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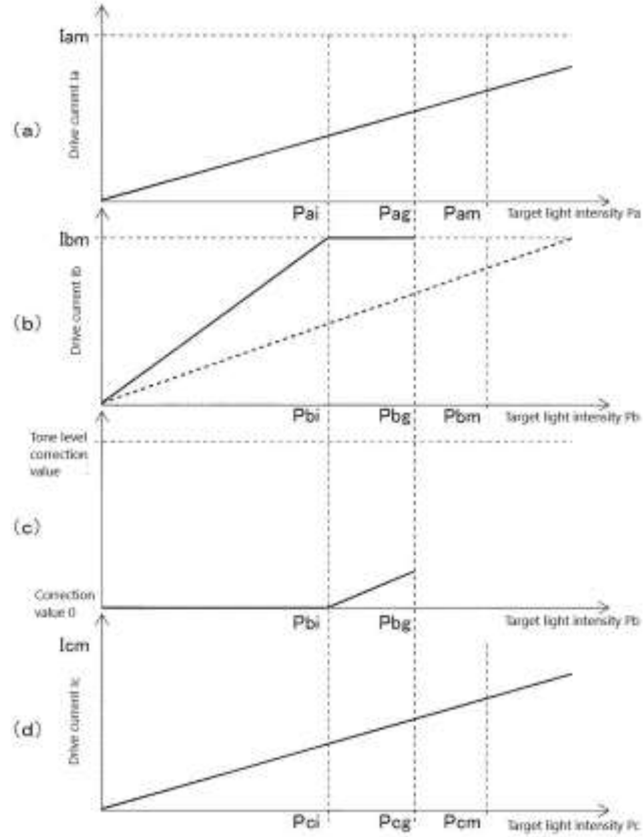
(54) **[Title of Invention]** **Vehicular Display Device**

(57) [Summary]
PROBLEM TO BE SOLVED
To display an image with excellent display quality even when there is a light source that has reached its maximum current value.
SOLUTION
When a light source control unit 110a controls the driving of a plurality of light sources in a light source unit 11 in such a way that the light intensities detected by a light intensity sensor 111 are brought into alignment with the target light intensities set by a target light intensity setting unit 110c; and a current limit detection unit 114 identifies a light source at maximum current, that is, a light source in the light source unit 11 whose drive current value has reached a predetermined maximum current value Iam (or Ibm or Icm); and the image is displayed above the brightness that can be generated by the light source at maximum current, then the white balance of the image is adjusted by using the target light intensity setting unit 110c to decrease the target light intensities of the light sources other than the light source at maximum current, and/or by using the display control unit 110c to increase the tone level of the light source at maximum current.
SELECTED DRAWING: FIG. 11



[Patent Claims]
[Claim 1]
A vehicular display device comprising: a light source unit comprising one or more light sources consisting of light emitting diodes emitting light of three different colors;
a light intensity sensor for detecting the light intensities of the color light emitted by the light sources;
a display unit for generating an image from the color light emitted from the light sources;
a target light intensity setting unit that sets the target light intensities used to adjust the brightness of the image generated by the display unit;
a light source control unit configured to control driving of the light sources in such a way that the light intensities detected by the light intensity sensor are brought into alignment with the target light intensities set by the target light intensity setting unit;
a display control unit that controls the tone levels of the display unit based on an input image signal; and
a current limit detection unit that, when the light source control unit is driving the light sources, identifies a light source at maximum current, that is, a light source whose drive current value has reached a predetermined maximum current value,
configured to adjust the white balance of the image when displaying the image above the brightness that can be generated by the light source at maximum current, by using the target light intensity setting unit to decrease the target light intensities of the light sources other than the light source at maximum current, and/or by using the display control unit to increase the tone level of the light source at maximum current.
[Claim 2]
The vehicular display device according to claim 1, wherein as the target light intensity setting unit increases the target brightness to a level greater than or equal to the brightness generated by the light source at maximum current,

the light source control unit maintains as constant or reduces the drive current value of the light source at maximum current, and

the display control unit increases the tone level of the light source at maximum current based on the image signal.

[Claim 3]

The vehicular display device according to claim 1 or claim 2, wherein the display control circuit drives the light source unit so as to emit a desired hue by changing the color tone levels of the image, and
in the case where the temperature information is greater than or equal to a predetermined value, the control unit adjusts the hue of the image by changing the tone levels.

[Detailed Description of the Invention]

[Technical Field]

[0001]

The present invention relates to a vehicular display device, and is suitable, for example, as a vehicular display device that generates display light by modulating and combining light of three primary colors based on image information.

[Background Technology]

[0002]

In a conventional vehicular display device, for example as disclosed in Patent Document 1, the light source device uses a light intensity sensor to detect the light intensity of the color light emitted by the light sources (RGB light sources) for generating light of the three primary colors, and even if the light source characteristics change in unwanted ways due to the temperature or other factors, the light source can be made to continue to project the desired light intensities by performing auto power control (APC) to adjust the drive current values of the light sources so that the light intensities detected by the light intensity sensor are the desired light intensities (the target light intensities P).

[Prior Art References]

[Patent Literature]

[0003]

[Patent Document 1] JP 2017-33645 A

[Summary of Invention]

[Problem to be Solved by the Invention]

[0004]

A characteristic of the conventional display device is that the hue may change or the light output efficiency may decrease due to a rise in the temperature of a light source or age-related deterioration, and even if target light intensities are set to display the image at the desired brightness, before the light intensities detected by the light intensity sensor reach their target light intensities, the limiting current value of the light source (current limit) might be reached, and the output of the light source cannot be raised any further, causing the light intensity balance with the other light sources to be lost. For example, when a display device is representing a white color, it may not be possible to adjust the color to a desirable white balance.

[0005]

Accordingly, the purpose of this invention is to provide a vehicular display device with excellent display quality, focusing on the issues described above.

[Means of Solving the Problem]

[0006]

In order to achieve the above objectives, the vehicle vehicular display device in the present invention comprises: a light source unit comprising one or more light sources consisting of light emitting diodes emitting light of three different colors;

a light intensity sensor for detecting the light intensities of the color light emitted by the light sources;

a display unit for generating an image by the color light emitted from the light sources;

a target light intensity setting unit that sets the target light intensities used to adjust the brightness of the image generated by the display unit;

a light source control unit configured to control driving of the light sources in such a way that the light intensities detected by the light intensity sensor are brought into alignment with the target light intensities set by the target light intensity setting unit;

a display control unit that controls the tone levels of the display unit based on an input image signal; and

a current limit detection unit that, when the light source control unit is driving the light sources, identifies a light source at maximum current, that is, a light source whose drive current value has reached a predetermined maximum current value,

configured to adjust the white balance of the image when displaying the image above the brightness that can be generated by the light source at maximum current, by using the target light intensity setting unit to decrease the target light intensities of the light sources other than the light source at maximum current, and/or by using the display control unit to increase the tone level of the light source at maximum current.

[Effects of the Invention]

[0007]

According to the present invention, it is possible to provide a vehicular display device with excellent display quality by identifying a light source that has reached its maximum current value (henceforth, "the light source at maximum current") and, when displaying an image above the brightness that can be generated by the light source at maximum current, using the target light intensity setting unit to decrease the target light intensities of the light sources other than the light source at maximum current, and/or by using the display control unit to increase the tone level of the light source at maximum current.

[Brief Description of the Drawings]

[0008]

FIG. 1 is a schematic view showing an embodiment of the present invention.

FIG. 2 is a cross-sectional view of a display device according to the same embodiment.

FIG. 3 is a cross-sectional view of a first unit according to the same embodiment.

FIG. 4 is a cross-sectional view of a light source unit according to the same embodiment.

FIG. 5 is a block diagram illustrating a control unit that controls the light sources and display unit according to the same embodiment.

FIG. 6 is a flowchart showing a predetermined procedure of the above embodiment.

FIG. 7 is a diagram illustrating the relationship between temperature and drive current value according to the same embodiment.

FIG. 8 is a diagram illustrating the relationship between temperature and tone level according to the same embodiment.

FIG. 9 is a diagram illustrating the relationship between temperature and tone level according to the same embodiment.

FIG. 10 is a diagram illustrating the relationship between the target light intensity and drive current value of each light source according to the same embodiment.

FIG. 11 is a diagram illustrating the relationship between the target light intensity and drive current value of each light source, and the relationship between the target light intensity and tone level correction amount according to a variation of the present invention.

[Description of Embodiments]

[0009]

An embodiment in which a vehicular display device according to the present invention is implemented in a head-up display is described below with reference to the accompanying drawings.

[0010]

The head-up display displays a virtual image V by reflecting the display light L projected by the display device (vehicular display device) 2 behind the dashboard 1 of the vehicle on the front windshield 3 on the side of the vehicle where the driver 4 sits. The vehicle driver 4 is able to see the virtual image V superimposed on the landscape.

[0011]

FIG. 2 shows a display device 2 with a first unit A1 and a second unit B1 containing reflectors 50 and 60, housing 71, and other components.

[0012]
FIG. 3 shows the first unit A1, which includes a projector 10, a flat mirror 21, a transparent screen 26, a heat sink 31, a housing 41, and the like.
[0013]
The projector 10 has a light source unit 11, a mirror part 12, a prism 13, a display unit 14, and a projection lens member 15, and is fixed to a heat sink 31. The projector 10 uses a field-sequential color system to display the image on the transparent screen 26.
[0014]
FIG. 4 shows the configuration of the light source unit 11 of the projector 10. The light source unit 11 includes a blue light emitting diode 11a, a red light emitting diode 11b, a green light emitting diode 11c, lens members 11d, 11e, 11f, a reflective mirror 11g, dichroic mirrors 11h and 11i, and a circuit board 11k. The lens members 11d, 11e, 11f, the reflective mirror 11g, and the dichroic mirrors 11h, 11i are held in place by the attaching part 11v of the frame member 11m.
[0015]
The blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c are composed of top view type LEDs and emit three different colors of light (blue light B, red light R, and green light G, respectively). The blue light emitting diode 11a, red light emitting diode 11b, and green light emitting diode 11c are mounted on the circuit board 11k. The circuit board 11k, which includes the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c, is fixed to a heat sink 31 by bolts (not shown). The circuit board 11k is in contact with the heat sink 31, and the heat generated by the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c is dissipated by the heat sink 31 through the circuit board 11k.
[0016]
The lens members 11d, 11e, 11f condense the blue light B, red light R, and green light G emitted by, respectively, the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c. The reflective mirror 11g reflects the blue light B emitted by the blue light emitting diode 11a and condensed by the lens member 11d. The dichroic mirror 11h reflects the red light R emitted by the red light emitting diode 11b and condensed by the lens member 11e, and transmits the blue light B reflected by the reflective mirror 11g. The dichroic mirror 11i reflects the green light G emitted by the green light emitting diode 11c and condensed by the lens member 11f, and transmits the blue light B and the red light R transmitted or reflected by the reflective mirror 11g and the dichroic mirror 11h.
[0017]
The display unit 19 houses the mirror part 12, the prism 13, the display unit 14, and the projection lens member 15 in the case body 18. The display unit 19 is not in direct contact with the light source unit 11. The prism 13 transmits light from the mirror part 12 to illuminate the display unit 14. The display light L generated by the display unit 14 is reflected by the inclined surface 13a of the prism 13 towards the projection lens member 15. The projection lens member 15 magnifies the display light L and projects it on the flat mirror 21. The projection lens member 15 may be composed of a single lens member or a plurality of lens members.
[0018]
The flat mirror 21 is held in place by a retaining member 23 and reflects the display light L from the projector 10 onto the transparent screen 26. The transparent screen 26 is held in place by a retaining member 24, and the display light L from the projector 10 is focused on the transparent screen 26. The heat sink 31 is made of metal such as aluminum and has a plurality of heat radiation fins 31a. The flat mirror 21 and the transparent screen 26 are fixed to the heat sink 31 via the retaining members 23 and 24. The housing 41 is a combination of an opaque resin (for example, polypropylene) and a metal, and houses the projector 10, the flat mirror 21, the transparent screen 26, and the like. The housing 41 is provided with a window section 41a through which the display light L is emitted.
[0019]
The reflector 50 has a flat mirror 51 and a support member 52. The flat mirror 51 reflects the display light L from the first unit A1 onto the concave mirror 61. The support member 52 is fixed to the housing

71 and holds the flat mirror 35. The reflector 60 has a concave mirror 61, a mirror holder 62, a stepping motor 63, and a support member 64. The concave mirror 61 has a reflective surface 61a formed by vapor-depositing a metal (for example, aluminum) on a resin (for example, polycarbonate). The reflective surface 61a is concave and enlarges the display light L reflected by the flat mirror 51 to display the virtual image V. The concave mirror 61 is affixed to the mirror holder 62 by double-sided adhesive tape. The mirror holder 62 is made of resin (for example, ABS), and the gear portion 65 and the shaft portion 66 are integrally formed.

[0020]

The rotating shaft of the stepping motor 63 is fitted with a gear 67, which meshes with the gear portion 65 of the mirror holder 62. The concave mirror 61 is supported in a state that allows it to rotate together with the mirror holder 62. The stepping motor 63 allows the concave mirror 61 to be rotated to adjust the projection direction of the display light L. The vehicle driver 4 operates a push-button switch (not shown) to adjust the angle of the concave mirror 61 so that the display light L is reflected at eye level (that is, so that the virtual image V can be viewed).

[0021]

The housing 71 is made of an opaque resin (for example, polypropylene) and houses the reflectors 50 and 60. The housing 71 is provided with a light-shielding wall 71a to prevent a phenomenon (washout) in which external light such as sunlight enters the transparent screen 26, making the virtual image V difficult to see. The light-shielding wall 71a is in the form of a flat plate and is formed so as to jut down obliquely from the upper portion of the housing 71. The top surface of the housing 71 is provided with an opening part 71b with an attached translucent cover 72 through which the display light L is emitted. The translucent cover 72 is made of a transparent resin such as polycarbonate and has a curved shape.

[0022]

Next, the configuration of the control unit 110 that controls the light sources 11a to 11c and the display unit 14 will be described with reference to FIG. 5.

[0023]

The first unit A1 is provided with a circuit board (not shown) on which the control unit 110 is mounted. The control unit 110 is responsible for the overall control of the projector 10, and includes a processing unit, a storage unit, and an input/output unit, which are not shown. The processing unit may include, for example, one or more microprocessors, microcontrollers, application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), and any other integrated circuits (ICs). The storage unit may include one or more memories capable of storing programs and/or data, for example rewritable RAM (Random Access Memory), read-only ROM (Read Only Memory), erasable programmable read-only EEPROM (Electrically Erasable Programmable Read-Only Memory), or non-volatile flash memory. The input/output unit has a communication unit or the like that is connected to a network such as a Controller Area Network (CAN) (not shown),

and is able to accept information from a network-connected vehicle ECU (Electronic Control Unit) (not shown) or an external illuminance detector (not shown) for detecting illuminance external to the display device 2.

[0024]

The control unit 110 is equipped with the light source control unit 110a that causes the light source unit 11 to emit the color lights B, R, and G at the desired light intensities; a display device drive unit 110b for driving the display unit 14; a display control unit 110c that controls the light source control unit 110a and the display device drive unit 110b; an illuminance sensor 111 for detecting the light intensities of the B, R, and G color lights by receiving some of the B, R, and G color light emitted by the light source unit 11; a temperature sensor 112 for measuring the temperature of the light source unit 11; a current detection unit 113 that detects the drive current value of the light source unit 11; and a current limit detection unit 114, which compares the drive current values of the light source unit 11 (specifically, the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c) detected by the current detection unit 113 to the predetermined maximum current values (rated currents) of the light source unit 11 (specifically, the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c) and identifies the light source in the light source unit 11 that has reached its maximum current value (rated current), if any, as the light source at maximum current. Although the function of the target light intensity setting unit as set forth in the claims is provided by the display control unit 110c in the present embodiment, some or all of these functions may be provided by the light source control unit 110a.

[0025]

The light source control unit 110a controls the light source unit 11 and causes it to emit the R, G, and B color light individually. It functions as an Auto Power Control (APC) that automatically ensures that the light source unit 11 emits the R, G, and B color light at the desired light intensities by feeding back the light intensities of the colored light emitted by the light source unit 11 from the illuminance sensor 111, which is described later. Specifically, the light source control unit 110a compares the light intensities (actual measured values) of the color lights fed back from the illuminance sensor 111 with the target light intensities P (target values) received from the control unit 110c, and controls the light source unit 11 in such a way that the light intensities (actual measured values) are brought into alignment with the target light intensities P (target values). The light source control unit 110a carries out PAM control that adjusts the output levels of the light source unit 11 by adjusting the voltage. However, the light source control unit 110a may also adjust the output levels of light source unit 11 using PWM control, which changes the pulse width driving the light source unit 11, as well as other known controls.

[0026]

The display device drive unit 110b is provided with a drive circuit for driving the display unit 14, and can perform the drive control so that the desired image is output from the display unit 14 based on the control signal from the display control unit 110c. Specifically, the display device drive unit 110b controls each pixel of the display unit 14 in accordance with the tone levels provided for each pixel and color of the image received from the display control unit 110c.

[0027]

The display control unit 110c causes the display unit 14 to display an image of the desired brightness by, for example, receiving image data and brightness data from the vehicle ECU and using the data as the basis for controlling the light source control unit 110a and the display device drive unit 110b. Specifically, the display control unit 110c causes the display unit 14 to display an image of the desired color by receiving image data including the tone levels provided for each pixel and color from the vehicle ECU and outputting the image data to the display device drive unit 110b. In particular, the display control unit 110c of the present embodiment adjusts the hue of the image by adjusting the tone levels in the case where the current limit detection unit 114 identifies a light source in the light source unit 11 that has reached its maximum current value (the light source at maximum current). Meanwhile, the display control unit 110c receives as input the brightness data specifying the brightness of the image from the vehicle ECU, retrieves the respective target light intensities P for the color lights B, R, and G corresponding to the brightness data, and then outputs the target light intensities P to the light source control unit 110a. Note that the display control unit 110c may also have the function of generating image data based on information obtained from the outside (for example, the vehicle ECU). Further, the display control unit 110c may also have the function of obtaining, from the outside, the illuminance external to the display device 2 and determining the brightness of the image from this illuminance, rather than obtaining brightness data specifying the brightness of the image.

[0028]

The illuminance sensor 111 detects the light intensities of the color lights emitted by the light sources 11a to 11c, possibly applying photodiode-based sensors. The illuminance sensor 111 is deployed on the light path of the color lights B, R, and G emitted by the light sources 11a to 11c in a manner that allows it to receive light not used for projection to the front windshield 3. A detection signal (light intensity information) corresponding to the light output value detected by the illuminance sensor 111 is output to the light source control unit 110a. In this case, the drive control of the light source control unit 110a and the display control unit 110c is used to illuminate the RGB light sources 11a to 11c one by one, and then the output values of each RGB light source 11a to 11c are detected by reading the detection signal of the illuminance sensor 111 as each light source is illuminated. Note that these output values are always read during display output, but depending on the arrangement and configuration of the illuminance sensor 111, they could be detected at a timing unrelated to the display.

[0029]

The temperature sensor 112 is mounted on the circuit board 11k and detects either the ambient temperature (temperature T) around the light sources 11a to 11c or the temperatures of the light sources 11a to 11c themselves. Based on these temperatures, the temperature sensor 112 outputs a detection signal (temperature T) to the display control unit 110C. In this case, the temperature T of the red light emitting diode 11b is detected as the representative value, but in another possible configuration, the detected temperatures correspond to the three light sources 11a to 11c corresponding to the three primary colors.

[0030]

The current detection unit 113 detects the amount of drive current flowing through a detection resistor (not shown) connected to the light sources in the light source unit 11 (the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c). Specifically, the current detection unit detects the voltage value applied to the detection resistor, calculates the amount of current from this voltage value, and outputs it to the current limit detection unit 114.

[0031]

The current limit detection unit 114 determines when the drive current values of the light source unit 11 detected by the current detection unit 113 have reached the maximum current value (also called the rated current value, allowable current value, limit current value, etc.), and notifies the display control unit 110c which light source in the light source unit 11 is the light source at maximum current. Specifically, the current limit detection unit 114 has a comparator (not shown) that compares the drive current values of the light source unit 11 detected by the current detection unit 113 with a predetermined maximum current value, and outputs the result of the determination of this comparator to the display control unit 110c. Note that the current detection unit 113 may output the voltage value applied to the detection resistor to the current limit detection unit 114 without calculating the current amount, and in this case, the current limit detection unit 114 may determine whether the drive current value of the light source unit 11 has reached the maximum current value in accordance with the voltage value.

[0032]

For the light sources 11a to 11c, light emitting diodes can be adopted as described above.

[0033]

The display unit 14 is for generating the desired display image based on a drive signal (image data including the tone levels set for each pixel and each color) from the display device drive unit 110b. A reflective display element such as a DMD (Digital Micromirror Device) can be adopted for this element.

[0034]

The display unit 14 consists of a large number of minute mirror surfaces arranged in a plane, and is equipped with a plurality of movable mirror elements, under which electrodes are placed and driven very rapidly in order to tilt each mirror surface by tilting the hinge of its mirror element about a fulcrum. For example, when a mirror element is on, its hinge is tilted by +12 degrees about the fulcrum, and the display light L emitted from the display unit 19 is reflected and delivered to the screen 26 via the prism 13 or the like. When the mirror element is off, the hinge is tilted by −12 degrees about the fulcrum, and the display light L is not reflected toward the prism 13. In this manner, the display light L is selectively projected onto the screen 26 by driving each mirror element individually based on the display image data representing the display image, thereby displaying a display image of the desired brightness and desired color on the screen 26 to be described later.

[0035]

Next, the output adjustment processing based on the change in the temperature T will be described with reference to FIGS. 6 to 9.

[0036]

The display control unit 110c receives as input the detection signal (temperature T) from the temperature sensor 112 (step S1). This step of input of the detection signal includes analog/digital conversion. The display control unit 110c measures the ambient temperature (temperature T) of the light sources 11a to 11c. In this case, the following processing is carried out based on the temperature T of the red light emitting diode 11b.

[0037]

The display control unit 110c determines whether or not the temperature T measured in the processing of step S1 is greater than or equal to a predetermined value (threshold) (step S2). This predetermined value sets the maximum allowable temperature limit for the red light emitting diode 11b. Note that the red light emitting diode 11b has an upper temperature limit that is lower than the other light sources 11a and 11c, which means that problems such as a decrease in brightness or failure to display the desired hue may occur if this predetermined value is exceeded, even when the light sources are driven at the same drive current value.

[0038]

In the case where the processing in step S2 determines that the measured temperature T is less than the predetermined value, the normal processing is executed; namely, the display control unit 110c uses the first table data stored in memory (not shown) to set the drive current values of the light sources 11a to 11c based on the ambient temperature (step S3). This correction is made to ensure that the desired output is produced by compensating for the fact that the output brightness of the light sources 11a to 11c changes depending on the temperature environment. For example, as shown in FIG. 7, in the range below the predetermined value Ta, the drive current values of each of the light sources 11a to 11c can be set according to the measured temperature T, and the drive current values are set to values roughly proportional to the ambient temperature.

[0039]

In the case where the processing in step S2 determines that the measured temperature T is greater than or equal to the predetermined value Ta, the higher-temperature-than-normal processing is executed; namely, the display control unit 110c uses the second table data (derating table data) stored in memory to set the drive current values of the light sources 11a to 11c (step S4). At this time, the drive current values of the light sources 11a and 11c are set based on the measured temperature T, while the drive current value of the light source 11b is either kept constant or set to a value that decreases as the temperature T rises. The former case, in which the drive current value of the light source 11b is kept constant, is labeled C1, while the latter case is labeled C2.

[0040]

The processing of step S4 described above disrupts the output balance of the light sources 11a to 11c, which means the desired color can no longer be expressed. In order to interpolate the output balance, the display control unit 110c performs the processing in steps S5 to S7 below to adjust the hue in the display unit 14 via the display device drive unit 110b.

[0041]

In step S5, the display control unit 110c determines whether or not the tone of the red output of the display unit 14 driven by the display device drive unit 110b is less than a predetermined value in any pixel. This predetermined value may also be a maximum value. Note that the tone of each color is set in advance by being mapped to either a lighting time per unit time or a lighting frequency in a field-sequential color system. This configuration information is stored in the memory 110e as table data or parameters.

[0042]

In the case where the processing in step S5 determines that the tone of the red output is smaller than the predetermined value, and the temperature T is greater than or equal to the predetermined value Ta as shown in FIG. 8, the display device drive unit 110b drives the display unit 14 in such a way that the tone of the red output is increased so that the red color is perceived as stronger (step S6). This makes it possible to express the desired hue even when the red output is reduced in brightness.

[0043]

In the case where the condition in step S5 is not met, that is, when it is not possible to increase the red tone, the light sources 11a to 11c are driven in such a way that the green and blue tones are reduced as shown in FIG. 9 in order to maintain the color balance that is actually output (step S7).

[0044]
Note that in the case where the drive current value of the red light emitting diode 11b is kept constant in steps S5 to S7 (case C1), if the temperature compensation level of the red light emitting diode 11b causes the allowable upper limit temperature value Tb (higher than the predetermined value Ta) to be reached based on the detection signal from the temperature sensor 112, the rise in temperature due to the heat generated by the light emitting diode 11b itself can be suppressed by forcibly reducing the drive current value of the red light emitting diode 11b and then setting the drive current value or tone as indicated in case C2 as shown in FIGS. 7 to 9.
[0045]
By having the display control unit 110c control the light sources 11a to 11c and display unit 14 using the values set in step S3 or in steps S4 through S7, while the light source control unit 110a executes feedback control based on the detection signal from the illuminance sensor 111 to correct the drive current values of the light sources 11a to 11c (step S8), it is possible to output the desired color more accurately.
[0046]
By repeating the processing in steps S1 to S8 described above, the display control unit 110c is able to maintain the output at the desired hue even under the harsh temperature conditions in the vehicle and within the dashboard 1. In particular, by maintaining the white balance of the display image, the display device 2 is able ensure the output is displayed without any sense of incongruity.
[0047]
The display device 2 comprises: the light sources 11a to 11c consisting of the light emitting diodes that output each of the three primary colors; the display device 14 for generating an image for projection using the light output from the light sources 11a to 11c; the temperature sensor 112 for detecting the temperature of the light sources 11a to 11c and outputting it as temperature information; the light source control unit 110a for driving the light sources 11a to 11c; the display device drive unit 110b for driving the display unit 14; and a display control unit 110c for controlling and dimming the light source control unit 110a based on the temperature information. In the case where the temperature information is greater than or equal to a predetermined value, the display control unit 110c adjusts the hue of the image by means of control by the display device drive unit 110b.
[0048]
In this way, it is possible to maintain the output at the desired hue even under harsh temperature conditions and ensure that the output is displayed without any sense of incongruity, resulting in a vehicular display device with excellent display quality.
[0049]
Furthermore, in the case where the temperature information is greater than or equal to a predetermined value, the display control unit 110c maintains as constant or reduces the drive current value of light source 11b, which emits red light, while adjusting the hue of the image by means of control by the display device drive unit 110b. In this way, images can be output in the desired hue, resulting in excellent display quality. The heat generated by light source 11b can also be reduced, thereby preventing further temperature rise.
[0050]
The display device drive unit 110b drives the light sources 11a to 11c so as to emit a desired hue by changing the color tone levels of the image, and in the case where the temperature information is greater than or equal to a predetermined value, the display control unit 110c adjusts the hue of the image by changing the tone levels. As a result, the display device maintains excellent display quality even under harsh temperature conditions.
[0051]
Next, the output adjustment processing when the light source unit 11 reaches the maximum current value will be described with reference to FIG. 10. FIG. 10 is a diagram illustrating the relationship between the target light intensity P and drive current value I of each light source in the light source unit 11. FIG. 10 (a)

shows the relationship between the target light intensity Pa and drive current value Ia of the blue light emitting diode 11a. FIG. 10 (b) shows the relationship between the target light intensity Pb and drive current value Ib of the red light emitting diode 11b. The dotted line indicates the characteristics of the normal red light emitting diode 11b, and the solid line indicates the characteristics of the red light emitting diode 11b after it has deteriorated. FIG. 10 (c) shows the relationship between the target light intensity Pc and drive current value Ic of the green light emitting diode 11c.

The maximum target light intensity P required to achieve the maximum brightness of the image is denoted Pam for the blue light emitting diode 11a, Pbm for the red light emitting diode 11b, and Pcm for the green light emitting diode 11c. The maximum drive current value (maximum current value) I that can be applied to the light sources in the light source unit 11 is denoted Iam for the blue light emitting diode 11a, Ibm for the red light emitting diode 11b, and Icm for the green light emitting diode 11c. Under normal conditions, the maximum target light intensities Pam, Pbm, and Pcm can be achieved at a lower current than when the drive current value I reaches the maximum current values Iam, Ibm, and Icm. However, if deterioration causes the light sources in the light source unit 11 to lose efficiency, it is conceivable that the drive current value Ib will reach the maximum current value Ibm when the target light intensity Pb reaches the target light intensity Pbi (< Pbm) before reaching the maximum target light intensity Pbm, as shown in the solid line of FIG. 10 (b).

[0052]

In the present embodiment, the current detection unit 113 detects the drive current values Ia, Ib, and Ic for the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c, respectively, and the current limit detection unit 114 determines whether the drive current values Ia, Ib, and Ic are greater than or equal to the maximum current values Iam, Ibm, and Icm, respectively. In the example shown in FIG. 10, the current limit detection unit 114 identifies the red light emitting diode 11b, which has reached a maximum current value of Ibm or greater, as the light source at maximum current. When the light source at maximum current 11b reaches the maximum current value Ibm, the display control unit 110c acquires the light intensity Pbi from the illuminance sensor 111, and in order to obtain a white balance with this light intensity Pbi, the corrected target light intensity Pai of the blue light emitting diode 11a and the corrected target light intensity Pci of the green light emitting diode 11c (that is, the light sources other than the light source at maximum current 11b) are read from table data stored in a memory (not shown) and output to the light source control unit 110a. The light source control unit 110a controls the red light emitting diode 11b, the blue light emitting diode 11a, and the green light emitting diode 11c so that their respective light intensities as detected by the illuminance sensor 111 are the target light intensities Pbi, Pai, and Pci, respectively. This makes it possible to maintain a good white balance even when the drive current value of a light source in the light source unit 11 has reached its maximum current value.

[0053]

Next, a variation of the output adjustment processing performed when the light source unit 11 reaches the maximum current value will be described with reference to FIG. 11. FIG. 11 is a diagram illustrating the relationship between the target light intensity P and drive current value of each light source in the light source unit 11, and the relationship between the target light intensity P and tone level correction amount. FIG. 11 (a) shows the relationship between the target light intensity Pa and drive current value Ia of the blue light emitting diode 11a. FIG. 11 (b) shows the relationship between the target light intensity Pb and drive current value Ib of the red light emitting diode 11b. The dotted line indicates the characteristics of the normal red light emitting diode 11b, and the solid line indicates the characteristics of the red light emitting diode 11b after it has deteriorated. FIG. 11 (c) shows the relationship between the target light intensity Pb and the red tone level correction amount. FIG. 11 (d) shows the relationship between the target light intensity Pc and drive current value Ic of the green light emitting diode 11c. This variation is different in that what is corrected is the tone level of the light source at maximum current, whose drive current value has reached its maximum current value.

[0054]

In the variation shown in FIG. 11, the current detection unit 113 detects the drive current values Ia, Ib, and Ic for the blue light emitting diode 11a, the red light emitting diode 11b, and the green light emitting diode 11c, respectively, and the current limit detection unit 114 determines whether the drive current values Ia, Ib, and Ic are greater than or equal to the maximum current values Iam, Ibm, and Icm, respectively. In the example shown in FIG. 11, the current limit detection unit 114 identifies the red light emitting diode 11b, which has reached a maximum current value of Ibm or greater, as the light source at maximum current. When the light source at maximum current 11b reaches the maximum current value Ibm, the display control unit 110c acquires the light intensity Pbi from the illuminance sensor 111, and in order to obtain a white balance with this light intensity Pbi, the corrected target light intensity Pai of the blue light emitting diode 11a and the corrected target light intensity Pci of the green light emitting diode 11c (that is, the light sources other than the light source at maximum current 11b) are read from table data stored in a memory (not shown) and output to the light source control unit 110a. The light source control unit 110a controls the red light emitting diode 11b, the blue light emitting diode 11a, and the green light emitting diode 11c so that their respective light intensities as detected by the illuminance sensor 111 are the target light intensities Pbi, Pai, and Pci, respectively.

Note that if the target light intensity Pb of the red light emitting diode 11b is greater than or equal to Pbi, the light source control unit 110a maintains the drive current value at the maximum current value Ibm, and the display controller 110c increases the tone level of the red color indicated in the image data. That is, even if the drive current value of a light source in the light source unit 11 has reached the maximum current value and its output can no longer be increased, the desired white balance of the image can be maintained by increasing the tone level of the color that is lacking in the light source unit 11.

[0055]

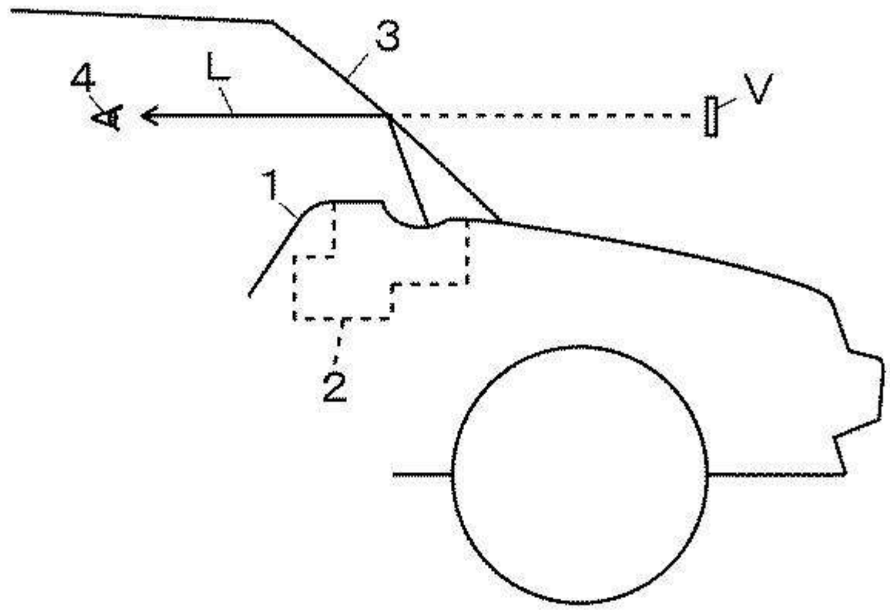
Although the present invention is described with reference to the configuration of the embodiment described above, the present invention is not limited thereto, and obviously various modifications and changes in display can be made without departing from the scope of the present invention. For example, in the above embodiment, a display unit 14 comprising a DMD is described as an example, but the same effect as the above embodiment could be obtained by using a liquid crystal display as the display unit, or by using a scanning laser display structure to draw the image by raster scanning the laser beam with a MEMS scanner and modulating the laser light in sync with the video signal.

[Reference Numerals]

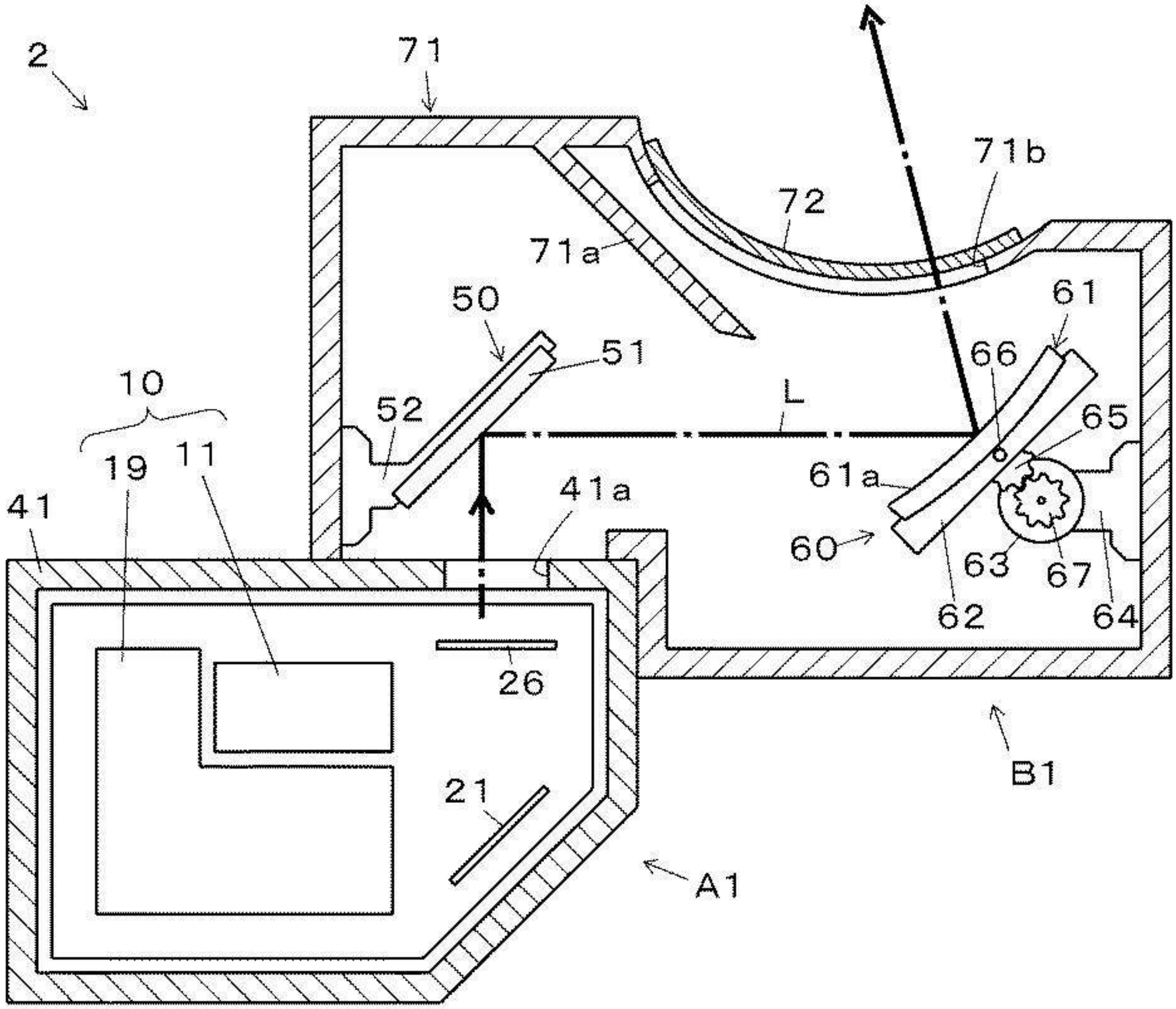
[0056]

2: Display device (vehicular display device)
11a to 11c: Light sources
110b: Control unit
110c: Light source drive circuit
110d: Display control circuit
111: Illuminance sensor
112: Temperature sensor
14: Display unit

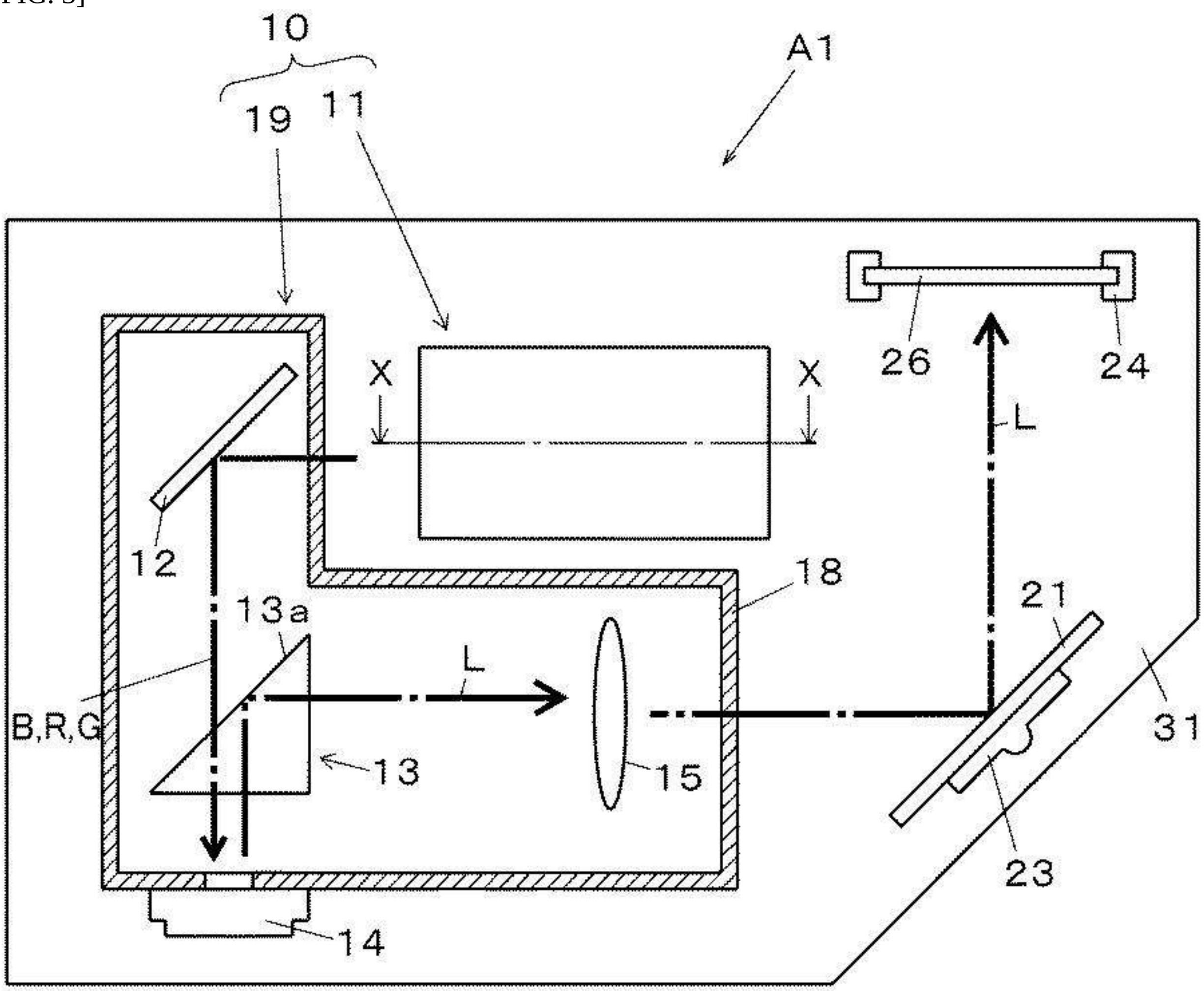
[FIG. 1]



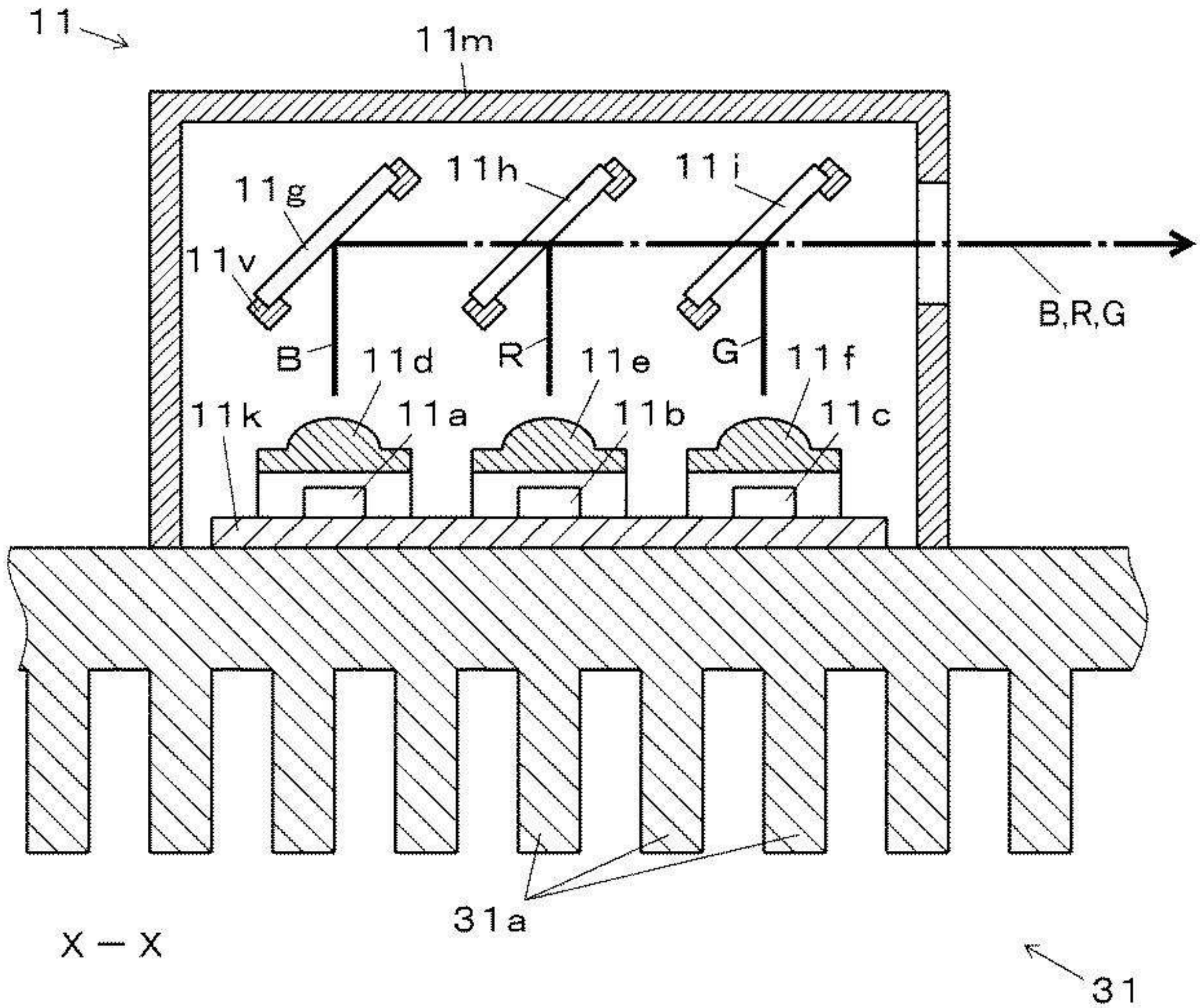
[FIG. 2]


2
71
71b
72
71a
50
51
61
66
52
L
65
10
19
11
61a
41
41a
60
63
67
62
64
26
B1
21
A1

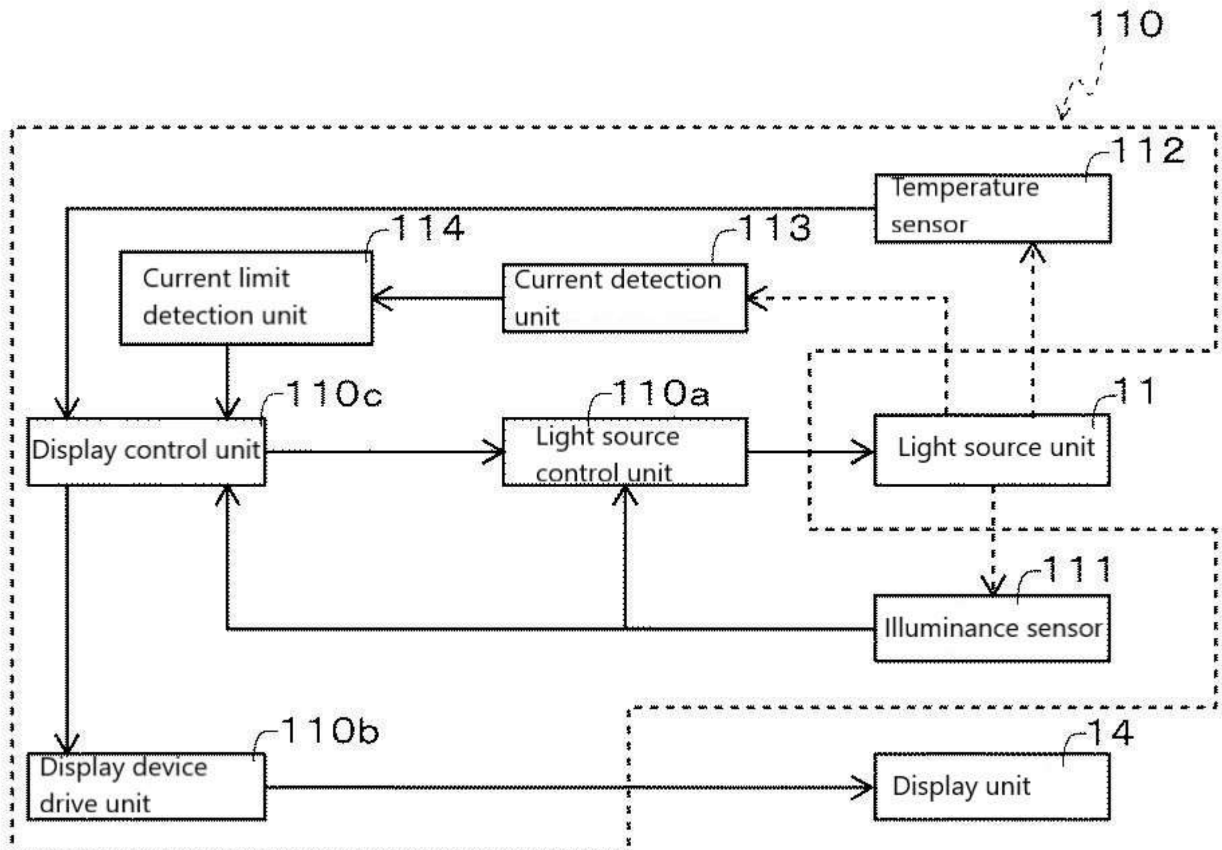
[FIG. 3]



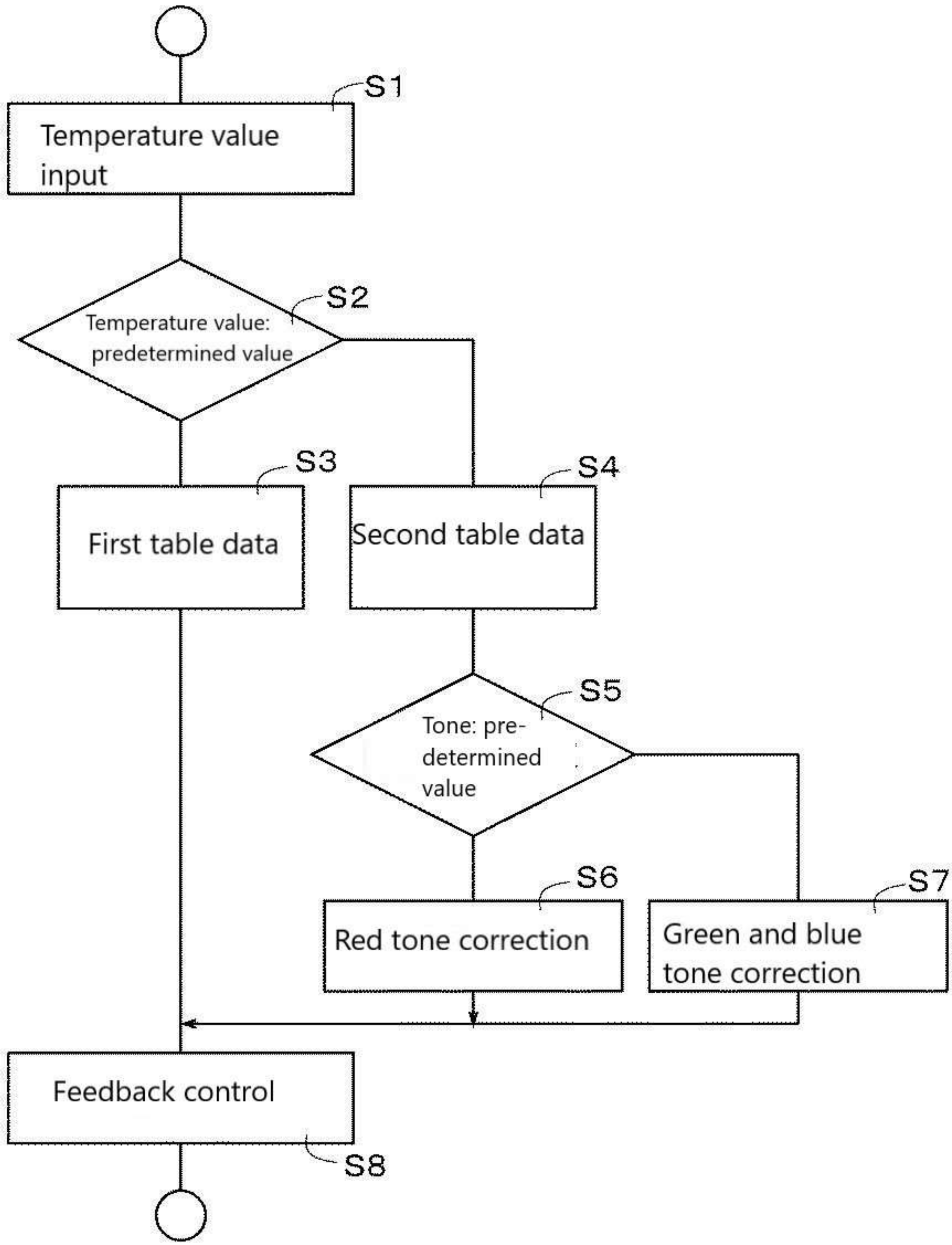
[FIG. 4]


11
11m
11g
11h
11i
11v
B,R,G
B
R
G
11d
11e
11f
11k
11a
11b
11c
31a
X − X
31

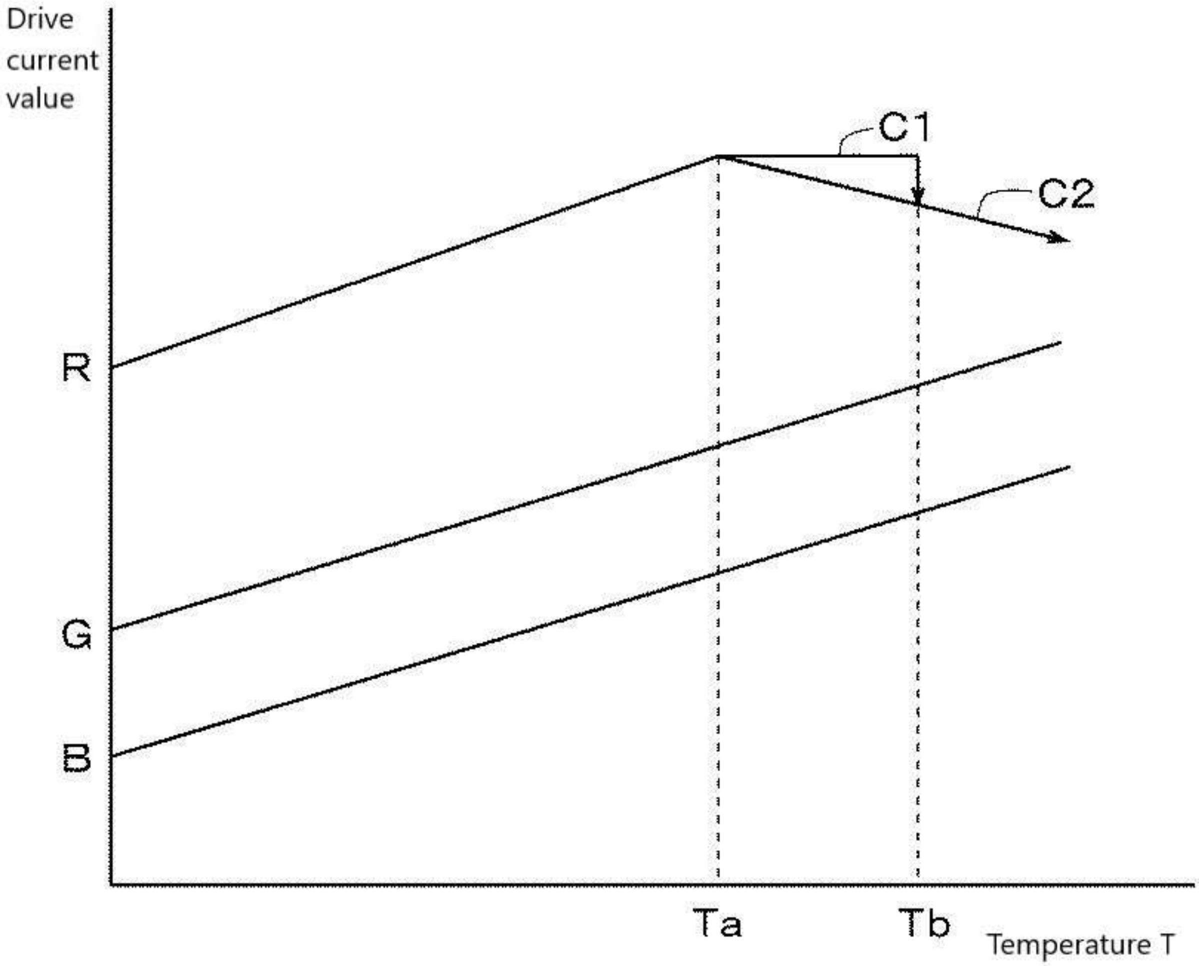
[FIG. 5]


110
112
Temperature sensor
114
Current limit detection unit
113
Current detection unit
110c
Display control unit
110a
Light source control unit
11
Light source unit
111
Illuminance sensor
110b
Display device drive unit
14
Display unit

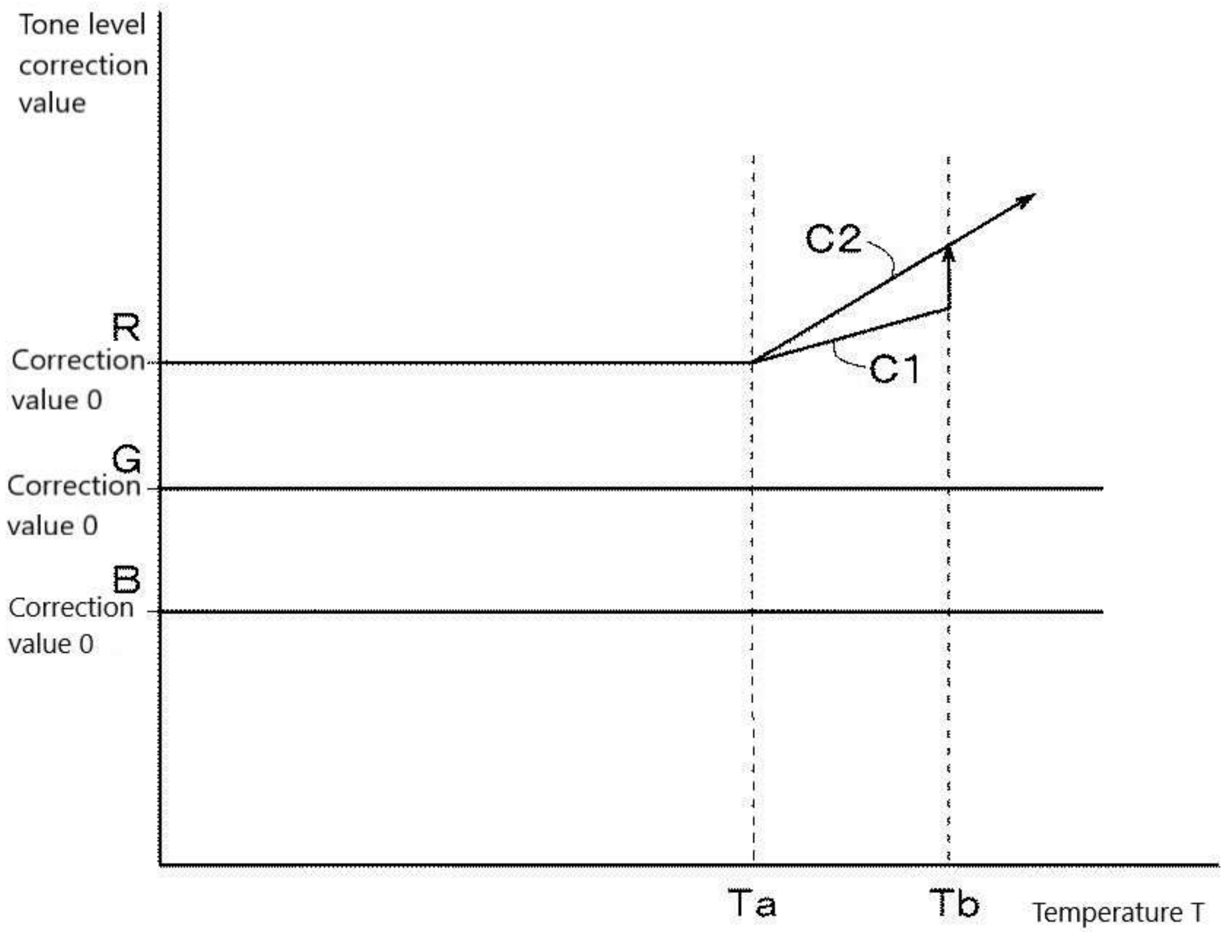
[FIG. 6]


S1
Temperature value input
S2
Temperature value: predetermined value
S3
First table data
S4
Second table data
S5
Tone: pre-determined value
S6
Red tone correction
S7
Green and blue tone correction
Feedback control
S8

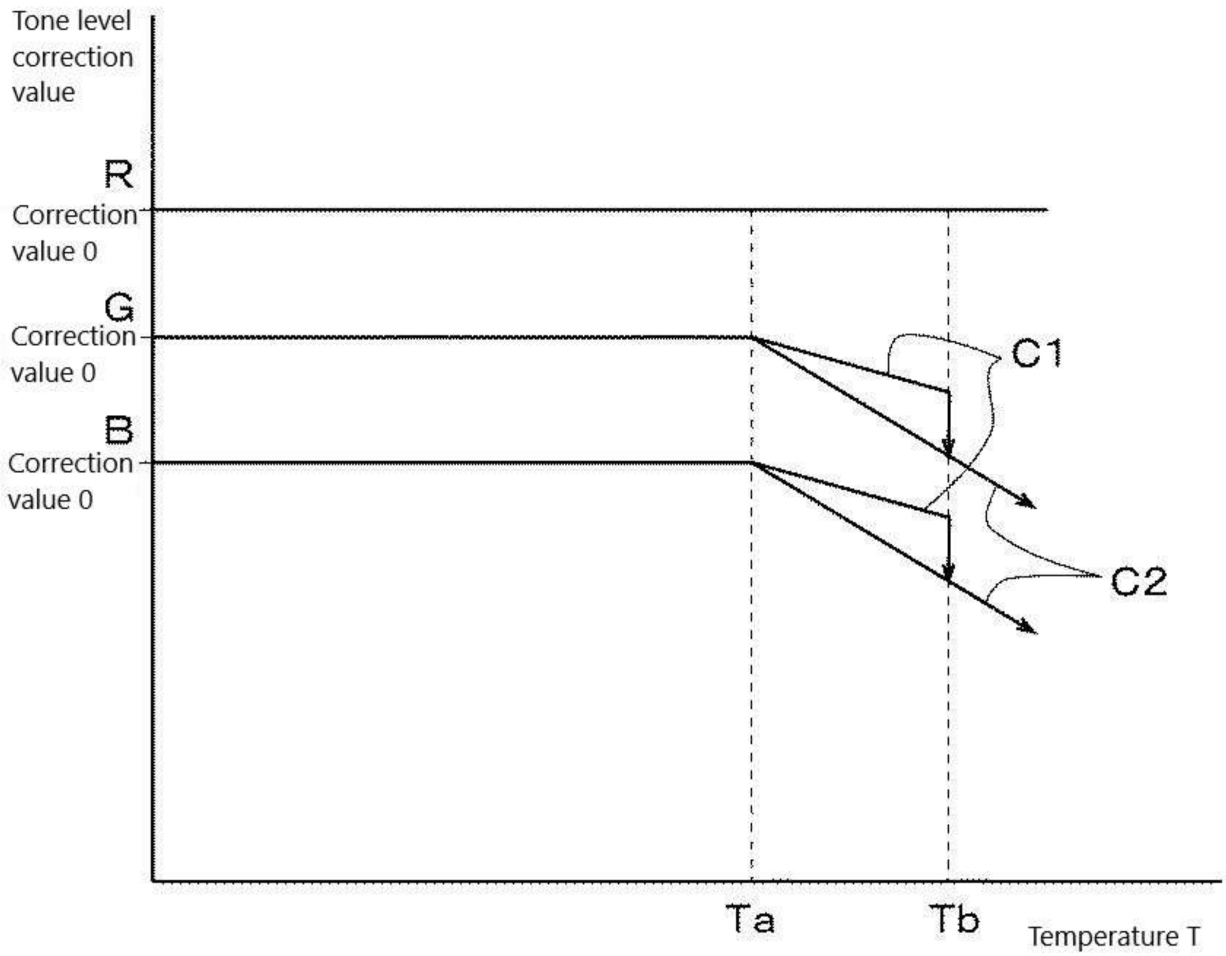
[FIG. 7]



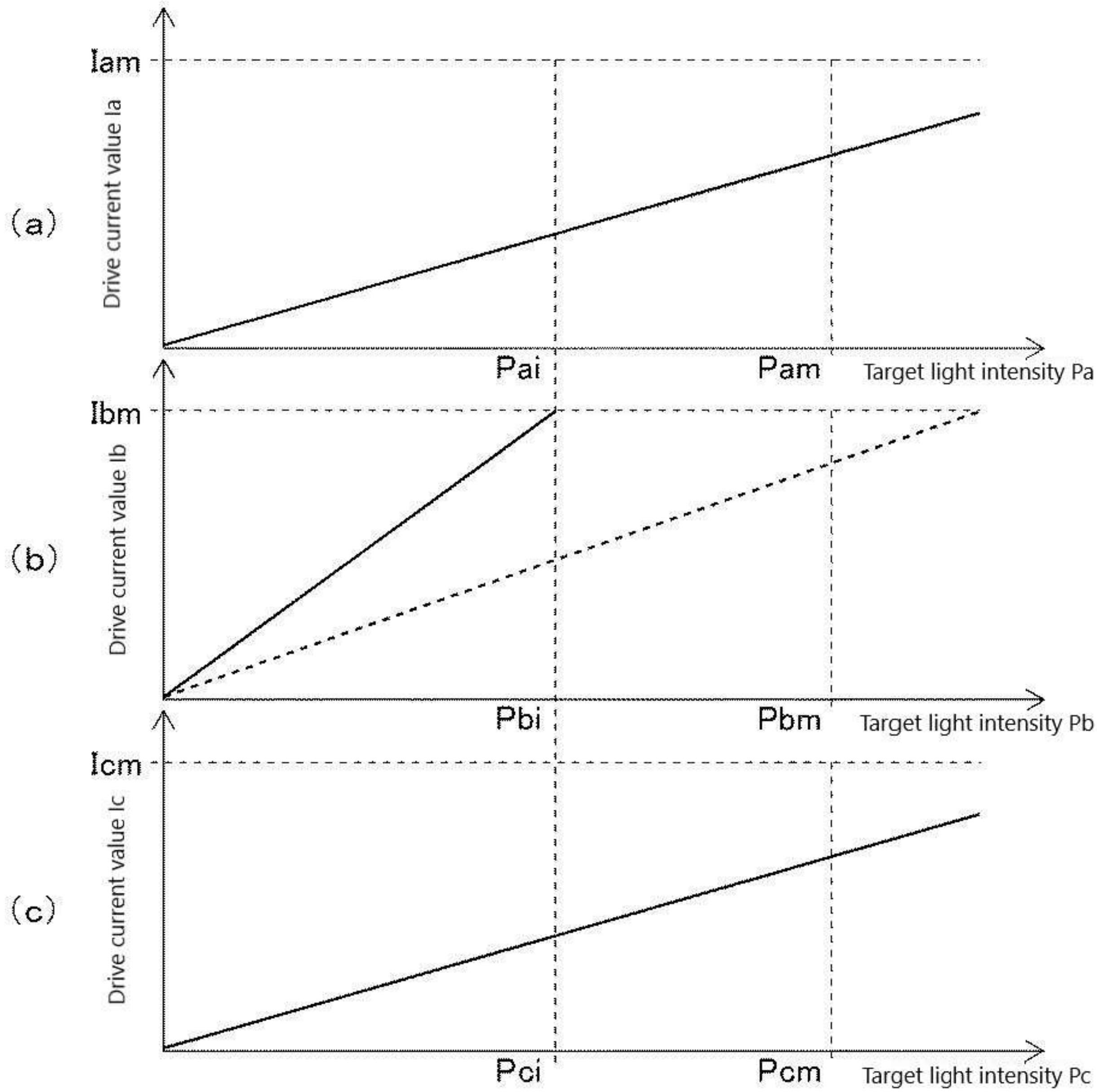
[FIG. 8]


Tone level correction value
R
Correction value 0
G
Correction value 0
B
Correction value 0
C2
C1
Ta
Tb
Temperature T

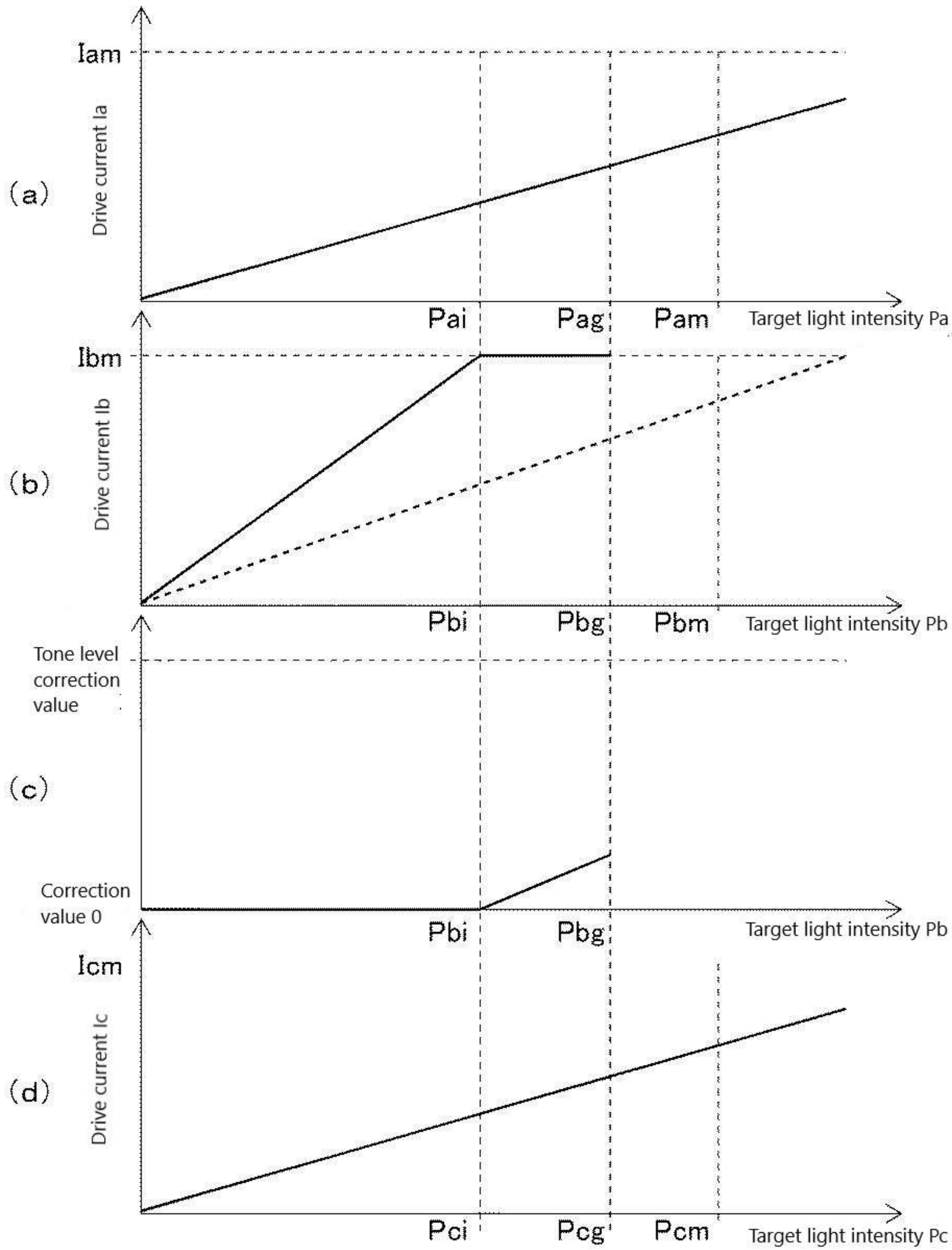
[FIG. 9]


Tone level correction value
R
Correction value 0
G
Correction value 0
B
Correction value 0
C1
C2
Ta
Tb
Temperature T

[FIG. 10]


(a)
Iam
Drive current value Ia
Pai
Pam
Target light intensity Pa
(b)
Ibm
Drive current value Ib
Pbi
Pbm
Target light intensity Pb
(c)
Icm
Drive current value Ic
Pci
Pcm
Target light intensity Pc

[FIG. 11]


(a)
Iam
Drive current Ia
Pai
Pag
Pam
Target light intensity Pa
(b)
Ibm
Drive current Ib
Pbi
Pbg
Pbm
Target light intensity Pb
(c)
Tone level correction value
Correction value 0
Pbi
Pbg
Target light intensity Pb
(d)
Icm
Drive current Ic
Pci
Pcg
Pcm
Target light intensity Pc

Continued from front page

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G09G	**9/31**	**(2006.01)**	G09G	3/20	642L	
			G09G	3/20	642J	
			G02B	27/01		
			B60K	35/00	A	
			H04N	9/31	820	

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