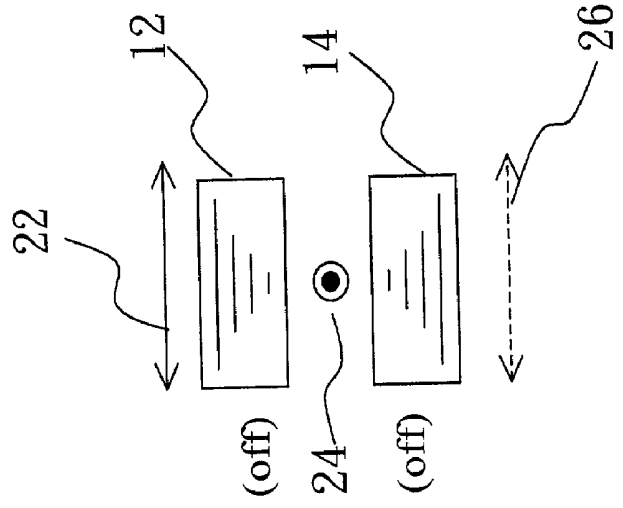


Fig. 4a

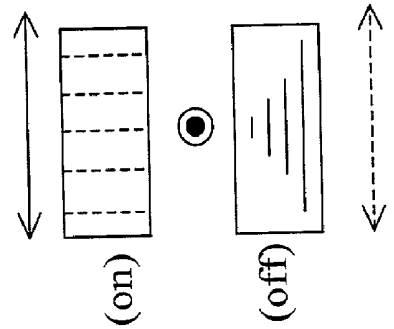


Fig. 4b

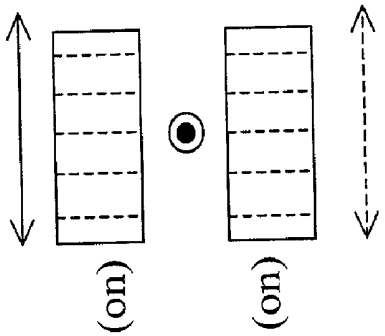


Fig. 4c

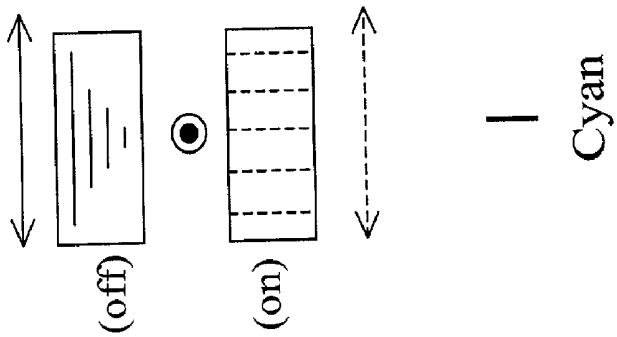


Fig. 4d

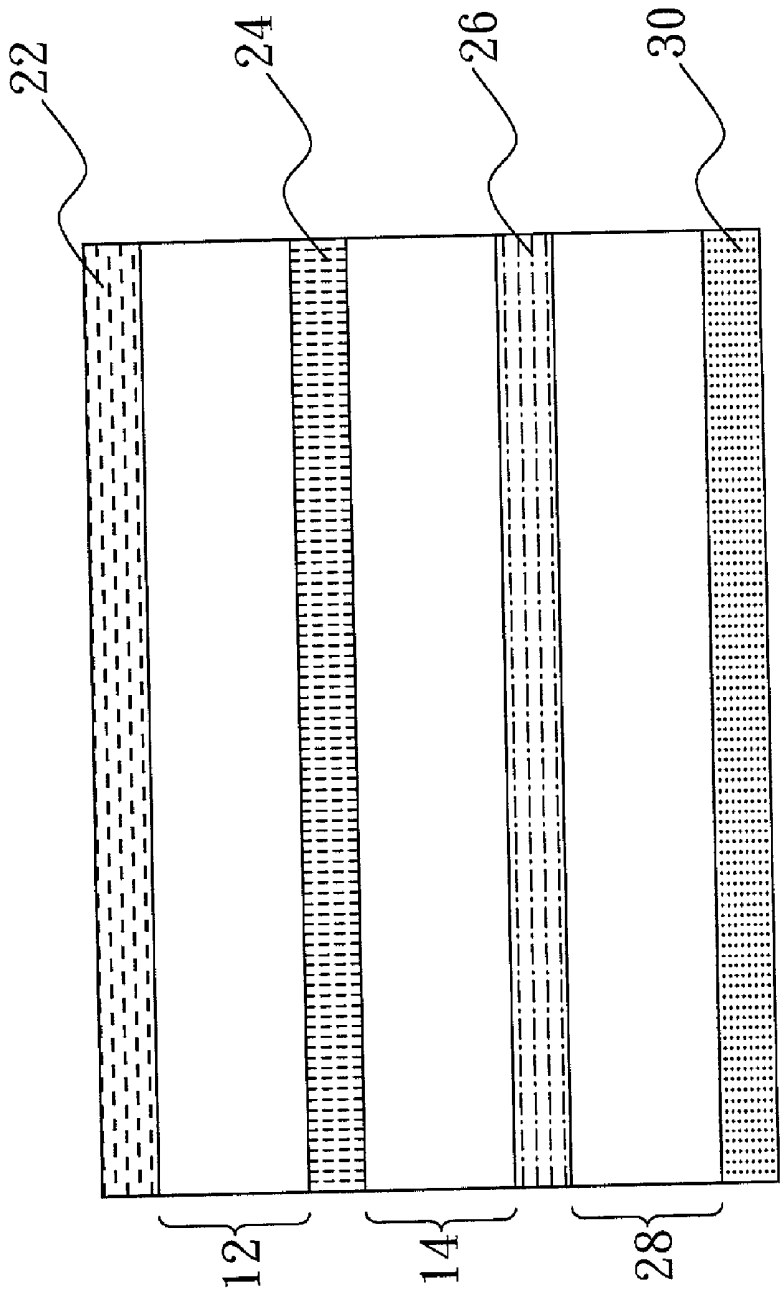


Fig. 5

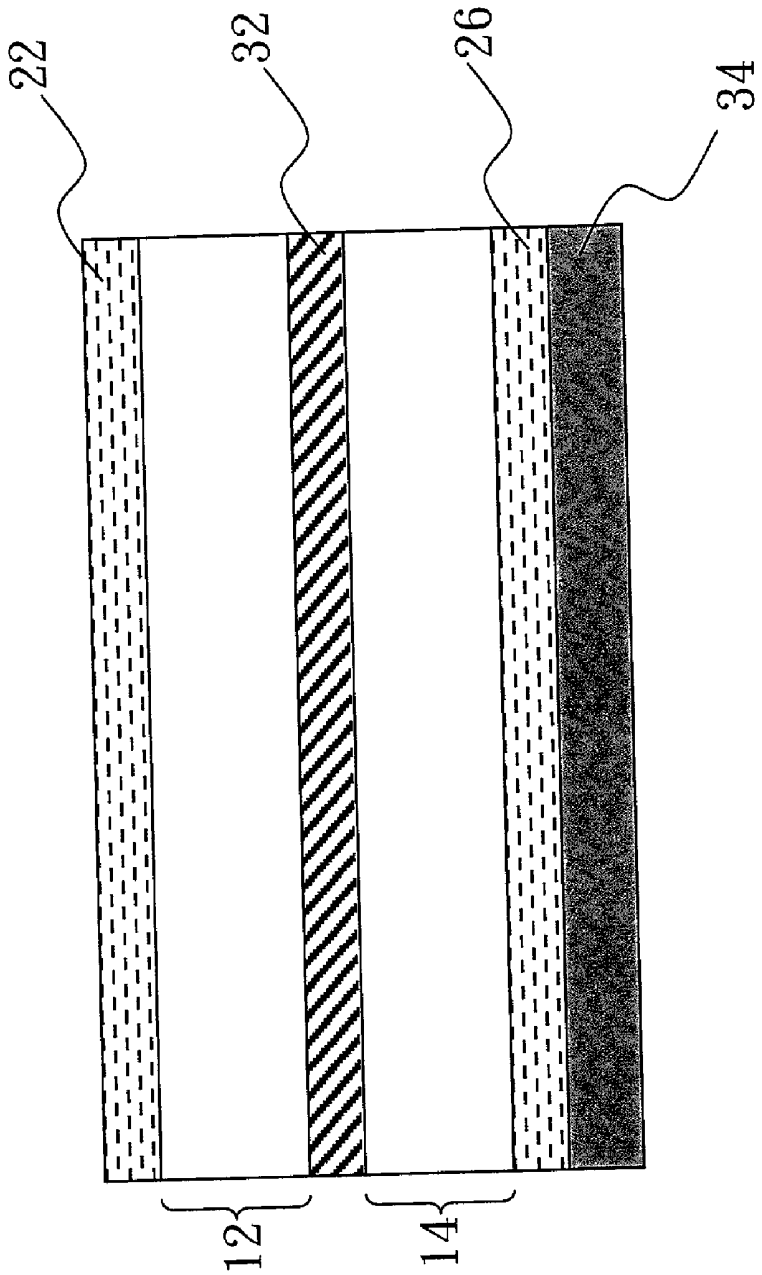


Fig. 6

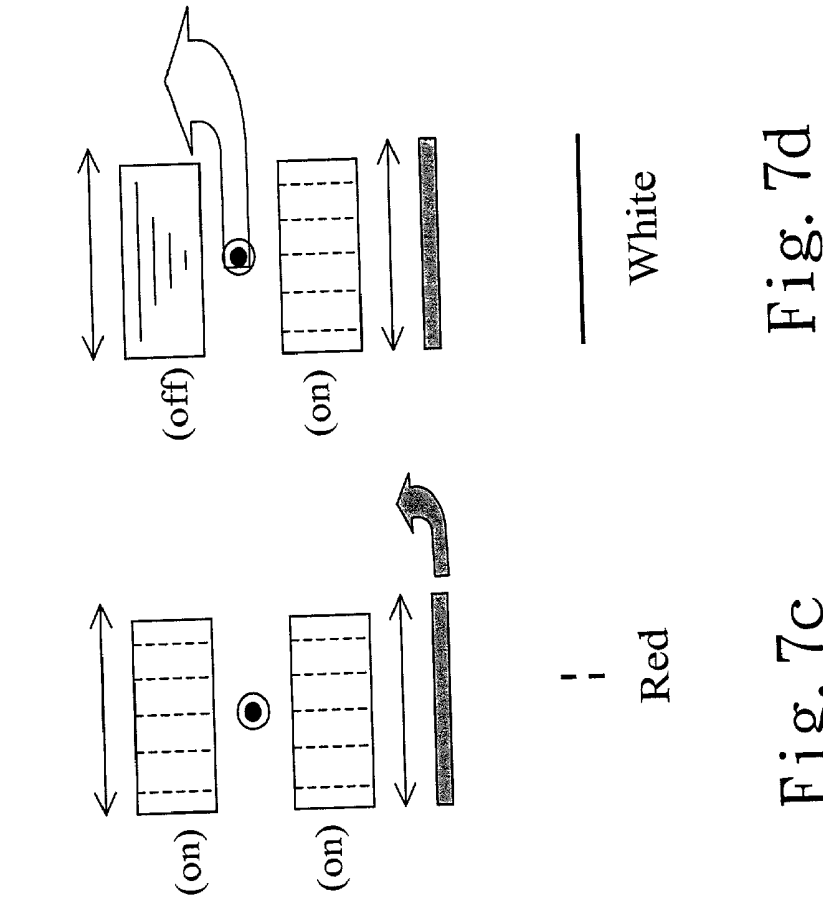


Fig. 7d

Fig. 7c

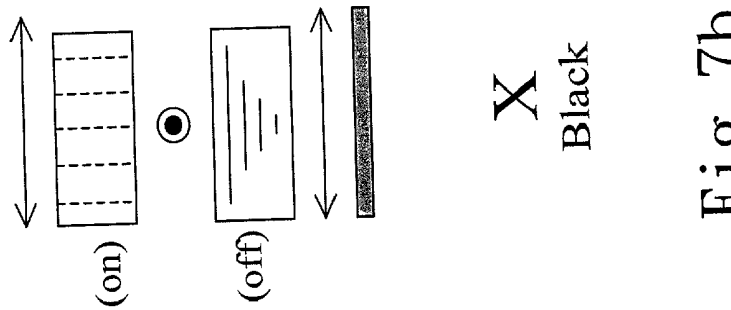


Fig. 7b

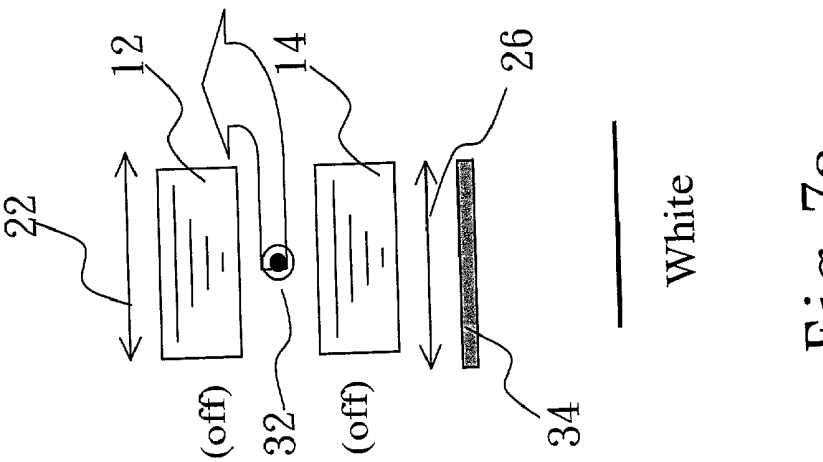


Fig. 7a

MULTI-COLOR LIQUID CRYSTAL DISPLAY

FIELD OF THE INVENTION

[0001] The present invention relates to a display and, more particularly, to a portable color liquid crystal display (LCD) having a low manufacturing cost.

BACKGROUND OF THE INVENTION

[0002] Along with increase of demand of portable communication products, compact displays have become point of importance of development in the communication industry. Most of conventional small LCDs such as panels of personal digital assistants (PDAs), mobile phones, and video games adopt the design of black-and-white display, hence having limited effect. Therefore, in order to achieve multi-color or full-color displaying effect, it is usually necessary to dispose a color filter in an LCD. Through the help of the color filter to display the three primary colors of red (R), green (G), and blue (B), full-color displaying mode can then be achieved by mixing different ratios of the three primary colors.

[0003] However, the color filter is expensive and has a high manufacturing cost. Because the required number of colors of the above small LCD is less, the price of this kind of products will go through the roof if the expensive color filter is applied to this kind of portable products, hence deteriorating the sell. Moreover, these small products have much limited display screens, and only need multi-color displaying effect.

[0004] Accordingly, the present invention aims to propose a multi-color LCD, which utilizes combinations and variations of polarizing plates to achieve multi-color displaying object so as to resolve the above problems.

SUMMARY OF THE INVENTION

[0005] The primary object of the present invention is to propose a multi-color LCD comprising at least two liquid crystal displaying modules and a plurality of polarizing plates to apply to some portable products requiring less number of colors.

[0006] Another object of the present invention is to provide a multi-color LCD having a low price.

[0007] According to the present invention, a first polarizing plate, a second polarizing plate, and a third polarizing plate are disposed above, between, and below two liquid crystal displaying modules stacked up and down, respectively. The polarizing plates are generally combinations of uncolored polarizing plates and absorption-type polarizing plates only absorbing monochromatic light. Presentation of different colors of the display is controlled by whether a voltage is applied onto the two liquid crystal displaying modules.

[0008] The various objects and advantages of the present invention will be more readily understood from the following detailed description when read in conjunction with the appended drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **FIG. 1** is a structure diagram of a three-color LCD of the present invention;

[0010] **FIGS. 2***a* to **2***d* show diagrams of four driving modes of **FIG. 1**;

[0011] **FIG. 3** is a structure diagram of a four-color LCD of the present invention;

[0012] **FIGS. 4***a* to **4***d* show diagrams of four driving modes of **FIG. 3**;

[0013] **FIG. 5** is a structure diagram of a multi-color LCD of the present invention;

[0014] **FIG. 6** is a structure diagram of a reflective multi-color LCD of the present invention; and

[0015] **FIGS. 7***a* to **7***d* show diagrams of four driving modes of **FIG. 6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The present invention adopts the design of more than two liquid crystal displaying modules matched with a set of polarizing plates to let an LCD achieve multi-color displaying object. A three-color LCD, a four-color LCD, and an RGB multi-color LCD will be described below to illustrate characteristics of the present invention.

[0017] As shown in **FIG. 1, a** multi-color LCD comprises a first liquid crystal displaying module **12** and a second liquid crystal displaying module **14**. In each of the two liquid crystal displaying modules **12** and **14**, transparent electrode layers **18** and **18'** are disposed on two opposite surfaces of an upper transparent substrate **16** and a lower transparent substrate **16'**, which are parallel spaced. A liquid crystal layer **20** is disposed between the two transparent substrates **16** and **16'**. A first polarizing plate **22** and a second polarizing plate **24** are pasted on outer surfaces of the upper and lower transparent substrates **16** and **16'** of the first liquid crystal displaying module **12**, respectively. Polarization directions of the first and second polarizing plates **22** and **24** are normal to each other. The upper transparent substrate **16** of the second liquid crystal displaying module **14** is disposed below the second polarizing plate **24** so that light passing through the second polarizing plate **24** can enter the second liquid crystal displaying module **14**. A third polarizing plate **26** is pasted on the outer surface of the lower transparent substrate **16'** of the second liquid crystal displaying module **14**. Polarization directions of the second and third polarizing plates **24** and **26** are normal to each other. The first and second polarizing plates **22** and **24** are generally uncolored polarizing plates, which let light with a polarization direction parallel to the polarization directions thereof pass through, and absorb light with a polarization direction perpendicular to the polarization directions thereof. The third polarizing plate **26** is an absorption-type polarizing plate only absorbing monochromatic light.

[0018] When the transparent electrode layers **18** and **18'** are off, liquid crystal molecules of the liquid crystal layer **20** will align toward a certain direction according the direction of thin trenches of an orientation film, and twist 90 degrees between the upper and lower transparent electrodes **18** and **18'**. When the transparent electrode layers **18** and **18'** are on, the alignment direction of liquid crystal molecules will be altered to be parallel to the electric field. In the present invention, presentation of different colors is controlled by whether a voltage is applied onto the two liquid crystal

displaying modules **12** and **14**. **FIGS. 2***a* to **2***d* show four driving modes of the two liquid crystal displaying modules **12** and **14**. The polarization directions of the first, second, and third polarizing plates **22**, **24**, and **26** are parallel to (denoted by ←----→), perpendicular to (denoted by ⊙), and parallel to (denoted by ←- - - →) the paper, respectively. The third polarizing plate **26** is a monochromatic polarizing plate only absorbing the red light.

[**0019**] When an incident light enters the first polarizing plate **22** and is converted to a polarized light parallel to the paper (as shown in **FIG. 2***a*), if no voltage is applied onto the two liquid crystal displaying module **12** and **14**, the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will rotate 90 degrees along with liquid crystal molecules to form a polarized light perpendicular to the paper, which successfully passes through the second polarizing plate **24** and then is incident into the second liquid crystal displaying module **14** to rotate 90 degrees along with liquid crystal molecules to form a polarized light parallel to the paper, which successfully passes through the third polarizing plate **26**. A white color is thus shown. If a voltage is applied onto the first liquid crystal displaying module **12** (as shown in **FIGS. 2***b* and **2***c*), no matter whether a voltage is applied onto the second liquid crystal displaying module **14**, the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will not rotate so as to be blocked by the second polarizing plate **24**, and thus cannot enter the second liquid crystal displaying module **14**. A black color is thus shown. Similarly, when no voltage is applied onto the first liquid crystal displaying module **12** while a voltage is applied onto the second liquid crystal displaying module **14** (as shown in **FIG. 2***d*), the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will rotate 90 degrees along with liquid crystal molecules to form a polarized light perpendicular to the paper, which successfully passes through the second polarizing plate **24** to enter the second liquid crystal displaying module **14**. Because not rotated by liquid crystal molecules, after the polarized light perpendicular to the paper passes through the third polarizing plate **26**, its red light will be absorbed so that a complementary cyan color is shown.

[**0020**] The above liquid crystal displaying modules **12** and **14** can be twisted-nemaic (TN) modules or other liquid crystal displaying modules. Phase-compensating sheets (not shown) can be disposed on upper and lower surfaces of the first, second, and third polarizing plates **22**, **24**, and **26**. The monochromatic absorption spectrum of the third polarizing plate **26** can be arbitrarily chosen according to necessity to let the display show a white color, a black color, and a complementary color of the selected absorbed light of the third polarizing plate **26**. The number of displayed colors can be increased by matching gray scale contrasts. Additionally, the above structures can be arbitrarily replaced to apply to transmission type, reflective type, and transflective type LCDs.

[**0021**] Similarly, a four-color LCD has a structure approximately the same as above. As shown in **FIG. 3, a** first liquid crystal displaying module **12** and a second liquid crystal displaying module **14** are stacked up and down. A first polarizing plate **22**, a second polarizing plate **24**, and a third polarizing plate **26** are disposed above, between, and below the two liquid crystal displaying modules **12** and **14**. The first polarizing plate **22** is generally an uncolored polarizing plate. The second and third polarizing plates **24** and **26** are absorption-type polarizing plates only absorbing monochromatic light. The absorption spectrum of the second and third polarizing plates **24** and **26** can be arbitrarily chosen. If the absorption spectrum of the second and third polarizing plates **24** and **26** are respectively cyan and its complementary red color, when no voltage is applied onto the two liquid crystal displaying modules **12** and **14** (as shown in **FIG. 4***a*), the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will successfully pass through the second and third polarizing plates **24** and **26** to show a white color. When a voltage is applied onto the first liquid crystal displaying module **12** while no voltage is applied onto the second liquid crystal displaying module **14** (as shown in **FIG. 4***b*), the cyan light of the polarized light parallel to the paper incident from the first polarizing plate **22** will be absorbed after passing through the second polarizing plate **24** so that only the red light of the polarized light parallel to the paper enters the second liquid crystal displaying module **14** and is then rotated 90 degrees to form a polarized light perpendicular to the paper, which will thus be blocked by the third polarizing plate **26** to show a black color. If a voltage is applied onto both the first and second liquid crystal displaying modules **12** and **14** (as shown in **FIG. 4***c*), the red light of the polarized light parallel to the paper incident from the first polarizing plate **22** will not be rotated after entering the second liquid crystal displaying module **14**, and will successfully pass through the third polarizing plate **26** to show a red color. Similarly, when no voltage is applied onto the first liquid crystal displaying module **12** while a voltage is applied onto the second liquid crystal displaying module **14** (as shown in **FIG. 4***d*), the polarized light parallel to the paper incident from the first polarizing plate **22** will be rotated 90 degrees to form a polarized light perpendicular to the paper after passing through the first liquid crystal displaying module **12** so as to successfully pass through the second polarizing plate **24**. The red light of the polarized light perpendicular to the paper will then be absorbed by the third polarizing plate **26** to show a cyan color. This display can thus display a white color, a black color, a red color, and a cyan color. A multi-color display can be obtained through mixing different ratios of colors and matching gray scale contrasts.

[**0022**] As shown in **FIG. 5, a** multi-color LCD can comprise three liquid crystal displaying modules **12**, **14**, and **28** stacked up and down. A first, a second, a third, and a fourth polarizing plates **22**, **24**, **26**, and **30** are disposed above the first liquid crystal displaying module **12**, between the first and second liquid crystal displaying modules **12** and **14**, between the second and third liquid crystal displaying modules **14** and **28**, and below the third liquid crystal displaying module **28**, respectively. The first polarizing plate **22** is generally an uncolored polarizing plate. The second, third, and fourth polarizing plates **24**, **26**, and **30** are polarizing plates absorbing red light, green light, and blue light, respectively. Eight configurations depending on whether a voltage is applied onto the three liquid crystal displaying modules **12**, **14**, and **28** are used to generate a white color, a black color, a red color, a cyan color, a green color, a purple

color, a blue color, and a yellow color, respectively. Multi-color display can be achieved by matching gray scale contrasts.

[0023] The present invention utilizes the combination of liquid crystal displaying modules and polarizing plates to achieve multi-color displaying effect without the need of an expensive color filter, hence lowering the cost and widely applying to display panels of portable products such as mobile phones, video games, PDAs, watches, and calculators.

[0024] Additionally, as shown in **FIG. 6, a** reflective type multi-color LCD comprises a first liquid crystal displaying module **12** and a second liquid crystal displaying module **14** stacked up and down. An optical polarizing plate **32** having a polarization direction perpendicular to the paper is disposed between the two liquid crystal displaying modules **12** and **14**. A first polarizing plate **22** and a third polarizing plate **26** are disposed above the first liquid crystal displaying module **12** and below the second liquid crystal displaying module **14**, respectively. The first and third polarizing plates **22** and **26** are generally uncolored polarizing plates. The polarization direction of the first and third polarizing plates **22** and **26** is normal to that of the optical polarizing plate **32** and parallel to the paper. A colored reflective layer **34** is disposed on the lower surface of the third polarizing plate **26**.

[0025] The above optical polarizing plate **32** reflects light having a polarization direction perpendicular to the paper, and lets light having a polarization direction parallel to the paper pass through. Operation of this embodiment of the present invention will be illustrated through four driving modes of the two liquid crystal displaying modules **12** and **14** matched with a red reflective layer **34**. As shown in **FIG. 7***a*, if no voltage is applied onto each of the two liquid crystal displaying modules **12** and **14**, the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will rotate 90 degrees along with liquid crystal molecules to become a polarized light perpendicular to the paper, which is then reflected back by the optical polarizing plate **32** to show a white color. When a voltage is applied on the first liquid crystal displaying module **12** while no voltage is applied onto the second liquid crystal displaying module **14** (as shown in **FIG. 7***b*), the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will pass through the optical polarizing plate **32** and enter the second liquid crystal displaying module **14** to rotate 90 degrees along with liquid crystal molecules to become a polarized light perpendicular to the paper, which is then blocked by the third polarizing plate **26**. A black color is thus shown. If a voltage is applied onto each of the two liquid crystal displaying modules **12** and **14** (as shown in **FIG. 7***c*), the polarized light parallel to the paper that enters the second liquid crystal displaying module **14** will pass through the third polarizing plate **26**, and then be reflected by the red reflective layer **34** to show a red color. Similarly, when no voltage is applied onto the first liquid crystal displaying module **12** while a voltage is applied onto the second liquid crystal displaying module **14** (as shown in **FIG. 7***d*), the polarized light parallel to the paper incident from the first polarizing plate **22** into the first liquid crystal displaying module **12** will be directly reflected back by the optical polarizing plate **32** to shown a white color.

[0026] In addition to being a reflective layer with color itself, the above colored reflective layer **34** can be a reflective layer on which a glue having color dye added therein is applied. The color dye can be arbitrarily chosen according to necessity. Additionally, a dyed layer can be disposed on the lower surface of the optical polarizing plate to achieve displaying effect of more colors.

[0027] Although the present invention has been described with reference to the preferred embodiments thereof, it will be understood that the invention is not limited to the details thereof. Various substitutions and modifications have been suggested in the foregoing description, and other will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intended to be embraced within the scope of the invention as defined in the appended claims.

I claim:

1. A multi-color liquid crystal display, comprising:

at least two liquid crystal displaying modules stacked up and down; and

at least three polarizing plates being a first, a second, and a third polarizing plates disposed above said upper liquid crystal displaying module, between said two adjacent liquid crystal displaying modules, and below said lower liquid crystal displaying module, said first polarizing plate converting an incident light into a unidirectional polarized light, said second and third polarizing plates being polarizing plates absorbing different monochromatic colors.

2. The multi-color liquid crystal display as claimed in claim 1, wherein disposition positions and polarization directions of said polarizing plates can be arbitrarily arranged and combined.

3. The multi-color liquid crystal display as claimed in claim 1, wherein one of said second and third polarizing plates can further be an uncolored polarizing plate to let a polarized light parallel to the polarization direction thereof pass through and to absorb a polarized light perpendicular to the polarization direction thereof.

4. The multi-color liquid crystal display as claimed in claim 1, wherein a colored or uncolored reflective layer can be disposed below said third polarizing plate to form a reflective type display.

5. The multi-color liquid crystal display as claimed in claim 1, wherein said polarizing plates can be replaced with non-absorption-type polarizing plates.

6. The multi-color liquid crystal display as claimed in claim 1, wherein said liquid crystal displaying modules can be twisted-nemaic modules or other liquid crystal displaying modules.

7. The multi-color liquid crystal display as claimed in claim 1, wherein at least a phase-compensating sheet can further be disposed on upper and lower surfaces of any one of said polarizing plates.

8. A multi-color liquid crystal display, comprising:

two liquid crystal displaying modules stacked up and down; and

a first and a second polarizing plates disposed above and below said two liquid crystal displaying modules, respectively;

an optical polarizing plate disposed between said two liquid crystal displaying modules, said optical polarizing plate being used to reflect a polarized light parallel to the polarization direction thereof and to let a polarized light perpendicular to the polarization direction thereof pass through; and

a colored reflective layer disposed below said second polarizing plate.

9. The multi-color liquid crystal display as claimed in claim 8, wherein said colored reflective layer is formed by disposing a glue on a surface of a reflective layer, and color dye is added in said glue.

10. The multi-color liquid crystal display as claimed in claim 8, wherein a dyed layer can further be disposed on a lower surface of said optical polarizing plate.

11. The multi-color liquid crystal display as claimed in claim 8, wherein said liquid crystal displaying modules can be twisted-nemaic modules or other liquid crystal displaying modules.

12. The multi-color liquid crystal display as claimed in claim 8, wherein at least a phase-compensating sheet can further be disposed on upper and lower surfaces of any one of said polarizing plates.

13. The multi-color liquid crystal display as claimed in claim 8, wherein said polarizing plates can be polarizing plates absorbing monochromatic light.

* * * * *

专利名称(译)	多色液晶显示器		
公开(公告)号	US20030081152A1	公开(公告)日	2003-05-01
申请号	US09/983563	申请日	2001-10-25
[标]申请(专利权)人(译)	常PIN 吴恒CHUNG LIN ALEX		
申请(专利权)人(译)	常PIN 吴恒-CHUNG LIN ALEX		
当前申请(专利权)人(译)	常PIN 吴恒-CHUNG LIN ALEX		
[标]发明人	CHANG PIN WU HENG CHUNG LIN ALEX		
发明人	CHANG, PIN WU, HENG-CHUNG LIN, ALEX		
IPC分类号	G02F1/1335 G02F1/1347		
CPC分类号	G02F1/13473 G02F1/133533		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种多色液晶显示器，其中偏振片设置在至少两个上下堆叠的液晶显示模块的上方，下方和之间。偏振片可以是吸收单色光的偏振片和一般无色偏振片的组合。根据是否将电压施加到液晶显示模块上，可以实现各种颜色。本发明具有低价格，适用于需要较少数量颜色的一些便携式产品。