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(54) **LIQUID CRYSTAL DISPLAY APPARATUS**

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(57) **ABSTRACT**

A display apparatus having an LCD panel and an LED backlight panel performs display, which includes a display area brightness calculation section which calculates brightness of each of a plurality of display areas based on the image data; a brightness sensor provided in each of a plurality of backlight areas to detect emitted light brightness of the plurality of backlight areas; a controller for adjusting the brightness of each of the backlight areas, based on the display area brightness and the emitted light brightness in each of the backlight areas; and an LED driver for driving each of the LEDs of the backlight panel.

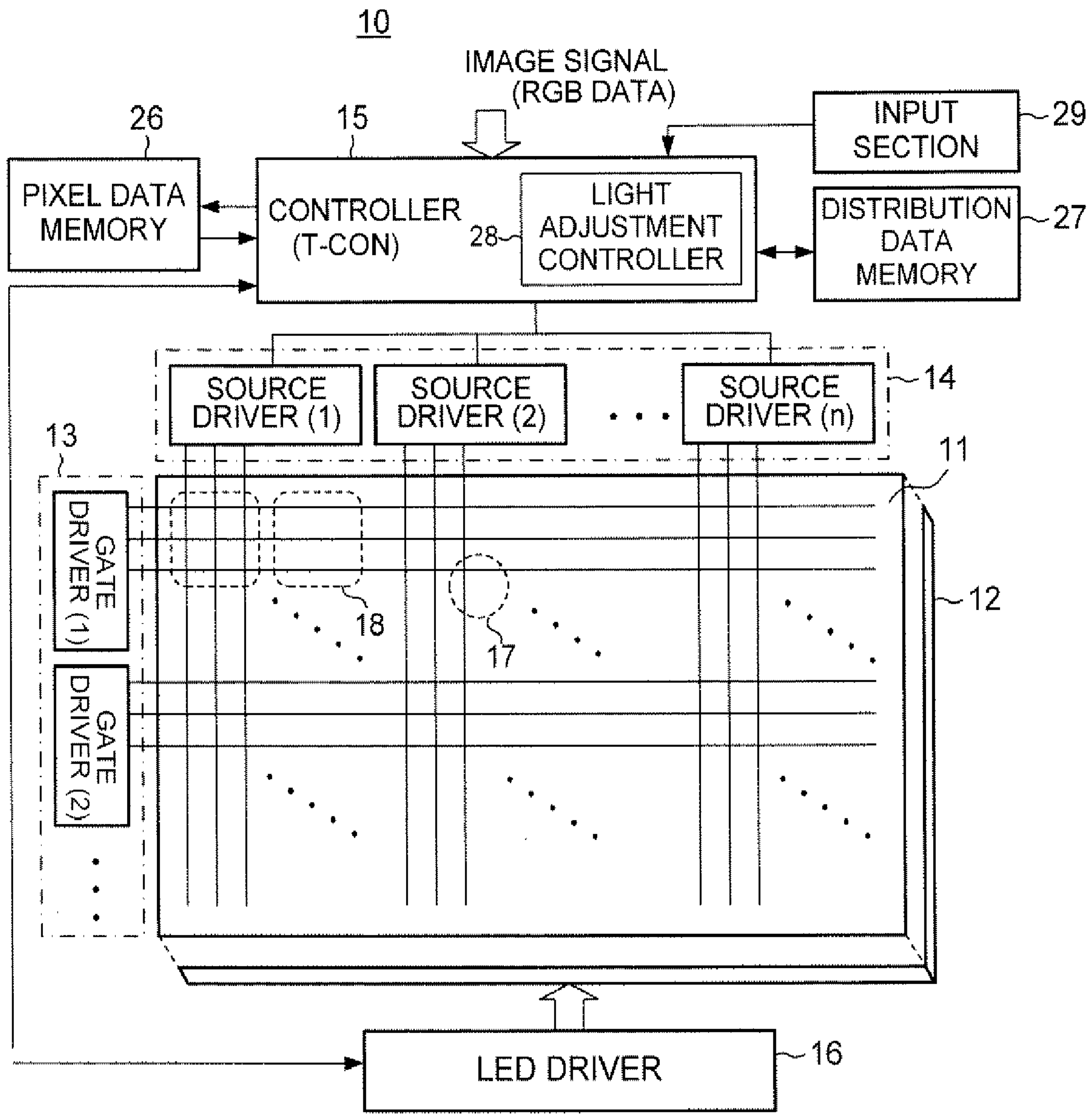


FIG.1

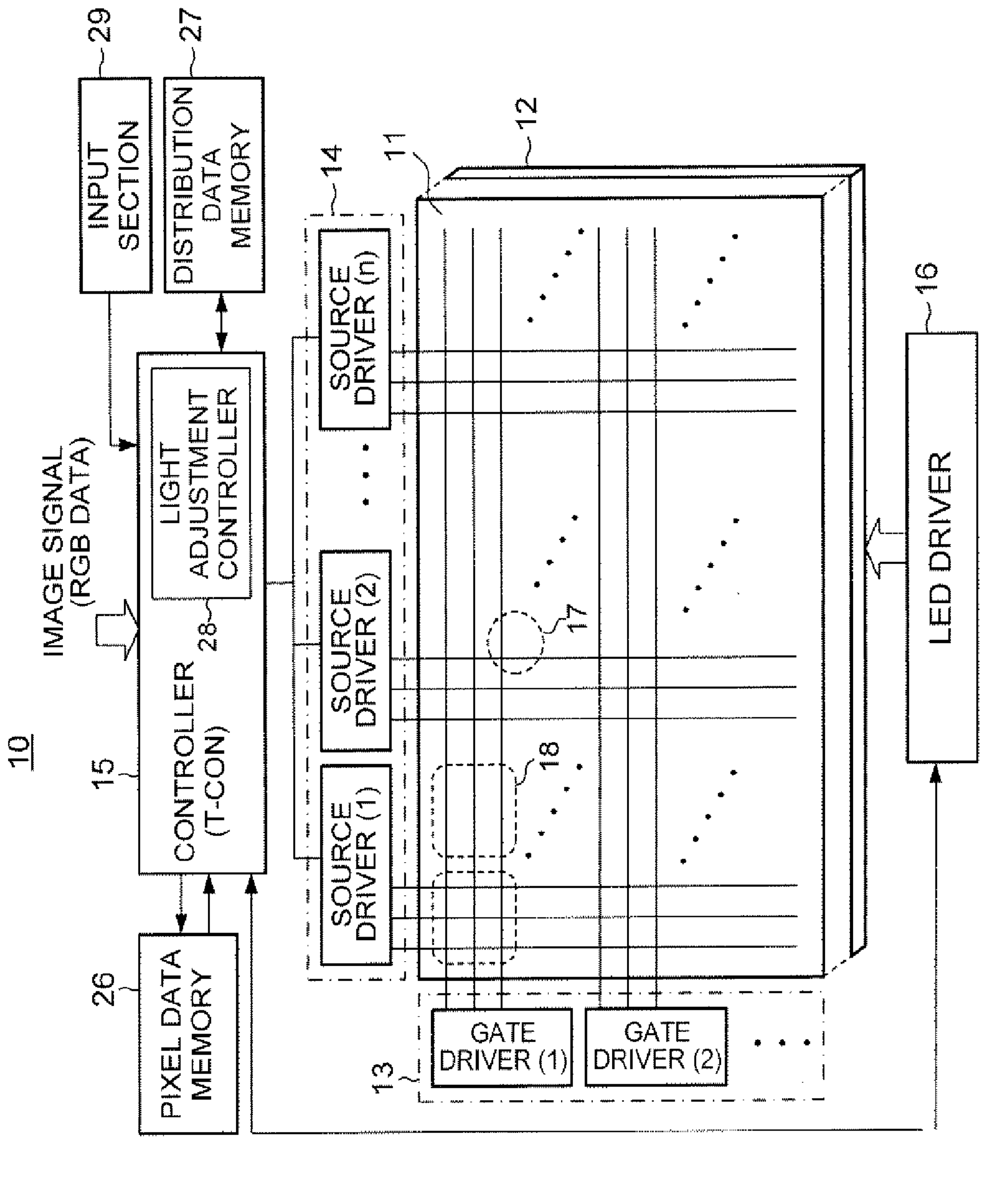

10
IMAGE SIGNAL (RGB DATA)
INPUT SECTION
29
DISTRIBUTION DATA MEMORY
27
CONTROLLER (T-CON)
15
LIGHT ADJUSTMENT CONTROLLER
28
PIXEL DATA MEMORY
26
SOURCE DRIVER (1)
SOURCE DRIVER (2)
SOURCE DRIVER (n)
14
11
12
17
18
GATE DRIVER (1)
GATE DRIVER (2)
13
LED DRIVER
16

FIG.2

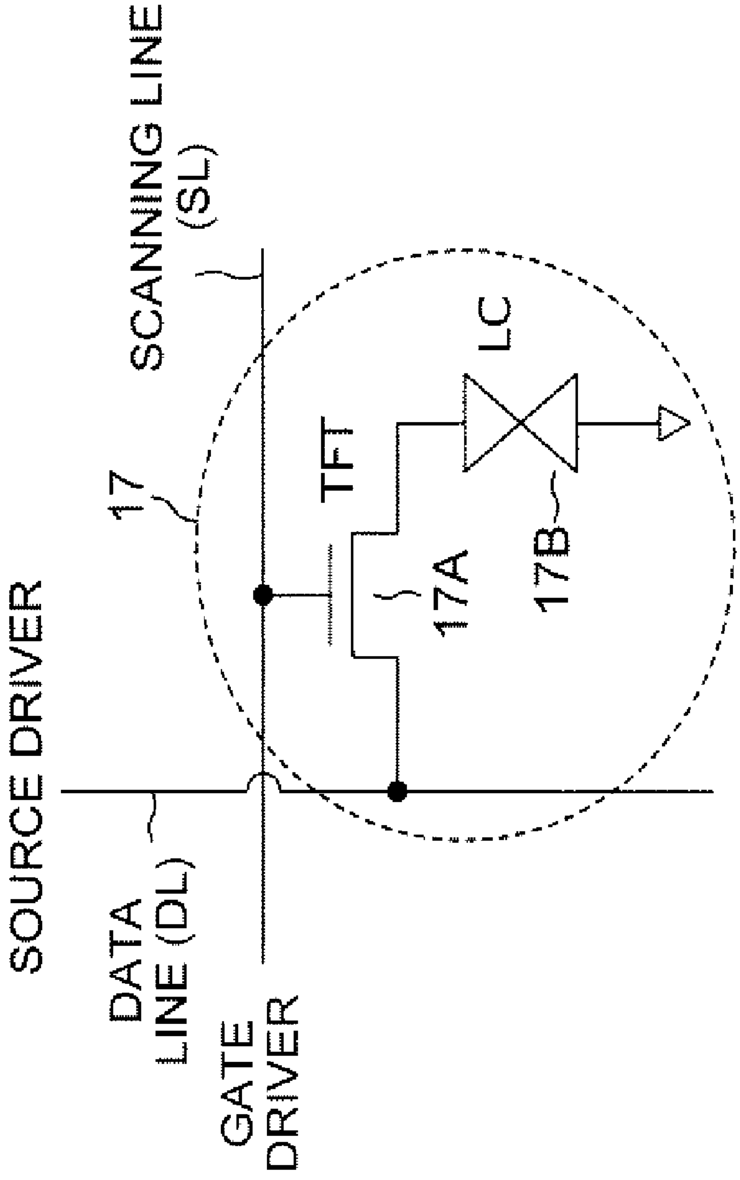

SCANNING LINE (SL)
17
TFT
LC
17A
17B
SOURCE DRIVER
DATA LINE (DL)
GATE DRIVER

FIG.3

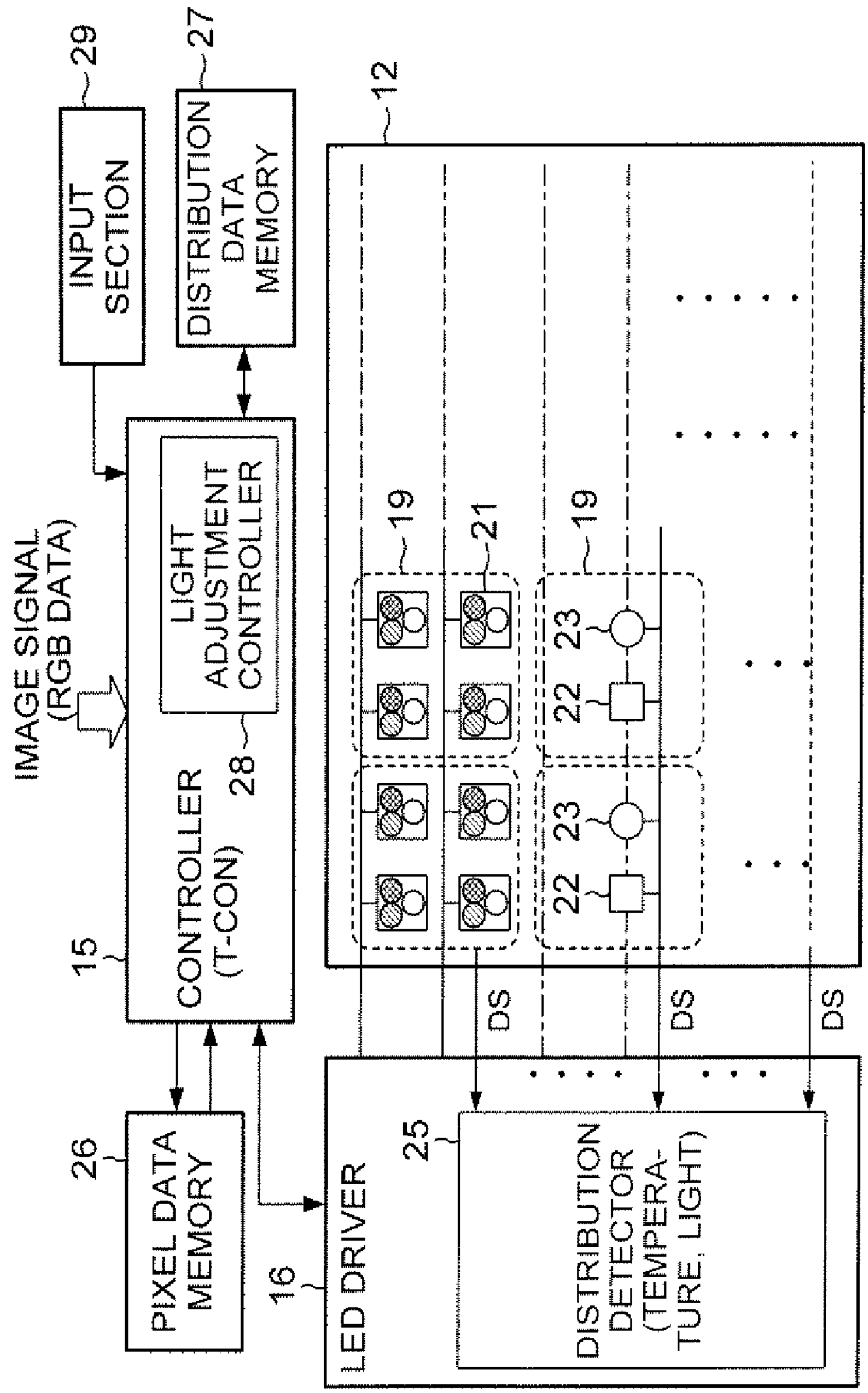
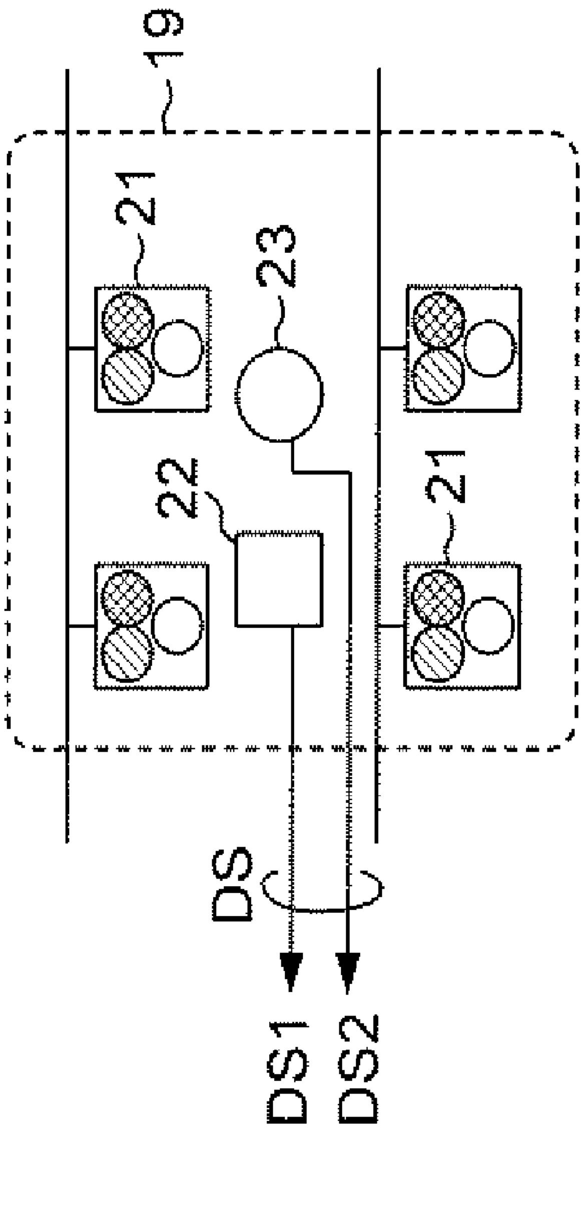

INPUT SECTION
29
DISTRIBUTION DATA MEMORY
27
12
IMAGE SIGNAL (RGB DATA)
LIGHT ADJUSTMENT CONTROLLER
28
CONTROLLER (T-CON)
15
19
21
19
23
22
23
22
DS
DS
DS
PIXEL DATA MEMORY
26
LED DRIVER
16
25
DISTRIBUTION DETECTOR (TEMPERA-TURE, LIGHT)

FIG.4



LIQUID CRYSTAL DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display, and more particularly, to a liquid crystal display apparatus having a backlight panel using light-emitting diodes.

[0003] 2. Description of the Related Art

[0004] The liquid crystal displays (LCD) are extremely widely used as a monitor display of the PC (personal computers), and a display device of the information terminal devices such as PDA (personal digital assistant). Moreover, LCD has recently been widely used for a display having a large screen of more than 30 inches, and researches and development on the more advanced liquid crystal displays are actively promoted.

[0005] In such crystal liquid displays, white light emitting diodes (LEDs) are sometimes used as a light source of the liquid crystal panel back face. Among the light-emitting diodes, there are one which emits white color by lighting the red, green and blue LEDs simultaneously to emit white color, and another one which emits white color by additive mixture of blue or blue-violet LED and yellow fluorescent material or the like. Such backlight light source had a problem of being poor in color rendering properties or capabilities due to variation in color, and the like. See, for example, refer to Japanese Unexamined Patent Publication Kokai No. 2002-231032 (hereinafter, also referred to as a Patent Document 1).

[0006] As mentioned above, in accordance with enlargement of applications to the large screen display (TV)and the like, in the backlight panel using a light-emitting diode also, strongly sought after are increased performance of the liquid crystal displays strongly sought after, such as uniformity of brightness, improvement of color rendering property or capability, and enlargement of chromaticity.

[0007] However, there has been a problem that the brightness and color rendering property over the entire surface of the panel become deteriorated due to individual difference in lighting property of the LED elements, non-uniformity of temperature during operation, or characteristics changes over time of the LED elements.

SUMMARY OF THE INVENTION

[0008] The present invention has been made in view of the points described above, and it is an object of the invention to provide a high-performance liquid crystal display apparatus having uniformity in brightness and color rendering property over the entire surface of the display panel.

[0009] A liquid crystal display apparatus according to the present invention is a liquid crystal display apparatus which includes a liquid crystal display panel and a backlight panel having LEDs (light emitting diodes) lighting the liquid crystal panel from the back face thereof, and performs display based on image data, the liquid crystal display apparatus comprises a display area brightness calculation section which divides the liquid crystal panel into a plurality of display areas, and calculates a display area brightness for each of the plurality of display areas, based on the image data; an emitted light brightness sensor which is provided in each of a plurality of backlight areas set in the backlight panel, and detects emitted light brightness for each of the backlight areas; a light adjustment controller for adjusting the brightness of each of the backlight areas, based on the display area brightness and the emitted light brightness in each of the backlight areas; and an LED driver for driving each of the LEDs of the backlight panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a block diagram schematically showing the configuration of a liquid crystal display apparatus according to an embodiment of the present invention;

[0011] FIG. **2** is a diagram schematically showing the detailed configuration of a liquid crystal panel, where switching elements (TFT) are provided at the intersections of scanning lines (SL) and the data lines (DL);

[0012] FIG. **3** is a diagram schematically showing the detailed configuration of a crystal liquid display (LCD) apparatus, in particular, a backlight panel according to the embodiment;

[0013] FIG. **4** is a diagram schematically showing the detailed configuration of a backlight panel, where RGB-LEDs, a temperature sensor, and a light sensor are provided in the backlight section.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In the following, preferred embodiments of the present invention will be described in detail with reference to the drawings. FIG. **1** is a block diagram schematically showing the configuration of a liquid crystal display apparatus **10** according to an embodiment of the present invention. The display section of the liquid crystal display (LCD) apparatus **10** is comprised of a liquid crystal (LCD) panel **11**, and a backlight panel (or backlight module) **12**. Further, the liquid crystal panel (LCD) apparatus **10** is provided with a gate driver **13** and a source driver **14** for driving the liquid crystal (LCD) panel **11**, and the gate driver **13** and the source driver **14** are controlled by a controller **15**.

[0015] Further, the liquid crystal display (LCD) apparatus **10** is provided with a backlight driver (LED driver) **16** for driving the backlight panel **12**. The backlight driver **16** is controlled by the controller **15**. In the liquid crystal (LCD) panel **11**, a liquid crystal material is held between two sheets of transparent plates such as glass plates opposed to each other. Specifically, adjustment of voltage applied to the liquid crystal changes light transmission from the backlight panel **12**, and thereby changes the brightness to perform display.

[0016] In the liquid crystal (LCD) panel **11**, provided are a plurality of scanning lines, and a plurality of data lines arrayed in a direction intersecting with the scanning lines (for example, in the orthogonal direction). Further, as shown in FIG. **2**, a thin film transistor (TFT) **17**A is provided at the intersecting position of the scanning lines (SL) and the data lines (DL). For example, scanning lines (SL) are connected the gates of the TFT **17**A, and the data lines are connected to the source of TFT **17**A. And, configuration is made so that the transmission of the liquid crystal section (LC) **17**B is controlled in accordance with a data signal supplied from the data line corresponding to scanning of the scanning line, thereby performing two-dimensional display.

[0017] Thus, a display element **17** is comprised of a thin film transistor (TFT) **17**A and the liquid crystal (LC) section **17**B. The display element **17** is arrayed in a form of matrix to form the liquid crystal (LCD) panel **11**.

[0018] Specifically, when a liquid crystal display (LCD) apparatus **10** is a color liquid crystal display apparatus, one picture element is comprised of three display elements **17** of red, green and blue (DGB), and color representation is performed by passing the transmission light through red, green and blue (RGB) filters.

[0019] The configuration of the liquid crystal display (LCD) apparatus **10** will be described in detail with reference to FIG. **1**. The scanning lines of the liquid crystal display (LCD) panel **11** are connected with the gate driver **13**, and the data lines are connected with the source driver **14**. In this event, as shown in FIG. **1**, the gate driver **13** may be comprised of one or more gate driver ICs (LSIs), i.e., may be comprised of a gate driver IC (**1**), a gate driver IC (**2**) . . . a gate driver IC (m) (hereinafter, these gate driver ICs are collectively called "gate driver"). Further, the source driver **14** may be comprised of one or more source driver ICs (LSI), i.e., may be comprised of a source driver IC (**1**), a source driver IC (**2**) . . . a source driver IC (n) (hereinafter, these source driver ICs are generically called "source driver") (where, "m" and "n" are a natural number).

[0020] An image signal (for example, RGB signals) input to the liquid crystal display (LCD) apparatus **10** is supplied to the controller **15**. The controller **15** has control capability as so-called "timing controller (T-CON)."

[0021] In the display operation of the liquid crystal display (LCD) apparatus **10**, the gate driver **13** performs line sequential scanning by sequentially supplying to the scanning lines a scanning voltage signal (scan pulse) which scans the scanning lines at a specified scanning timing.

[0022] The source driver **14** receives a data signal (data signal such as gradation data and color data) supplied from the controller **15**. The source driver **14** supplies to each of the data lines the voltage applied to the liquid crystal, in correspondence with the data signal. In this event, the voltage applied to the data lines is supplied in accordance with the scanning timing by the gate driver **13**.

[0023] For example, the source driver **14** receives digital data (for example, 8 bits) as color data from the controller **15**. The source driver **141** for example, converts the color data signal into an analog voltage signal corresponding to the gamma characteristic representing the relation between applied voltage and transmission of a liquid crystal material. That is, the source driver **14** may have a digital-analog conversion circuit (DAC). The analog voltage generated by the DAC is output to the panel.

[0024] The applied voltage signal described above is applied to the liquid crystal section (LC) **17**B of each pixel through TFT **17**A. That is, the applied voltage signal is written to each of pixels, and is displayed in correspondence with the applied voltage, and such display state is held by the capacitance of the liquid crystal in itself until next writing.

[Configuration Concerning Lighting Control]

[0025] The configuration and operation concerning light adjustment control will now be described in more detail. Referring to FIG. **3**, in the backlight panel **12**, provided is a plurality of white LED elements **21** each comprised of three colors of red, green and blue (RGB) LED (hereinafter called "RGB-LED"). The plurality of RGB-LEDs **21** is connected with the LED driver **16**, and are driven by the LED driver **16**. The LED driver **16** is connected bi-directionally with the controller **15**, and is operated by control of the controller **15**.

[0026] In this event, the LED driver **16** may be comprised of one or more driver IC's (LSI's). Below, these driver ICs comprising LED driver are generically called the LED driver **16**.

[0027] The backlight panel **12** is divided into a plurality of lighting areas **19** (also called "backlight sectional area" or simply "backlight section"), and each of the backlight sections **19** comprises at least one RGB-LED **21**. And, each of the backlight sections **19** is provided with a temperature sensor **22** and a light sensor **23**, respectively.

[0028] In more detail, as shown in FIG. **3** and FIG. **4**, the backlight section **19** is provided with a temperature sensor **22** and a light sensor **23**, in addition to four RGB-LEDs **21**. The temperature sensor **22** and light sensor **23** detect the temperature and light intensity respectively at the areas **19**, and supply a detection signal DS (a temperature detection signal DS**1**, a light intensity detection signal DS**2**) to a distribution detector **25** provided in LED driver **16**.

[0029] In this event, each of the backlight sections **19** is not meant to be physically divided, but is meant to be divided (set) as a measured area to detect temperature and light intensity.

[0030] Further, FIG. **3** and FIG. **4** show a case where each of the backlight sections **19** comprises four RGB-LEDs **21**, but they are shown as an example. Further, the number of RGB-LEDs **21** comprised in each of the backlight sections may be different. In short, such configuration may be admitted when temperature distribution and light intensity in the backlight panel **12** are adequately obtained. In this event, the backlight section **19** may be divided in such a way as to correspond to an area comprised of a plurality of pixels (display section) **18**, later described. Or, the backlight section **19** may be divided independently of the display section **18**.

[0031] The distribution detector **25** receives a temperature detection signal DS**1** and light intensity detection signal DS**2**, respectively from each of the temperature sensors **22** and each of the light sensors **23**, which are provided in the backlight panel **12**, and calculates the temperature distribution and the light intensity distribution in the backlight panel **12**. In more detail, the distribution detector **25** measures the temperature and the light intensity in each of the backlight sections **19**, and calculates the temperature distribution and the light intensity distribution (dispersion information) in the backlight panel **12** based on the measured values. The RGB-LED **21** varies in emitted light brightness with temperature change and with time. Further, there is an individual difference due to variation in manufacture of the LED elements. For example, there is a variation of about 10% in terms of driving voltage.

[0032] Therefore, the temperature sensor **22** and the light sensor **22** serve as an emitted light sensor provided in the backlight section **19**.

[0033] The temperature distribution and/or the light intensity distribution (dispersion information) of the backlight panel **12** calculated by the distribution detector **25** are made into digital data, and are supplied to the controller **15**. For example, according to such measured temperature distribution and/or measured light intensity distribution, they are calculated as brightness distribution data (distribution data of backlight emitted light brightness) and are made into digital data. The distribution data of the backlight brightness is stored in a distribution data memory **27** by control of the controller **15**. The distribution data memory **27** is comprised of nonvolatile memories.

[Light Adjustment Control Operation]

[0034] The controller **15** receives RGB pixel data which is an image signal. Further, the controller **15** temporarily stores in the pixel data memory **26**, image data equivalent to one frame, based on the received image signal. The controller **15**

calculates the brightness of the frame (screen) based on such stored data equivalent to one frame.

[0035] The controller **15** sends the calculated distribution data to the LED driver **16**, and adjusts the brightness of the entire screen or desired part of the screen area.

[0036] In more detail, for example, as shown in FIG. **1**, the screen area (display area) of the liquid crystal (LCD) panel **11** is divided into a plurality of areas **18** (also called "display sectional area" or simply "display section").

[0037] In this event, each of the display sections **18** is not meant to be physically divided, but is meant to be divided (set) as a calculated area to calculate the brightness by image data.

[0038] The controller **15** is provided with a light adjustment control section **28** which has computation processing capability for RGB-LED light adjustment control of the backlight panel **12**. Based on data stored (primary retention) in the pixel data memory **26**, the controller **15** performs computation processing for the entire screen or any screen display area (display section). By this processing, the brightness of the entire screen or each of any display sections is calculated. Information on each of the RGB-LEDs **21** stored in the nonvolatile memory is used as a parameter for the computation processing, and is sent to the LED driver **16** for optimum brightness adjustment.

[0039] The light adjustment control section **28** serves as a display area brightness calculation section for calculating the brightness of the display area (display section). The controller **15** and the light adjustment control section **28** jointly perform light adjustment control, later described.

[0040] The light adjustment control section **28** sends the calculated brightness data to the LED driver **16**, and performs brightness adjustment of the display sections and the entire display. The red LED element (R), the green LED element (G) and the blue LED element (B) of the RGB-LED **21** are respectively submitted to individual luminance graduation control. For example, gradation control in 8-bit gradation (256 steps) is performed. By such control, variation of the brightness and emitted light color of the RGB-LEDs **21** can be restricted.

[0041] Therefore, by such control, the brightness or luminance control and variation of the emitted light color on the display screen can be adjusted in correspondence to change of the image data, i.e., dynamic change of the image brightness.

[0042] The computation processing and brightness adjustment described above, by the controller **15** (and the light adjustment control section **28**) may be performed for each frame of image data, or may be performed by a specified number of frames. On the other hand, the light adjustment control section **28** may be configured so as to calculate the brightness change between frames, and to perform brightness adjustment in accordance with the brightness change. In this event, configuration can be made so that pixel data corresponding to several frames is stored in the pixel data memory **26**.

[0043] Further, as described above, the brightness distribution data of the backlight panel **12** which is stored in the distribution data memory **27** such as nonvolatile memory or the nonvolatile memory-built-in the LED driver **16** is read by the light adjustment control section **28**, and is used as a computation processing parameter in the lighting control section **28**. Then, the computed data is supplied to the LED driver **16**; the LED driver **16** is controlled according to the computed data; and each of the backlight sections **19** is adjusted to an optimum brightness. Specifically, as described above, each of the backlight sections **19** is configured so as to include one or more of the RGB-LEDs **21**. For example, configuration can be made so that a temperature sensor **22** and/or a light sensor **23** are provided for each of the RGB-LEDs **21** so as to permit the control to each of the RGB-LEDs.

[0044] In this event, the light adjustment control is performed by the measured values of the temperature sensor **22** and the light sensor **23**, or by distribution of the measured values. Further, the light adjustment control by the measured values or the distribution of measured values is performed independently of the pixel data.

[0045] Specifically, the LED driver **16** for driving The LED **21** has a nonvolatile memory, and in the nonvolatile memory, stored as data are the measured values of the temperature sensor and the light sensor, as well as year-by-year information or information on variation over time of the measured information. The light adjustment control section **28** may be configured in such a manner as to perform brightness adjustment based on the year-by-year information or the information on variation over time.

[0046] In this event, the calculation and/or collection of the brightness distribution (temperature and light intensity distribution) data of the backlight section **19** can be configured at desired time or at a desired interval of time based on user input to an input section **29**, under the control of the controller **15**. On the other hand, in response to the user input to the input section **29**, for example, the execution can be configured in response to input made by depressing a command switch which commands distribution data collection, and the like.

[0047] As explained in detail in the embodiment, for both dynamic change of image brightness and variation (brightness distribution) of each the LED of the backlight, an optimum adjustment can be made, and uniform adjustment with good color rendering property can be made, while restricting variation of the emitted light color, and the like.

[0048] Further, as the brightness distribution information of the backlight LED is retained in the nonvolatile memory, an optimum brightness control can be made immediately after rising at the power-on time of the liquid crystal display (LCD) apparatus.

[0049] Therefore, solved is the problem of the conventional art in that the brightness in the entire display panel and uniformity of color rendering property or capability deteriorate due to temperature non-uniformity during operation, change of the LED elements over time, and a high-quality and high-performance liquid crystal display can be provided.

[0050] The invention has been described with reference to the preferred embodiments thereof. It should be understood by those skilled in the art that a variety of alterations and modifications may be made from the embodiments described above. It is therefore contemplated that the appended claims encompass all such alterations and modifications.

[0051] This application is based on Japanese Patent Application No. 2007-087498 which is hereby incorporated by reference.

What is claimed is:

1. A liquid crystal display apparatus which includes a liquid crystal display panel and a backlight panel having LEDs (light emitting diodes) lighting the liquid crystal panel from the back face thereof, and performs display based on image data, the liquid crystal display apparatus comprising:

a display area brightness calculation section which divides the liquid crystal panel into a plurality of display areas, and calculates a display area brightness for each of the plurality of display areas, based on the image data;

an emitted light brightness sensor which is provided in each of a plurality of backlight areas set in the backlight panel, and detects emitted light brightness for each of the backlight areas;

a light adjustment controller for adjusting the brightness of each of the backlight areas, based on the display area brightness and the emitted light brightness in each of the backlight areas; and

an LED driver for driving each of the LEDs of the backlight panel.

2. A liquid crystal display apparatus according to claim **1**, wherein the light adjustment controller calculates the display area brightness based on pixel data for each of the frames of the image data.

3. A liquid crystal display apparatus according to claim **1**, wherein the backlight panel is comprised of a plurality of light sources, each one of which is comprised of red, green and blue (RGB) LEDs in the inside of the lighting face.

4. A liquid crystal display apparatus according to claim **1**, wherein the emitted light sensor comprises a temperature sensor and a light sensor.

5. A liquid crystal display apparatus according to claim **1**, wherein the LED driver for driving the LED has a nonvolatile memory, and stores the measured values of the temperature sensor and light sensor, and changes over time of the measured values.

6. A liquid crystal display apparatus according to claim **3**, wherein the light adjustment controller performs individual luminance control of each of the red, green and blue (RGB) LEDs.

7. A liquid crystal display apparatus according to claim **3**, wherein the light adjustment controller calculates a brightness change between frames to perform brightness adjustment in accordance with the brightness change.

8. A liquid crystal display apparatus according to claim **1**, further comprising a distribution detector which calculates brightness distribution of the backlight panel on the basis of detected emitted light brightness for each of the backlight areas, wherein the light adjustment controller adjust the brightness of each of the backlight areas on the basis of the brightness distribution.

9. A liquid crystal display apparatus according to claim **5**, further comprising a command input section to receive a command input, wherein the distribution detector performs calculation of the brightness distribution in response to the command input.

10. A liquid crystal display apparatus according to claim **5**, wherein the light adjustment controller performs brightness control of each of the backlight areas based on the changes over time of the measured values.

* * * * *

专利名称(译)	液晶显示装置		
公开(公告)号	US20080238860A1	公开(公告)日	2008-10-02
申请号	US12/043191	申请日	2008-03-06
申请(专利权)人(译)	冲电气工业有限公司.		
当前申请(专利权)人(译)	OKI半导体CO.，LTD.		
[标]发明人	ONODERA YOSHINORI		
发明人	ONODERA, YOSHINORI		
IPC分类号	G02F1/13357		
CPC分类号	G02F1/133603 G09G3/3413 G09G3/3426 G09G2320/0233 G09G2320/0242 G09G2320/041 G09G2320/043 G09G2320/0646 G09G2360/145		
优先权	2007087498 2007-03-29 JP		
外部链接	Espacenet USPTO		

摘要(译)

具有LCD面板和LED背光面板的显示装置执行显示，其包括显示区域亮度计算部分，其基于图像数据计算多个显示区域中的每一个的亮度;设置在多个背光区域中的每一个中的亮度传感器，以检测多个背光区域的发光亮度;控制器，用于根据每个背光区域中的显示区域亮度和发光亮度调节每个背光区域的亮度;以及用于驱动背光板的每个LED的LED驱动器。