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(54) **LIGHT SOURCE DEVICE, BACKLIGHT UNIT, AND LIQUID CRYSTAL DISPLAY DEVICE**

(75) Inventor: **Tetsuya Hamada**, Mie (JP)

Correspondence Address:
SHARP KABUSHIKI KAISHA
C/O KEATING & BENNETT, LLP
1800 Alexander Bell Drive, SUITE 200
Reston, VA 20191 (US)

(73) Assignee: **SHARP KABUSHIKI KAISHA**, Osaka-shi, Osaka (JP)

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(57) **ABSTRACT**

A light source device, a backlight unit, and a liquid crystal display device are each capable of improving uniformity of a luminance and a color of a display surface. The light source device includes a board; a plurality of point light sources arranged on a surface of the board and connected in series; and a variable resistor, wherein the variable resistor is disposed on the surface on which the plurality of point light sources are arranged of the board; at least one point light source arranged on an end side among the plurality of point light sources is connected in parallel to the variable resistor; and the board has a through-hole in a region where a variable resistor is located.

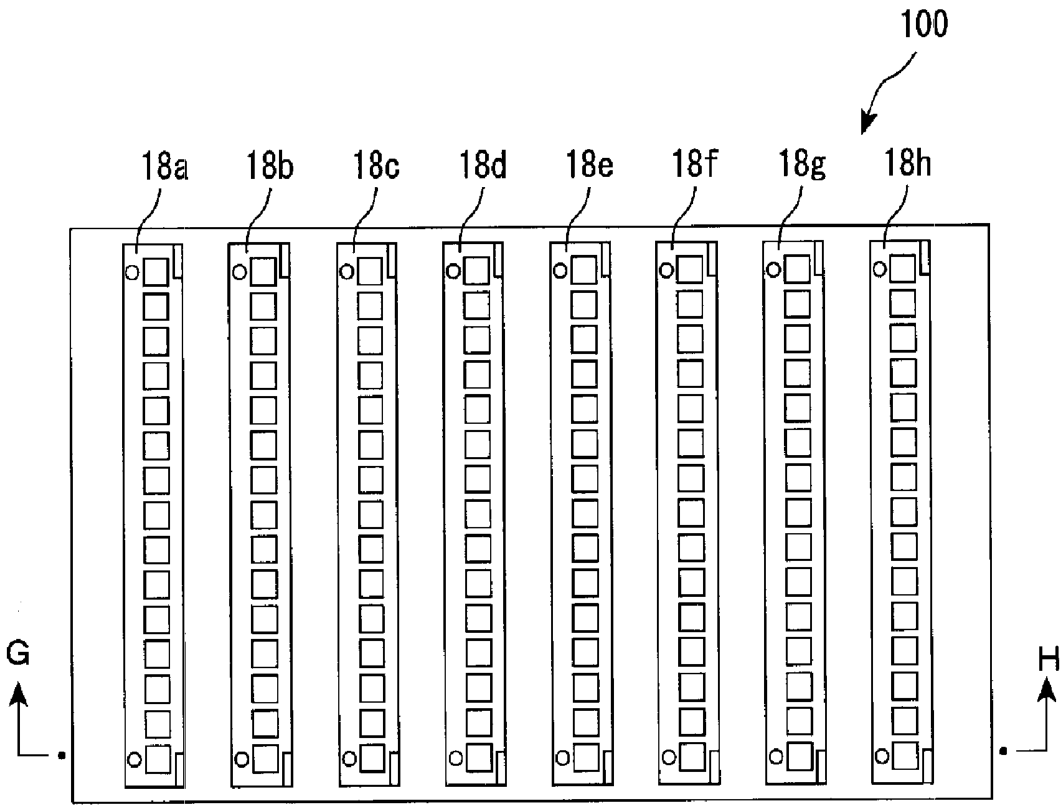


FIG. 1A

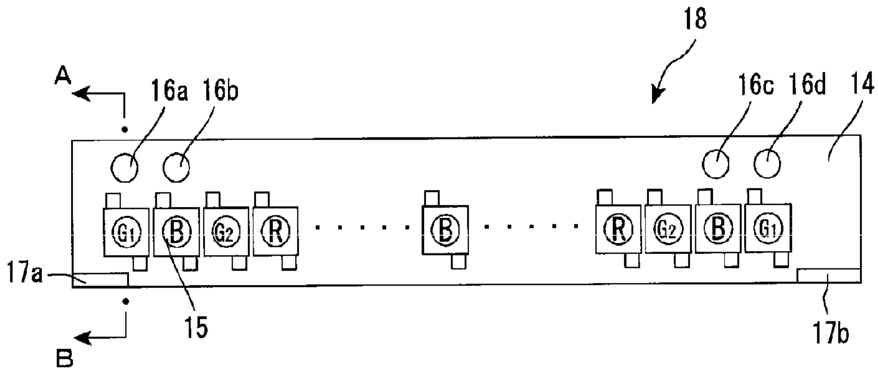


FIG. 1B

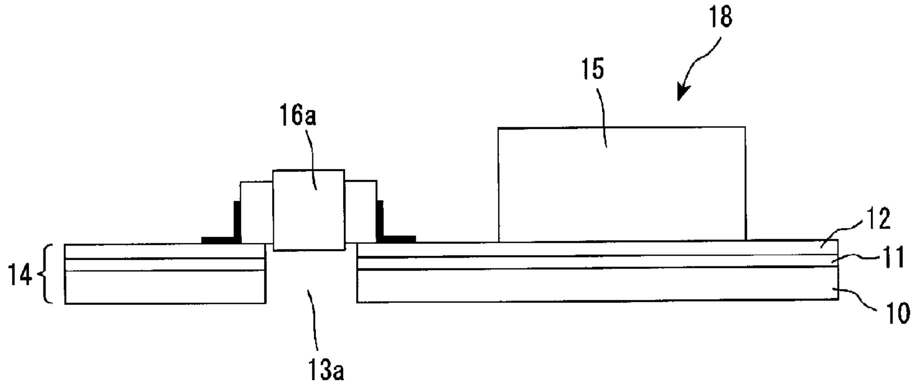
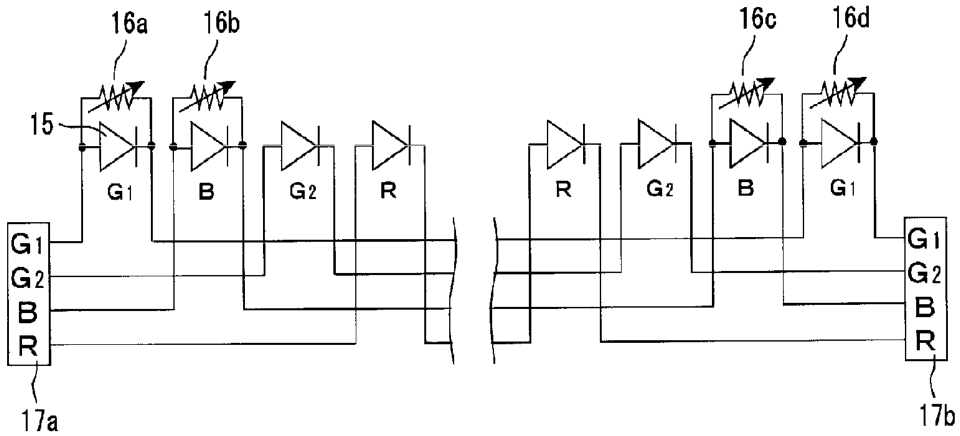


Fig.2



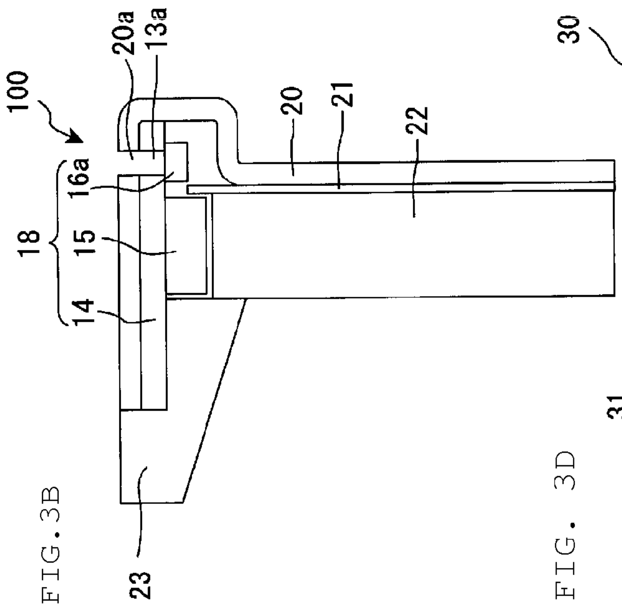


FIG.3B

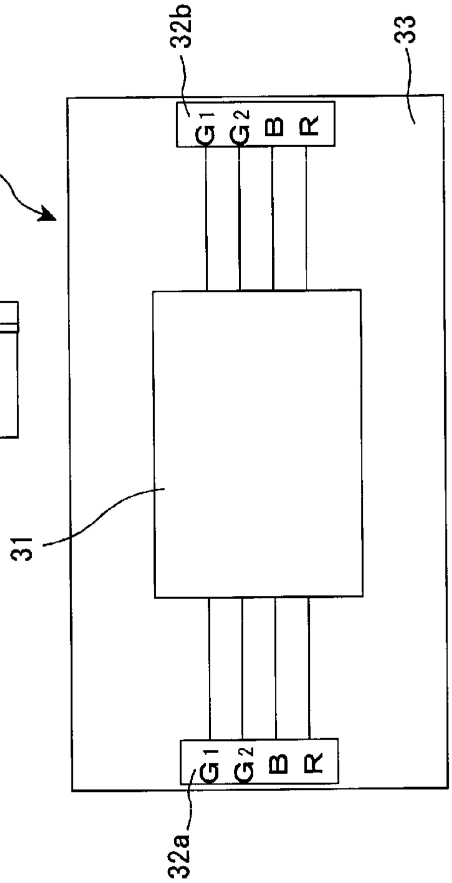


FIG. 3D

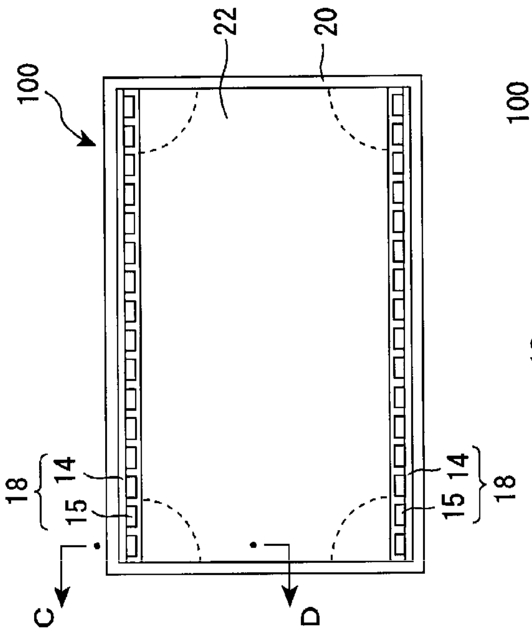


FIG. 3A

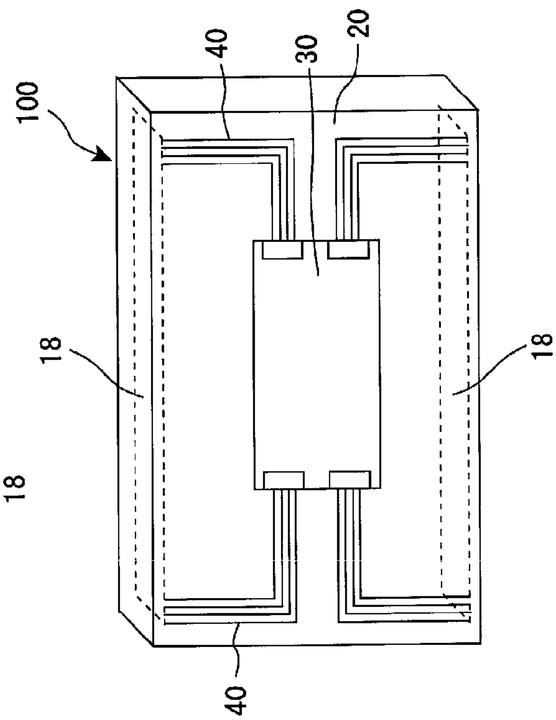


FIG. 3C

FIG.4A

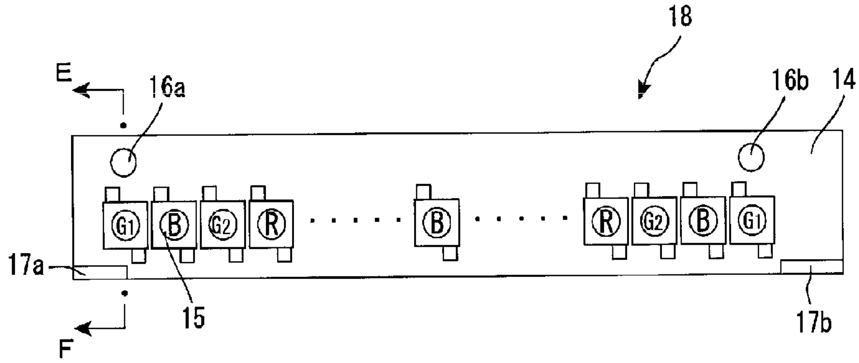


FIG. 4B

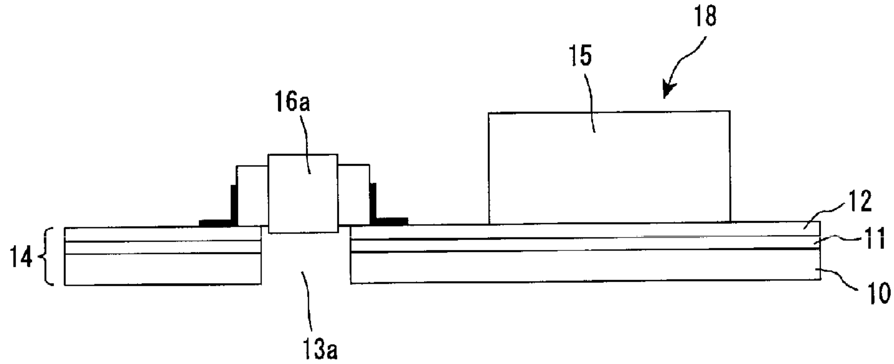
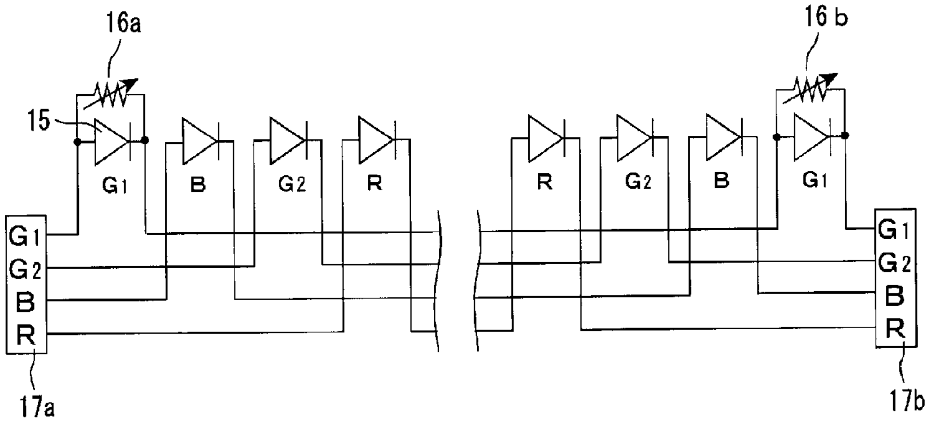


Fig.5



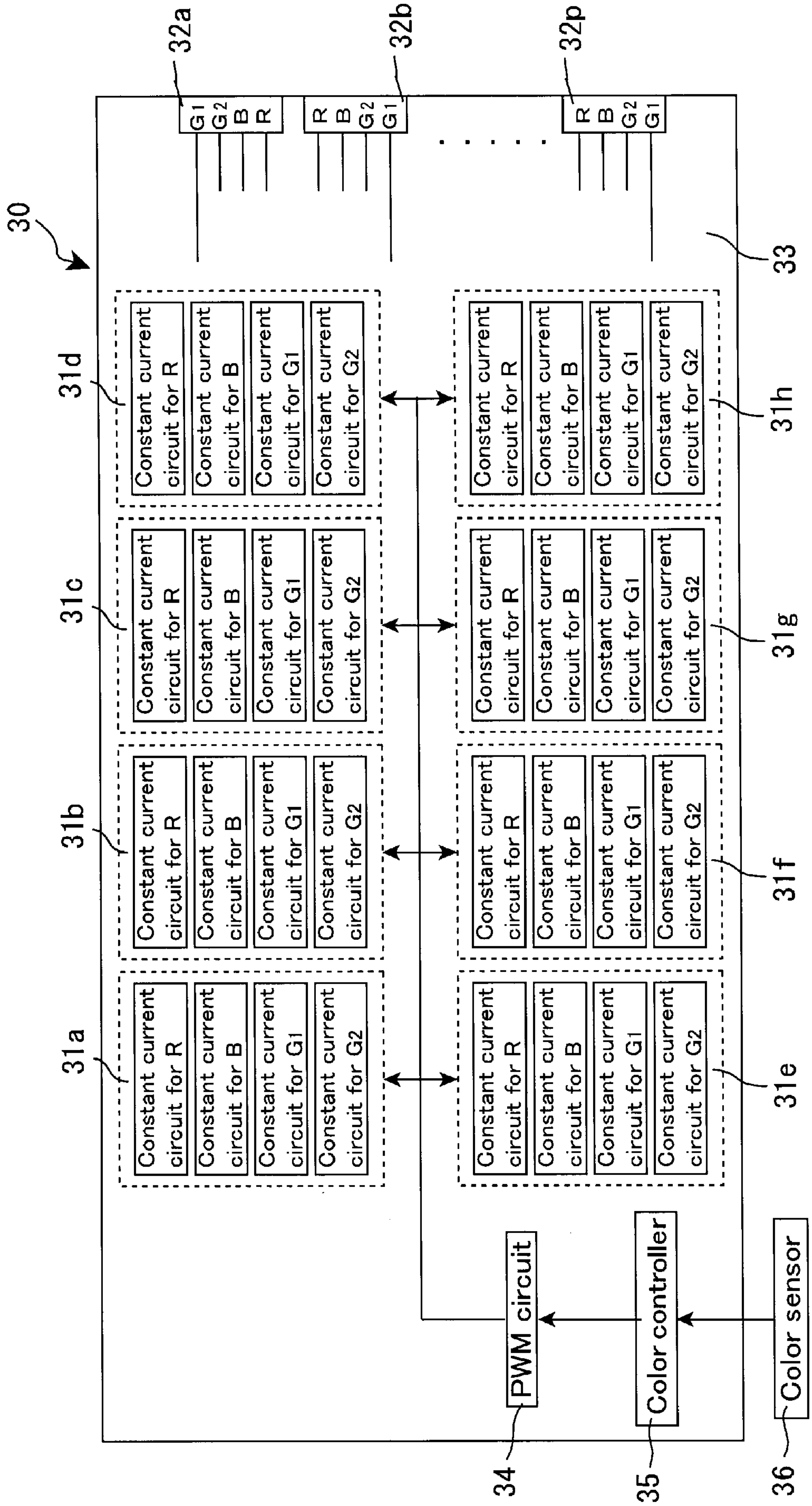

30
31a
31b
31c
31d
31e
31f
31g
31h
Constant current circuit for R
Constant current circuit for B
Constant current circuit for G1
Constant current circuit for G2
32a
32b
32p
G1
G2
B
R
33
PWM circuit
Color controller
Color sensor
34
35
36

FIG.6

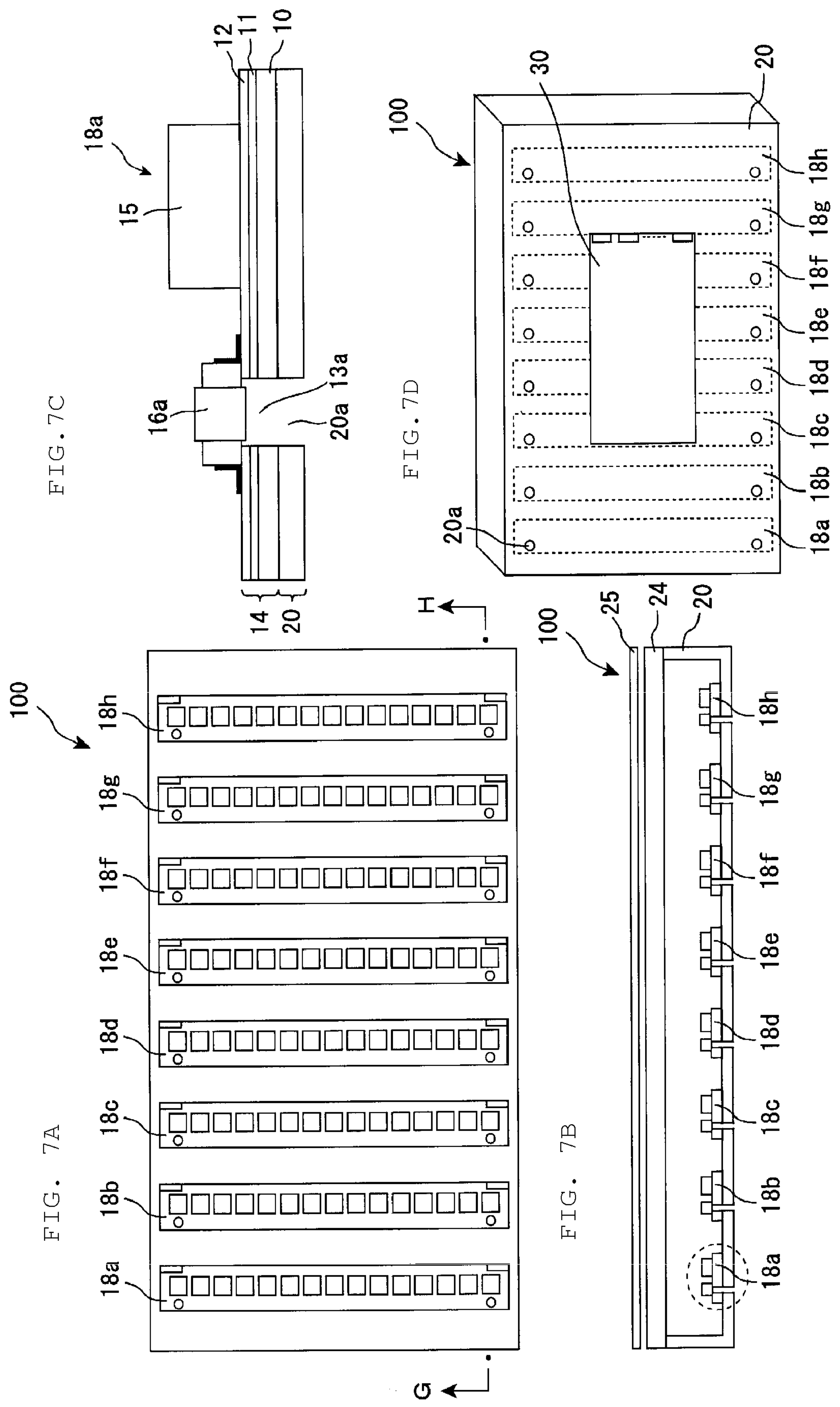


FIG. 7C

FIG. 7D

FIG. 7A

FIG. 7B

FIG. 8A
PRIOR ART

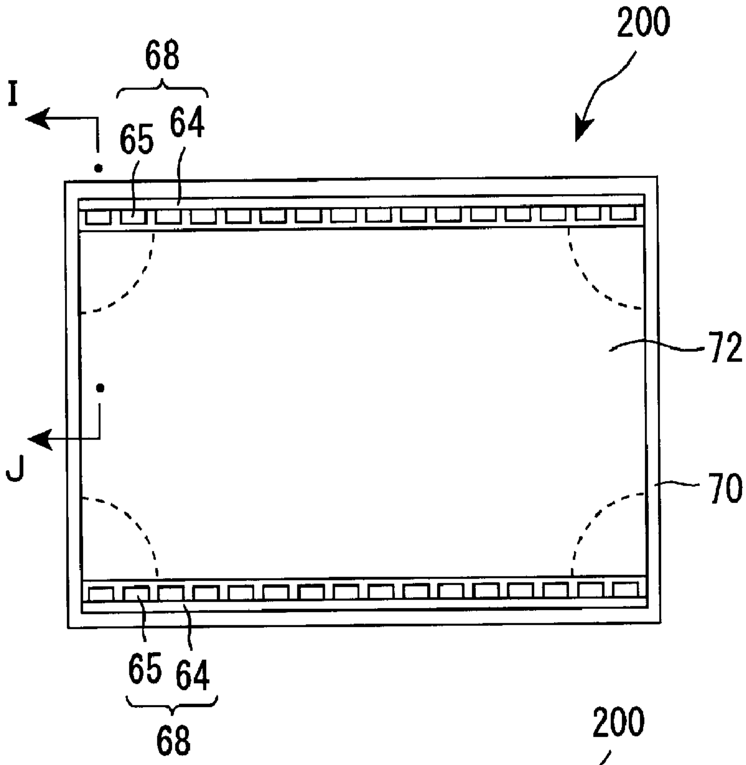
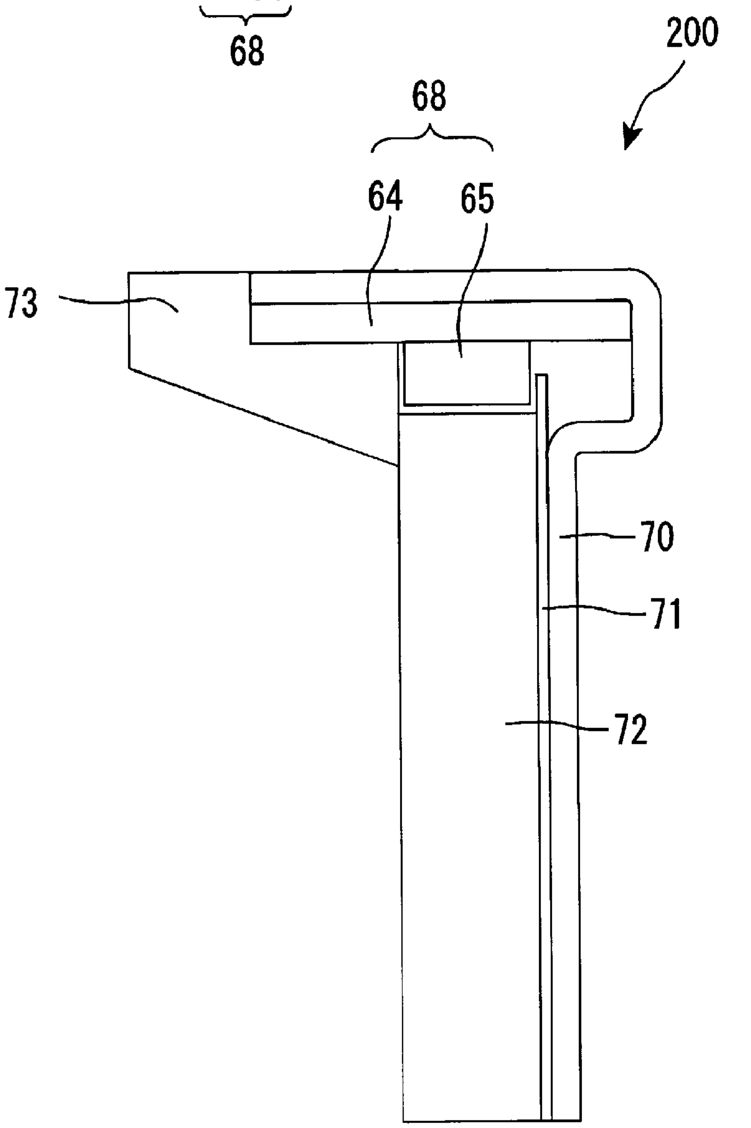


FIG. 8B
PRIOR ART



LIGHT SOURCE DEVICE, BACKLIGHT UNIT, AND LIQUID CRYSTAL DISPLAY DEVICE

[0001] This Nonprovisional application claims priority (under the Paris Convention and the domestic law in the country to be entered into the national phase) of Japanese Patent Application No. 2005-282816 filed in Japan on Sep. 28, 2005, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to light source devices, backlight units, and liquid crystal display devices. More specifically, the present invention relates to a light source device that is used as a component of a backlight unit mounted for a display device such as a liquid crystal display device. The present invention also relates to a backlight unit, and a liquid crystal display device.

[0004] 2. Description of the Related Art

[0005] A liquid crystal display device is a non-self-luminous display, and therefore, it generally includes a backlight unit on the back surface of a liquid crystal display panel in order to improve display visibility. This backlight unit includes a light source and its driving circuit as components. Based on the position where the light source is arranged, such backlight units are classified into a direct backlight unit in which the light source is arranged on the lower surface of a liquid crystal display panel and a side backlight unit in which the light source is arranged on a side surface of a liquid crystal display panel. The direct backlight unit has high light use efficiency and a high luminance, and therefore it has been used in in-vehicle applications and the like for which a high luminance is needed but a slim profile is not needed. The side backlight unit has a slim profile and has high luminance uniformity, and therefore, for example, it has been used in laptop computers for which a slim profile is needed or used in display for full color images for which high image qualities are needed.

[0006] Among such backlight units, a light-emitting diode backlight unit including a light-emitting diode (hereinafter, also referred to as "LED") as the light source has recently attracted much attention. This is because the LED backlight unit permits a reduction in costs, direct drive by a direct-current power, noise free operation, and the like. Further, an LED backlight unit including LEDs of many colors such as red (R), green (G) and blue (B) can display bright color images with high saturation.

[0007] FIG. **8**A is a planar view schematically showing a configuration of a conventional side LED backlight unit. FIG. **8**B is a cross-sectional view schematically showing the conventional side LED backlight unit taken along line I-J in FIG. **8**A.

[0008] As shown in FIGS. **8**A and **8**B, according to a conventional side LED backlight unit **200**, a reflective sheet **71** and a light guide plate **72** are stacked on the bottom surface of a back frame **70**. Further, in an LED backlight module **68** arranged on the end surface side of the light guide plate **72**, an LED **65** is arranged toward the end surface side of the light guide plate **72**. Light emitted from the LED **65** is repeatedly reflected inside the light guide plate **72**, and then emitted to the display surface side. According to the LED backlight unit **200** having such a configuration, as shown in FIG. **8**A, LEDs **65** of a plurality of colors are connected in series for every color. The LEDs **65** are arranged from one end to the other end of the sides of the display surface at regular intervals. As shown in FIG. **8**A, corners (regions shown by the dotted line) and other regions of the display surface have different light amounts from the LEDs **65** of the respective colors. Therefore, uneven color is displayed on the display surface.

[0009] Japanese Kokai Publication No. 2004-279921 describes a display device in which a substrate is provided with an exposure part such as a through-hole so that variable electronic components are exposed in order to freely adjust the variable electronic components even after combining the substrate provided with the variable electronic components with an electro-optic device. This reference discloses that a variable resistor (variable electronic component) is adjusted and a voltage for driving liquid crystals is varied, and thereby contrast of displayed images is adjusted.

SUMMARY OF THE INVENTION

[0010] The present invention has been made in view of the above-mentioned state of the art. Preferred embodiments of the present invention provide a light source device, a backlight unit, and a liquid crystal display device, each capable of improving uniformity of a luminance and a color on a display surface.

[0011] The present inventors made various investigations of a light source device including a board on which a plurality of point light sources such as LEDs, connected in series, are formed. The inventors discovered that if a fixed resistor for adjusting a luminance is connected in parallel to the point light source arranged on the end side, an amount of an electric current flowing into the point light source is reduced to decrease an amount of luminescence, and as a result, the corners and other regions of the display surface have substantially the same color tone and the uniformity of the luminance and the color on the display surface can be improved.

[0012] However, the results of the study show that even if the above-mentioned measures are taken, uneven color cannot be sufficiently prevented from being displayed at the corners of the display surface because the point light sources such as LEDs have various light-emitting characteristics. Further, the uneven color on the display surface is generally examined after the backlight unit is assembled. According to the configuration of the conventional LED backlight unit **200** shown in FIG. **8**B, the LED backlight module (light source device) **68** is fixed to the side surface of the back frame **70**. Therefore, once a fixed resistor is attached inside the LED backlight module **68** and the unit **200** is assembled, the fixed resistor cannot be exchanged until the unit **200** is disassembled.

[0013] Therefore, the present inventors further made various investigations and discovered that if a variable resistor is formed on the surface where the point light sources are formed on the board, at least one point light source arranged on the end side among the point light sources is connected in parallel to the variable resistor, a resistance value can be adjusted without exchange of the resistor. The inventors further discovered that if a through-hole is formed in a variable resistor-arranged region on the board and a through-hole is also formed in the side surface of the back frame to be connected to the through-hole of the board, a resistance value of the variable resistor can be adjusted through these through-holes from the side opposite to the side where the point light sources are formed, without disassembling the backlight unit even after the unit is assembled. As a result, the inventors discovered that the uniformity of the luminance and the color on the display surface can be improved. The above-mentioned problems can be admirably solved, leading to the development and completion of various preferred embodiments of the present invention.

[0014] According to a preferred embodiment of the present invention, a light source device includes: a board; a plurality of point light sources arranged on a surface of the board and connected in series; and a variable resistor, wherein the variable resistor is formed on the surface on which the plurality of point light sources are arranged of the board; at least one point light source arranged on an end side among the plurality of point light sources is connected in parallel to the variable resistor; and the board has a through-hole in a variable resistor-arranged region.

[0015] According to the light source device, a plurality of point light sources connected in series are arranged on the board. Examples of the point light sources include light-emitting elements such as a light-emitting diode (LED), and laser light sources such as a semiconductor laser light source. The color of the light emitted from the point light sources is not especially limited. Examples of the color include chromatic colors such as red (R), green (G), blue (B), yellow (Y), cyan (C), magenta (M), and orange, and white (W). The plurality of point light sources include point light sources of one color. However, it is preferable that the number of colors of the point light sources is larger in terms of expansion of the color reproduction range in the display device. The plurality of point light sources preferably include point light sources of two or more colors, and more preferably include point light sources of three or more colors. If the plurality of light sources include point light sources of two or more colors, it is preferable that the point light sources are arranged in such a way that a specific color array pattern (for example, GBGR) is repeated in view of improvement in color uniformity on the display surface. If the color array pattern consists of an odd number of the point light sources, it is preferable that the point light sources are arranged to be symmetric to the center point light source. If the color array pattern consists of an even number of the point light sources, it is preferable that the point light sources are arranged to be symmetric to the center of the array. The plurality of point light sources connected in series mean that at least two of the point light sources are connected in series. It is preferable that all of the plurality of point light sources are connected in series. If the plurality of point light sources include point light sources of two or more colors, it is preferable that the point light sources are generally connected to one another in series every color. However, if the color array repeatable pattern includes the same color, that is, if the point light source array repeatable pattern include the point light sources of the same color, it is preferable that the point light sources of the same color are individually connected in series. For example, if the color array repeatable pattern consists of G_1BG_2R (G_1 and G_2 are both G), it is preferable that the G_1 point light source and the G_2 point light source are individually connected in series.

[0016] In the present description, the term "on the board" means "on the internal surface of the board (the surface toward the inside of the backlight unit and the like)" or "on the external surface of the board (the surface toward the outside of the backlight unit and the like)". The point light sources are generally arranged on the internal surface of the board. It is preferable that the plurality of point light sources are substantially linearly arranged. The plurality of point light sources are preferably arranged in a zig-zag pattern as long as the operation and effects of the present invention are exhibited. Reflow soldering and the like may preferably be used as a method of mounting the point light sources. The configuration of the board includes a configuration in which a circuit layer is arranged on a support board. In this case, the point light sources are generally arranged on the circuit layer. The material for the support board preferably has reflectivity in terms of improvement in directionality of light emitted from the point light sources. Aluminum and the like may preferably be used as the material for the support board. Metals and the like may preferably be used as a material for the circuit layer. A printing method and the like may preferably be used as a method of forming the circuit layer. If the support board is made of a conductive material such as aluminum, an insulating layer is generally arranged between the support board and the circuit layer.

[0017] The light source device includes a variable resistor on the same surface where the point light sources are formed on the board. At least one point light source arranged on the end side among the point light sources is arranged parallel or substantially parallel to the variable resistor. The board has a through-hole in a variable resistor-arranged region. According to this unique configuration, a resistance value of the variable resistor can be adjusted, through the through-hole, from the side opposite to the side where the point light sources are mounted without disassembling the backlight unit even after the unit is assembled. Therefore, the uniformity of the luminance and the color on the display surface can be improved.

[0018] The variable resistor is not especially limited as long as the resistance value of the variable resistor can be adjusted through the through-hole. Reflow soldering and the like may preferably be used as a method of mounting the variable resistor. If the board has a configuration in which the circuit layer is arranged on the support board, the variable resistor is generally arranged on the circuit layer, as in the point light sources. In this case, it is preferable that the variable resistor is mounted in the same step of mounting the point light sources.

[0019] In the present description, the term "at least one point light source arranged on the end side" includes not only the point light source arranged at the end (the end point light source) but also the point light sources arranged near the end on the board. The number of the point light sources arranged on the end side is not especially limited, and it is appropriately determined in view of the size of the light source device or the operation and effects of the present invention. Examples of the configuration in which at least one point light source arranged on the end side is connected in parallel to the variable resistor include a configuration in which only the point light source at the end is connected in parallel to the variable resistor, a configuration in which the point light source at the end and the point light source that is the second from the end are individually connected in parallel to the variable resistors, and a configuration in which the point light source at the end, the point light source that is the second from the end, and the point light source that is the third from the end are individually connected in parallel to the variable resistors. A configuration in which all of the point light sources are each connected in parallel to the variable resistors also may preferably be used. With respect to the variable resistor, it is preferable that one variable resistor is connected in parallel to one point light source. However, a plurality of variable resistors may be connected in parallel to one point light source. The point light source may be connected in parallel to a fixed resistor, in addition to the variable resistor. Among the point light sources arranged on the end side, a point light source not connected to the variable resistor may be connected in parallel to only a fixed resistor. The end side generally means both end sides, but it may be either one end side.

[0020] The shape of the through-hole is not especially limited, and examples thereof include a columnar shape and a prismatic shape. The size of the through-hole is not especially limited as long as the resistance value of the variable resistor can be adjusted. One through-hole is generally formed for one variable resistor. However, a plurality of through-holes may be formed for one variable resistor. One through-hole may be formed for a plurality of variable resistors. The method of forming the through-hole is not especially limited, and the through-hole may be formed when the board is formed.

[0021] The light source device in accordance with preferred embodiments of the present invention is not especially limited and it may or may not include other components as long as it includes the plurality of point light sources, the variable resistor, and the board as components. It is preferable that the light source device includes a connector for connecting the point light source to a circuit for driving the point light source. The connector may be arranged on the external surface of the board, but it is generally arranged on the internal surface of the board.

[0022] According to another preferred embodiment of the present invention, a light source device includes: a board; a plurality of point light sources arranged on a surface of the board and connected in series; and a variable resistor, wherein the variable resistor is disposed on a surface opposite to the surface on which the plurality of point light sources are arranged; and at least one point light source arranged on an end side among the plurality of point light sources is connected in parallel to the variable resistor. According to this unique structure, the variable resistor is arranged on the side opposite to the side where the point light sources are mounted. Therefore, the resistance value of the variable resistor can be adjusted from the outside without disassembling the backlight unit even after the unit is assembled. Therefore, the uniformity of the luminance and the color on the display surface can be improved. In this case, it is preferable that the variable resistor has an adjusting portion arranged to adjust the resistance on a side other than the board side (for example, the side opposite to the board).

[0023] It is preferable that the plurality of point light sources are light-emitting diodes. According to this configuration, a reduction in costs, direct drive by a direct-current power, noise free operation, and the like, can be realized. The colors of the light emitted from the light-emitting diodes are not especially limited. Examples of the colors include chromatic colors such as red (R), green (G), blue (B), yellow (Y), cyan (C), magenta (M), and orange, and white (W). The light-emitting diodes of chromatic colors may be white light-emitting diodes having a surface on which a chromatic film is formed to convert light of white into light of another chromatic color.

[0024] It is preferable that the light-emitting diodes include a red light-emitting diode, a green light-emitting diode, and a blue light-emitting diode. As a result, the color reproduction range of the display device can be more effectively expanded. White light is produced using the light-emitting diodes of three primary colors of RGB, and thereby a luminous efficiency higher than that of a white light-emitting diode can be obtained. The green light-emitting diode has a luminance smaller than luminances of a red light-emitting diode and a blue light-emitting diode. Therefore, it is preferable that the number of the green light-emitting diode is larger than the numbers of the red light-emitting diode and the blue light-emitting diode. It is more preferable that the number of the green light-emitting diode is substantially two times larger than that of the red light-emitting diode and/or the blue light-emitting diode. Examples of the color array pattern of the light-emitting diodes in this configuration include GBGR and GRGB. It is more preferable that the light-emitting diodes include another chromatic light-emitting diode such as a yellow light-emitting diode, in order to more effectively expand the color reproduction range.

[0025] It is preferable that an amount of an electric current flowing into a variable resistor connected in parallel to a light-emitting diode at an end is adjusted to about 50% or more and about 90% or less relative to an amount of an electric current flowing into the light emitting diode at the end. As a result, the luminance of the light-emitting diode at the end can be properly reduced, and therefore, the uniformity of the luminance and the color on the display surface can be more improved. It is more preferable that the amount of the electric current flowing into the variable resistor connected in parallel to the light-emitting diode at the end is adjusted to about 75% relative to the amount of the electric current flowing into the light emitting diode at the end.

[0026] It is preferable that an amount of an electric current flowing into a variable resistor connected in parallel to a second light-emitting diode from the end is adjusted to about 20% or more and about 50% or less relative to an amount of an electric current flowing into the second light-emitting diode from the end. According to such a configuration, the luminance of the second light-emitting diode from the end can be properly reduced. Therefore, the uniformity of the luminance and the color on the display surface can be further improved. It is more preferable in the light source device that the amount of the electric current flowing into the variable resistor connected in parallel to the second light-emitting diode from the end is adjusted to about 25% relative to the amount of the electric current flowing into the second light-emitting diode from the end.

[0027] It is preferable in the point light sources that a green light-emitting diode is arranged at the end, and a blue light-emitting diode is arranged at the second from the end. According to this configuration, the yellowish color at the corners of the display surface is improved and thereby the color uniformity on the display surface can be particularly improved.

[0028] Other preferred embodiments of the present invention include: (1) a backlight unit including the light source device, wherein the plurality of point light sources are arranged on a side of a display surface toward a display surface side, and (2) a backlight unit including the light source device, wherein the plurality of point light sources are arranged just below a display surface toward the display surface. According to the side backlight unit (1), the thickness of the display device can be reduced and simultaneously a high luminance uniformity can be obtained. According to the direct backlight unit (2), the light use efficiency can be increased and therefore a high luminance can be obtained.

According to the configuration (1), the "point light sources are arranged toward a display surface side" means that the point light sources are arranged on the internal surface of the board.

[0029] Examples of the configuration (1) include a configuration in which a reflective plate and a light guide plate are stacked in this order on the internal bottom surface of a chassis, and the light source device is arranged between at least one internal side surface of the chassis and the side surface of the light guide plate. According to this configuration, a through-hole is formed in the side surface of the chassis. At least a portion of this through-hole overlaps with the through-hole of the board of the light source device, and thereby, the resistance value of the variable resistor can be adjusted from the outside of the chassis even after assembling the backlight unit. The light guide plate is arranged on the reflective plate and the side surface of the light guide plate (except the side surface adjacent to the light source device) is generally covered with a reflective film and the like. Therefore, light incident into the side surface of the light guide plate from the point light sources can be emitted to the display surface with efficiency.

[0030] According to the configuration (1), the light source device is arranged on at least one side of the display surface, and may be arranged on a plurality of sides of the display surface. In view of uniformity of the luminance distribution in the display surface, it is preferable that the light source device is arranged on two sides opposite to each other of the display surface. For example, it is preferable that the light source device is arranged on the upper and lower sides of the display surface if a plurality of point light sources (LEDs and the like) are mounted. The light source device is generally fixed to the side surface of the chassis. The way of fixing it is not especially limited. Adhesion, cohesion, fixing using a holder, fixing using a screw and the like may preferably be used. It is preferable that a diffuser is stacked on the light guide plate in order to diffuse light emitted from the light guide plate to improve the luminance uniformity. It is preferable that various optical sheets such as a lens film (prism sheet) are appropriately stacked on the light guide plate (or the diffuser) in order to improve the luminance per unit area of the display surface. The configuration (1) may be a configuration in which the board of the light source device serves as the side surface of the chassis of the backlight unit.

[0031] Examples of the configuration (2) include a configuration in which a plurality of the light source devices are arranged on the internal bottom surface of the chassis and the diffuser is stacked on the plurality of light source devices. According to this configuration, a through-hole is formed in the bottom surface of the chassis and at least a portion of this through-hole overlaps with the through-hole of the board of the light source device. As a result, the resistance value of the variable resistor can be adjusted from the outside of the chassis even after assembling the backlight unit. The internal surface of the chassis is generally covered with the reflective plate. Therefore, light from the point light sources is emitted to the display surface with efficiency, and simultaneously, the emitted light can be diffused into a planar shape by the diffuser.

[0032] According to the configuration (2), the light source devices may be arranged in such a way that the array direction of the plurality of point light sources is substantially parallel to the horizontal direction of the display surface. However, it is preferable that the light source devices are arranged in such a way that the array direction of the plurality of point light sources is substantially parallel to the vertical direction of the display surface. The light source devices are generally fixed to the bottom surface of the chassis, and the way of fixing it is not especially limited. Adhesion, cohesion, fixing using a holder, fixing using a screw and the like may preferably be used. It is preferable that various optical sheets such as a lens film (prism sheet) are appropriately stacked on the plurality of light source devices in order to improve the luminance per unit area of the display surface. The configuration (2) may be a configuration in which the boards of the light source devices serve as the bottom surface of the chassis of the backlight unit.

[0033] The backlight unit generally includes a circuit board in which a driving circuit for the point light sources is arranged on another board. The driving circuit is connected to the point light sources through wirings and the like, and it may be arranged on the internal surface of the another board, but preferably arranged on the external surface of the another board. It is preferable that the circuit board includes connectors for connecting the point light sources to the driving circuit. The connectors may be arranged on the internal surface of the another substrate, but they are preferably arranged on the external surface of the another substrate. The circuit board is generally arranged on the external bottom surface (back surface) of the chassis of the backlight unit. In this case, the circuit board is fixed to the back surface of the chassis, and the way of fixing it is not especially limited.

[0034] According to another preferred embodiment of the present invention, a liquid crystal display device includes the backlight unit described above. Such a liquid crystal display device can display high-quality images having high color uniformity on the display surface. Preferable configurations of the liquid crystal display device of the present invention include a configuration in which the liquid crystal display device include a liquid crystal display panel unit on the display surface side of the backlight unit. According to this configuration, using the backlight unit of various preferred embodiments of the present invention, light with high uniformity of the luminance and the color can be emitted from the back surface of the liquid crystal display panel to the liquid crystal display panel inside the liquid crystal display panel unit. As a result, display with high qualities can be realized.

[0035] The liquid crystal display device may be a transmissive liquid crystal display device or a transflective (semi-transmissive) liquid crystal display device. The display mode of the liquid crystal display device is not especially limited. Examples thereof include VA (vertical alignment) mode, TN (twisted nematic) mode, IPS (in-plane switching) mode, and OCB (optically compensated birefringence) mode.

[0036] According to the light source device of various preferred embodiments of the present invention, the resistance value of the variable resistor connected in parallel to the point light source can be adjusted without disassembling the backlight unit even after the unit is assembled. Therefore, the uniformity of the luminance and the color on the display surface can be improved.

[0037] Other features, elements, processes, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] FIG. **1**A is a planar view schematically showing a configuration of the LED backlight module according to a first preferred embodiment of the present invention.

[0039] FIG. **1**B is a cross sectional view schematically showing the LED backlight module taken along line A-B in FIG. **1**A.

[0040] FIG. **2** is a view schematically showing the circuit for the LED backlight module according to the first preferred embodiment of the present invention.

[0041] FIG. **3**A is a planar view schematically showing a configuration of a front surface of the side LED backlight unit in the first preferred embodiment of the present invention.

[0042] FIG. **3**B is a cross-sectional view schematically showing the side LED backlight unit taken along line C-D in FIG. **3**A.

[0043] FIG. **3**C is a perspective view schematically showing a configuration of a back surface of the side LED backlight unit.

[0044] FIG. **3**D is a planar view schematically showing a configuration of the LED power board in FIG. **3**C.

[0045] FIG. **4**A is a planar view schematically showing a configuration of the LED backlight module in accordance with a second preferred embodiment of the present invention.

[0046] FIG. **4**B is a cross-sectional view schematically showing the LED backlight module taken along line E-F in FIG. **4**A.

[0047] FIG. **5** is a view schematically showing a circuit of the LED backlight module according to the second preferred embodiment of the present invention.

[0048] FIG. **6** is a planar view schematically showing a configuration for the LED power board according to the second preferred embodiment of the present invention.

[0049] FIG. **7**A is a planar view schematically showing a configuration of the direct LED backlight unit according to the second preferred embodiment of the present invention.

[0050] FIG. **7**B is a cross-sectional view showing the direct LED backlight unit taken along line G-H in FIG. **7**A.

[0051] FIG. **7**C is an enlarged view of the region shown by the dotted line in FIG. **7**B.

[0052] FIG. **7**D is a planar view schematically showing a configuration of the back surface of the direct LED backlight unit according to the second preferred embodiment of the present invention.

[0053] FIG. **8**A is a planar view schematically showing a configuration of a conventional side LED backlight unit.

[0054] FIG. **8**B is a cross-sectional view schematically showing the conventional side LED backlight unit taken along line I-J in FIG. **8**A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0055] The present invention is described in more detail below with reference to preferred embodiments thereof, but the present invention is not limited to only these preferred embodiments.

First Preferred Embodiment

[0056] Steps of assembling a liquid crystal display device in accordance with the first preferred embodiment of the present invention are mentioned below.

Production of LED Backlight Module (Light Source Device)

[0057] FIG. **1**A is a planar view schematically showing a configuration of an LED backlight module in accordance with the first preferred embodiment. FIG. **1**B is a cross sectional view schematically showing the LED backlight module taken along line A-B in FIG. **1**A.

[0058] On an aluminum board **10**, a transparent insulating layer **11** with a thickness of about 80 μm, for example, was formed. Thereon, a copper foil layer **12** with a thickness of about 70 μm, for example, was formed by printing. Then, the outline of the stacked body was shaped by a punching process and simultaneously, a through-hole **13***a* was formed at a position where a variable resistor was to be mounted. As a result, a flexible printing circuit (FPC) **14** was completed.

[0059] Then, light-emitting diodes (LEDs) **15**, variable resistors **16***a* to **16***d*, connectors **17***a* and **17***b* were mounted on the FPC **14** by reflow soldering. The LEDs **15** included LEDs of three primary colors of a red LED (R-LED), a green LED (G-LED), and a blue LED (B-LED), and twelve R-LEDs, twenty-six G-LEDs, and thirteen B-LEDs were used. As shown in FIG. **1**A, such LEDs were arrayed at regular intervals based on a color array pattern of green (G_1), blue (B), green (G_2), and red (R). The variable resistors **16***a* to **16***d* were arranged on the through-holes **13***a* to **13***d* of the FPC **14**, respectively, as shown in FIG. **1**B. Adjustment portions of the variable resistors **16***a* to **16***d* were exposed to the outside through the through-holes **13***a* to **13***d*, respectively.

[0060] FIG. **2** is a view schematically showing a circuit for a LED backlight module **18** in the first preferred embodiment. As shown in FIG. **2**, a G_1-LED, a B-LED, a G_2-LED, and an R-LED of the LEDs **15** were individually connected in series to be individually driven. The variable resistors **16***a* and **16***d* were connected in parallel to the G_1-LEDs at right and left ends, respectively. The variable resistors **16***b* and **16***d* were connected in parallel to the B-LEDs that were the second from each end, respectively. According to a side LED backlight unit, light emitted from the LEDs **15** at the ends is reflected by the internal side surface of the back frame and emitted from an emission surface of the light guide plate. Therefore, light emitted from the corners of the display surface has a relatively larger intensity than that of light emitted from other regions. Accordingly, the variable resistors **16***a* to **16***d* were connected in parallel to the LEDs **15** at the ends, and the resistance values were previously set to specific values so that the luminance and the color could become uniform between the corner regions and other regions of the display surface. As a result, an LED backlight module **18** was completed.

Assembling of Side LED Backlight Unit

[0061] FIG. **3**A is a planar view schematically showing a configuration of a front surface of a side LED backlight unit in accordance with the first preferred embodiment. FIG. **3**B is a cross-sectional view schematically showing the side LED backlight unit taken along line C-D in FIG. **3**A. FIG. **3**C is a perspective view schematically showing a configuration of a back surface of the side LED backlight unit in accordance with the first preferred embodiment. FIG. **3**D is a planar view schematically showing a configuration of an LED power board **30** in FIG. **3**C.

[0062] As shown in FIG. **3**A, the LED backlight module **18** was mounted on the upper and lower side surfaces of a back frame **20**. In this case, as shown in FIG. **3**B, the through-hole **13***a* of the FPC **14** overlapped with a through-hole **20***a* that was formed in the side surface of the back frame **20**. Similarly, other through-holes of the FPC **14** overlapped with through-holes that were formed in the side surface of the back frame **20**, respectively. Then, as shown in FIG. **3**B, a reflective sheet

21 and a light guide plate **22** were stacked on the bottom surface of the back frame **20**. Then, the reflective sheet **21** and the light guide plate **22** were fixed by being covered with a front frame **23**.

[0063] As shown in FIG. **3**D, wirings **40** and the LED power board **30** were mounted on the back surface of the back frame **20**. In the LED power board **30**, a LED power circuit **31** that was a circuit for driving the LEDs **15** and connectors **32***a* and **32***b* were arranged on a board **33**, as shown in FIG. 3D. The LED power circuit **31** inside the LED power board **30** was connected to the LED backlight module **18** through the wirings **40** and the connectors **32***a* and **32***b*, respectively, as shown in FIG. **3**C. As a result, an LED backlight unit **100** was completed.

Examination of Uneven Color of Side LED Backlight Unit

[0064] The LED backlight unit **100** assembled in the above-mentioned process was examined for uneven color. At four corners (the regions shown by the dotted line in FIG. **3**A) of the light guide plate **22**, a yellowish color was observed. This is attributed to variation of characteristics of the LEDs **15**. This is not found until the unit is assembled and then LEDs **65** that are connected to the LED power circuit **31** are driven. In the present preferred embodiment, the variable resistors **16***a* to **16***d* that were connected in parallel to the G_1-LEDs and B-LEDs at the end sides were exposed to the outside through the through-holes **13***a* to **13***d* and **20***a* to **20***d*, as shown in FIG. **3**B. Accordingly, resistance values of the variable resistors **16***a* to **16***d* could be adjusted from the outside without disassembling the LED backlight unit **100**. As a result, the color uniformity could be improved.

Assembling of Liquid Crystal Display Device

[0065] On the front frame **23** of the LED backlight unit **100**, a diffuser (not shown) and an optical sheet (not shown) were stacked. Then, using a module assembly device, the backlight unit **100** and a liquid crystal display panel unit (not shown) were positioned at specific positions, respectively, and superimposed upon each other to be assembled. After specific connection procedures and the like, a liquid crystal display device was completed.

[0066] According to the liquid crystal display device assembled in the present preferred embodiment, even after the LED backlight unit **100** was assembled, the resistance values of the variable resistors **16***a* to **16***d* that were connected to the LEDs **15** at the end sides could be adjusted without disassembling the unit **100**. Therefore, high display qualities could be obtained. In addition, the LEDs **15** were adopted as a light source, and therefore, a reduction in costs, direct drive by a direct-current power, noise free operation, and the like, could be realized. Further, bright colors with high saturation could be displayed because the LEDs of RGB three colors were used.

Second Preferred Embodiment

[0067] Steps of assembling a liquid crystal display device in accordance with the present preferred embodiment are described below. A direct LED backlight unit was used as the LED backlight unit in the present preferred embodiment.

Production of LED Backlight Module (Light Source Device)

[0068] FIG. **4**A is a planar view schematically showing a configuration of an LED backlight module in the second preferred embodiment. FIG. **4**B is a cross-sectional view schematically showing the LED backlight module taken along line E-F in FIG. **4**A. FIG. **5** is a view schematically showing a circuit for the LED backlight module in the second preferred embodiment.

[0069] The LED backlight module in the present preferred embodiment was produced in the same manner as in the first preferred embodiment, except that only G_1-LEDs at the right and left ends were connected in parallel to the variable resistors **16***a* and **16***b*, respectively, as shown in FIGS. **4**A, **4**B, and **5**.

[0070] The variable resistors **16***a* and **16***b* were disposed on the through-holes **13***a* of the FPC **14**, respectively. The adjustment portions of the variable resistors **16***a* and **16***b* were exposed to the outside through the through-holes **13***a*, respectively. The resistance values of the variable resistors **16***a* and **16***b* were previously set to specific values, respectively, so that the uneven luminance and color between the side region and other regions of the display surface due to the arrangement of the LEDs **15** that were light sources could be prevented. In the present preferred embodiment, preferably eight, for example, LED backlight modules **18** were prepared and used as LED backlight modules **18***a* to **18***h*.

Production of LED Power Board (Circuit Board)

[0071] FIG. **6** is a planar view schematically showing a configuration of an LED power board in the second preferred embodiment.

[0072] As shown in FIG. **6**, LED power circuits **31***a* to **31***h* that were connected to the LED backlight modules **18***a* to **18***h*, respectively, a pulse width modulation (PWM) circuit **34**, a color controller **35** that controlled information from a color sensor **36**, were disposed on aboard **33**. Successively, preferably sixteen, for example, connectors **32***a* to **32***p* were mounted. As a result, an LED power board **30** was completed.

Assembling of Direct LED Backlight Unit

[0073] FIG. **7**A is a planar view schematically showing a configuration of a front surface of a direct LED backlight unit in accordance with the second preferred embodiment. FIG. **7**B is a cross-sectional view showing the direct LED backlight unit taken along line G-H in FIG. **7**A. FIG. **7**C is an enlarged view of the region surrounded by the dotted line in FIG. **7**B. FIG. **7**D is a planar view schematically showing a configuration of a back surface of the direct LED backlight unit in the second preferred embodiment.

[0074] As shown in FIGS. **7**A and **7**B, the LED backlight modules **18***a* to **18***h* were mounted on the internal bottom surface of the back frame **20**. In this case, as shown in FIG. **7**C, the through-hole **13***a* of the FPC **14** was arranged to overlap with the through-hole **20***a* formed in the bottom surface of the back frame **20**. Then, a diffuser **24** and an optical sheet **25** were stacked and fixed.

[0075] As shown in FIG. **7**D, an LED power board **30** was mounted on the back surface of the back frame **20**. Then, the LED backlight modules **18***a* to **18***h* were connected to the LED power circuits **31***a* to **31***h* through wirings (not shown) and the like, respectively. As a result, an LED backlight unit **100** was completed.

Examination of Uneven Color of Direct LED Backlight Unit

[0076] The LED backlight unit **100** assembled in the above-mentioned process was examined for uneven color. A yellowish color was observed at the side region. This is attributed to variation of characteristics of the LEDs **15**. This is not found until the unit is assembled and the LEDs **65** that are connected to the LED power circuits **31** are driven. In the present preferred embodiment, the variable resistors **16***a* and **16***b* connected in parallel to the G_1-LEDs on the end sides were exposed to the outside through the through-holes **13***a* and **13***b* and the through-holes **20***a* and **20***b* of the back frame **20**, as shown in FIG. **7**C. Accordingly, the resistances of the variable resistors **16***a* and **16***b* were adjusted from the outside without disassembling the LED backlight unit **100**. As a result, the color uniformity could be improved.

Assembling of Liquid Crystal Display Device

[0077] Using a module assembly device, the backlight unit **100** and a liquid crystal display panel unit (not shown) were positioned at specific positions, respectively, and superimposed upon each other to be assembled. After specific connection procedures and the like, a liquid crystal display device was completed. The liquid crystal display device assembled in the present preferred embodiment also could exhibit the operation and effects as in the first preferred embodiment of the present invention.

[0078] The terms "or more" and "or less" include the described values, respectively.

[0079] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

1-20. (canceled)

21. A light source device comprising:

a board;

a plurality of point light sources arranged on a surface of the board and connected in series; and

a variable resistor; wherein

the variable resistor is disposed on the surface on which the plurality of point light sources are arranged of the board;

at least one of the point light sources arranged on an end side among the plurality of point light sources is connected in parallel to the variable resistor; and

the board has a through-hole in an area where the variable resistor is located.

22. The light source device according to claim **21**, wherein the plurality of point light sources are light-emitting diodes.

23. The light source device according to claim **22**, wherein the light-emitting diodes include a red light-emitting diode, a green light-emitting diode, and a blue light-emitting diode.

24. The light source device according to claim **22**, wherein an amount of an electric current flowing into a variable resistor connected in parallel to one of the light-emitting diodes at an end is adjusted to about 50% or more and about 90% or less relative to an amount of an electric current flowing into the light emitting diode at the end.

25. The light source device according to claim **24**, wherein an amount of an electric current flowing into a variable resistor connected in parallel to a second light-emitting diode from the end is adjusted to about 20% or more and about 50% or less relative to an amount of an electric current flowing into the second light-emitting diode from the end.

26. The light source device according to claim **25**, wherein a green light-emitting diode is arranged at the end, and a blue light-emitting diode is arranged at the second from the end.

27. A backlight unit comprising the light source device of claim **21**, wherein the plurality of point light sources are arranged on a side of a display surface facing toward a display surface side.

28. A backlight unit comprising the light source device of claim **21**, wherein the plurality of point light sources are arranged just below a display surface facing toward the display surface.

29. A liquid crystal display device comprising the backlight unit of claim **27**.

30. A liquid crystal display device comprising the backlight unit of claim **28**.

31. A light source device comprising:

a board;

a plurality of point light sources arranged on a surface of the board and connected in series; and

a variable resistor; wherein

the variable resistor is disposed on a surface opposite to the surface on which the plurality of point light sources are arranged; and

at least one of the point light sources arranged on an end side among the plurality of point light sources is connected in parallel to the variable resistor.

32. The light source device according to claim **31**, wherein the plurality of point light sources are light-emitting diodes.

33. The light source device according to claim **31**, wherein the light-emitting diodes include a red light-emitting diode, a green light-emitting diode, and a blue light-emitting diode.

34. The light source device according to claim **32**, wherein an amount of an electric current flowing into a variable resistor connected in parallel to a light-emitting diode at an end is adjusted to about 50% or more and about 90% or less relative to an amount of an electric current flowing into the light-emitting diode at the end.

35. The light source device according to claim **34**, wherein an amount of an electric current flowing into a variable resistor connected in parallel to a second light-emitting diode from the end is adjusted to about 20% or more and about 50% or less relative to an amount of an electric current flowing into the second light-emitting diode from the end.

36. The light source device according to claim **35**, wherein a green light-emitting diode is arranged at the end, and a blue light-emitting diode is arranged at the second from the end.

37. A backlight unit comprising the light source device of claim **31**, wherein the plurality of point light sources are arranged on a side of a display surface and are facing toward a display surface side.

38. A backlight unit comprising the light source device of claim **31**, wherein the plurality of point light sources are arranged just below a display surface and are facing toward the display surface.

39. A liquid crystal display device comprising the backlight unit of claim **37**.

40. A liquid crystal display device comprising the backlight unit of claim **38**.

* * * * *

专利名称(译)	光源装置，背光单元和液晶显示装置		
公开(公告)号	[US20090116223A1](US20090116223A1)	公开(公告)日	2009-05-07
申请号	US12/088113	申请日	2006-05-18
[标]申请(专利权)人(译)	夏普株式会社		
申请(专利权)人(译)	夏普株式会社		
当前申请(专利权)人(译)	夏普株式会社		
[标]发明人	HAMADA TETSUYA		
发明人	HAMADA, TETSUYA		
IPC分类号	G02F1/13357 F21V21/00 G09F13/08		
CPC分类号	G02B6/0031 G02B6/0055 G02B6/0068 G02B6/0083 G02F1/133603 G09G3/3413 H05K2201/10196 H05B33/083 H05K1/181 H05K2201/09072 H05K2201/10022 H05K2201/10106 G09G2320/0233 H05B45/48 Y02P70/611 Y10S362/80		
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其他公开文献	US7850358		
外部链接	Espacenet USPTO		

摘要(译)

光源装置，背光单元和液晶显示装置均能够改善显示表面的亮度和颜色的均匀性。光源装置包括板;多个点光源设置在板的表面上并串联连接;可变电阻器，其中可变电阻器设置在板上设置有多个点光源的表面上;在多个点光源中，配置在端侧的至少一个点光源与可变电阻并联连接。并且电路板在可变电阻器所在的区域中具有通孔。