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(71) Applicant: 596080813
Masanori MINATO
3-6-26 Wakakusa, Utsunomiya-shi, Tochigi

(71) Applicant: 397019807
Satoshi TAMAOKI
4-7-5 Yagiyama-Minami, Taihaku-ku, Sendai-shi, Miyagi

(72) Inventor: Masanori MINATO
3-6-26 Wakakusa, Utsunomiya-shi, Tochigi

(72) Inventor: Satoshi TAMAOKI
4-7-5 Yagiyama-Minami, Taihaku-ku, Sendai-shi, Miyagi

(74) Agent: Patent Attorney Kazutoshi NAKAMURA

(54) [TITLE OF THE INVENTION] LIGHT-EMITTING DISPLAY DEVICE

(57) [ABSTRACT]
[PROBLEM] To provide a light-emitting display device which is compatible with a conventional electric bulb set, can be driven easily by AC 100 V, can save electric power, has a long life, and can easily change the brightness or color of emitted light.
[MEANS FOR SOLVING] Two light-emitting diodes with different luminescent colors are connected in antiparallel – that is, the directions of the two light-emitting diodes are reversed. A basic unit is formed by connecting the anodes and cathodes of the respective light-emitting diodes, and the light-emitting diodes are lit by a commercial power supply. A light-emitting display device is formed by connecting a plurality of such basic units in series.

[SCOPE OF THE PATENT CLAIMS]

[CLAIM 1] A light-emitting display device comprising a first light-emitting diode having first luminescent color and a second light-emitting diode having a second luminescent color, the first and second light-emitting diodes being connected in antiparallel; the first light-emitting diode being driven at the time of one polarity of an AC power supply; and the second light-emitting diode being driven at the time of another polarity of the AC power supply.

[CLAIM 2] A light-emitting display device comprising a plurality of light-emitting units connected in series, the light-emitting units being formed by connecting, in three-stage series, units comprising a first light-emitting diode having a first luminescent color and a second light-emitting diode having a second luminescent color connected in antiparallel; the device being driven by a commercial AC power supply.

[CLAIM 3] The light-emitting display device according to claim 1 or 2 having a control circuit for controlling a voltage, current, or conduction angle of at least one polarity of the commercial AC power supply.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001] The present invention relates to a light-emitting display device. More particularly, the present invention relates to a light-emitting display device which can be used for electric decoration used to decorate Christmas trees or street trees, electric decoration provided on store signs, or danger marking for road construction or the like.

[0002]

[PRIOR ART] Conventionally, a device formed by connecting multiple electric bulbs in series or in parallel has been used as electric decoration such as electric decoration for small household Christmas trees as well as electric decoration for store signs or the like and danger marking lights for construction sites. In addition, lately there are many places where rows of trees along streets are decorated with electric bulbs in order to improve the night view in cities or for Christmas or year-end events.

[0003] FIG. 10 illustrates an example of a electric bulb set used for electric decoration such as a Christmas tree. Symbols L101 to L150 are ordinary small electric bulbs, wherein two chains, comprising a chain in which 25 electric bulbs from electric bulb L101 to L125 are connected in series and a chain in which 25 electric bulbs from electric bulb L126 to L150 are connected in series, are connected in parallel to form one set. Symbol P111 in the drawing is a plug connected to an AC 100 V commercial power supply. A 4 V voltage is applied to each of the electric bulbs by applying AC 100 V to terminals 112 and 113 of the plug so as to light the bulbs.

[0004] In addition, the electric bulbs can be made to blink at constant intervals by using electric bulbs with a bimetal strip for any one of the electric bulbs – for example, L125 and L150 – of the chains of the electric bulb set.

[0005] By decorating a tree by connecting one or a plurality of the electric bulb sets in parallel, a Christmas tree, for example, is formed. In households, various colors can be expressed by adding color to the glass itself of the electric bulbs or adding a colored resin-based cover. In order to prevent confusion with traffic signals outdoors, electric bulbs are often only lit continuously in a color close to orange. Such a electric bulb set can be used easily and is inexpensive since it can be lit by simply connecting directly to an AC 100 V power supply.

[0006] However, the average life of a electric bulb used for the purposes described above is only about 1,000 hours, and when used for a long period of time, there are electric bulbs that do not light due to a broken filament. When 25 electric bulbs are connected in series in one chain, as in FIG. 10, all 25 of the electric bulbs simultaneously fail to light when there is even one electric bulb with a broken filament. When attempting to repair the chain by replacing a electric bulb, it is practically impossible to distinguish a electric bulb that is broken from one that is not from its appearance, so it takes a large amount of effort and time to find and replace a broken electric bulb.

[0007] On the other hand, in comparison to electric bulbs, light-emitting diodes have higher efficiency, do not generate heat, and have a longer life, so they are typically used for display devices. When light-emitting diodes are used for the electric decoration described above, not only is the power consumption low, but the life is also extremely long, so the need to replace the bulbs is practically eliminated. Moreover, since the diodes are placed in a transparent resin-based package, there is no risk of the glass breaking, as in the case of electric bulbs, which makes the diodes particularly suitable for outdoor use.

[0008] Configurations in which light-emitting diodes are arranged in a matrix have recently been used in direction boards and the like for roads or train stations. FIG. 11 illustrates one segment of a matrix of light-emitting diodes, wherein D201 is a red light-emitting diode and D202 is a green light-emitting diode, for example. The cathode of the red light-emitting diode D201 and the cathode of the green light-emitting diode D202 are connected to form a common electrode terminal 211. An anode terminal 212 of the red light-emitting diode D201 and an anode terminal 213 of the green light-emitting diode D202 are independent electrode terminals which are housed in a single transparent resin-based package. In such a segment, the diodes are lit red when a DC voltage of approximately 1.5 to 2 V is applied between the anode terminal 212 of the red light-emitting diode D201 and the common electrode terminal 211, green when a DC voltage of approximately 1.5 to 2 V is applied between the anode terminal 213 of the green light-emitting diode D202 and the common electrode terminal 211, and orange when a voltage is applied to both simultaneously. A DC current of approximately 1 to 100 mA is applied.

[0009] FIG. 12 illustrates a matrix of m×n of the light-emitting diodes illustrated in FIG. 11. D211 to D2mn are light-emitting diodes, C21 to C2m are control lines of common electrodes of the cathodes, R21 to R2n are control lines of the anodes of the red light-emitting diodes, and G21 to G2n are control lines of the anodes of the green light-emitting diodes. By selecting given rows and columns of the matrix with a control circuit and applying a current, it is possible to display characters of any three colors of red, green, and orange.

[0010] However, in order to use such light-emitting diodes for electric decoration, even if a complex control circuit for driving the matrix is made unnecessary, a total of at least three signal lines including two signal lines for red and green and a common ground line are required to drive one chain of light-emitting diodes. Therefore, the diodes cannot be easily connected to an AC 100 V power supply and used in the same manner as a conventional electric bulb set.

[0011]

[PROBLEM TO BE SOLVED BY THE INVENTION] An object of the present invention is to provide a light-emitting display device which is compatible with a conventional electric bulb set and can be easily driven by AC 100 V.

[0012] Another object of the present invention is to provide a light-emitting display device which saves electric power and has a long life. Another object of the present invention is to provide a light-emitting display device with which the brightness or color of emitted light can be changed easily.

[0013] Yet another object of the present invention is to provide a control device suitable for the light-emitting display device described above.

[0014]

[MEANS FOR SOLVING THE PROBLEM] In the light-emitting display device of the present invention, the direction of two light-emitting diodes with different luminescent colors are reversed, and a basic unit is formed by connecting the anodes and cathodes of the respective light-emitting diodes. An AC voltage for driving the device is set by connecting a plurality of such basic units in series. That is, the voltage is aligned with the driving voltage of the electric bulbs requiring compatibility. As a result, the device can be lit with a conventional commercial power supply – that is, AC 100 V.

[0015] The brightness or color of the light-emitting diodes is changed by independently controlling the voltage, current, or conduction angle with respect to the positive half-cycle and the negative half-cycle of one AC cycle. If no particular control is administered, the two light-emitting diodes will emit light simultaneously, resulting in a mixed color of both light-emitting diodes. In addition, by using either of the AC polarities, it is possible to emit light of either one of the colors.

[0016]

[EMBODIMENT OF THE INVENTION] FIG. 1 illustrates a basic unit of the light-emitting display device of the present invention. In FIG. 1(a), a red light-emitting diode D11 and a green light-emitting diode D12 are connected in parallel in opposite directions. That is, the anode of the red light-emitting diode D11 and the cathode of the green light-emitting diode D12, and the cathode of the red light-emitting diode D11 and the anode of the green light-emitting diode D12 are respectively connected to one another to form two electrodes or terminals 13 and 14.

[0017] When an AC voltage of 1.5 to 2 V is applied between the electrodes 13 and 14 as a peak value, the red light-emitting diode D11 and the green light-emitting diode D12 are lit so that the light appears orange. In addition, using a thyristor or the like, it is possible to light only the red light-emitting diode D11 by applying a voltage for only the positive half-cycle of one AC cycle, and it is possible to light only the green light-emitting diode D12 by applying a voltage for only the negative half-cycle.

[0018] The current flowing through the light-emitting diodes is ordinarily preferably set to approximately 1 to 100 mA in order to suppress the thermal breakdown thereof. Therefore, resistors may be connected in series to the light-emitting diodes. FIG. 1(b) illustrates a configuration in which a resistor R11 and a resistor R12 are respectively connected between the anode of the red light-emitting diode D11 and the electrode 13 and between the cathode of the green light-emitting diode D12 and the electrode 13. The resistances of the inserted resistors are set so that the voltage drop at both ends of the resistors is approximately 0.1 to 1 V when a desired current flows through the device. In addition, the respective resistors may also be connected between the cathode of the red light-emitting diode D11 and the electrode 14 and between the anode of the green light-emitting diode D12 and the electrode 14.

[0019] FIG. 1(c) illustrates an example in which a resistor R13 is connected in series on the electrode 13 side for both the light-emitting diodes D11 and D12. A constant-current element such as a field effect transistor or a bipolar transistor may also be inserted in series instead of a resistor.

[0020] FIG. 1(d) illustrates an example in which constant-voltage elements T11 and T12 comprising field effect transistors are connected in series to the anode sides of the light-emitting diodes D11 and D12 respectively connected in antiparallel.

[0021] The AC voltage for driving the light-emitting display device of the present invention can be changed based on how many stages of the basic units illustrated in FIG. 1 are connected.

[0022] FIG. 2 illustrates a light-emitting unit in which the basic units illustrated in FIG. 1 are connected in three-stage series, wherein D21, D23, and D25 are red light-emitting diodes, and D22, D24, and D26 are green light-emitting diodes. When driven by applying an AC voltage with a peak value of 4.5 to 6 V between the electrodes or terminals 21 and 22 of the basic units, the diodes are lit with an orange color relatively close to the color of an electric bulb. When a reverse voltage is applied to either of the light-emitting diodes, a forward voltage is applied to the other light-emitting diodes, so there is no need for a bleeder resistor for uniformly distributing the reverse voltage to each of the light-emitting diodes. Further, as described above, when only one of the polarities of the AC voltage is used, it is possible to light either only red or only green diodes. Ordinarily, a transparent or translucent resin-based package having optical directivity in one direction is used as a package for the light-emitting diodes. However, in a light-emitting display device for electric decoration, it is preferable for the emitted light to be visible from various directions. Therefore, a polyhedral reflective plate which reflects light in various directions may be provided inside a resin mold.

[0023] FIG. 3 illustrates a resin-molded light-emitting unit. FIG. 3(a) is an example in which a polyhedral reflective plate is provided inside a resin mold, and FIG. 3(b) is an example in which a polyhedral mount part is used.

[0024] In FIG. 3(a), 31 is a mount part on which each light-emitting diode is arranged in the same plane, 32 is a resin mold, 33 is a polyhedral reflective plate, 34 is an opening part of the reflective plate, and the arrows indicate the directions in which light advances. Each light-emitting diode is connected to a power supply via electrode terminals 21 and 22 in the same manner as in FIG. 2. In FIG. 3(b), 31 is a polyhedral mount part, and each light-emitting diode is disposed on each surface of the mount part. In either case, by using the same connection port shape as that of an electric bulb in the resin molds, the diodes can be used directly by simply exchanging them with the electric bulbs of a conventional electric bulb set.

[0025] In FIGS. 3(a) and (b), a light-emitting diode chip is used for each light-emitting diode, but it is also possible to configure a light-emitting unit by using commercially available resin-sealed light-emitting diodes as light-emitting diodes, providing the light-emitting diodes on a substrate such as a printed wiring board, and combining the diodes with the sockets of a conventional electric bulb set.

[0026] FIG. 4 illustrates a light-emitting display device in which 25 of the light-emitting units illustrated in FIG. 2 are connected in series, wherein the device is driven by AC 100 V, as in the case of a conventional electric bulb set. Symbols D401 to D450 are the light-emitting units. Two chains, comprising a chain in which 25 light-emitting units from D401 to D425 are connected in series and a chain in which 25 light-emitting units from D426 to D450 are connected in series, are connected in parallel, and a 4 V voltage is applied to each light-emitting unit in the same manner as in the aforementioned electric bulb set so as to form one set. Symbol P41 in the drawing is a plug connected to an AC 100 V commercial power supply. When the light-emitting display device is driven by AC 100 V, it is lit orange, but by using one of the polarities of AC 100 V, it is possible to light the device either red or green. This color can be controlled based on which polarity of one AC cycle is used, which eliminates the need for a complex circuit or multiple signal lines.

[0027] FIG. 5 illustrates a circuit for controlling the luminescent color of the light-emitting display device, and FIG. 5(a) is a control circuit for lighting the device either red or green. Symbol D51 is a rectification diode having a reverse voltage resistance of at least 100 V, 51 and 52 are AC voltage input terminals for the control circuit, and 53 and 54 are output terminals of the control circuit. By connecting one diode D51 in series, it is possible to determine the luminescent color of the light-emitting diodes based on the orientation of the diodes.

[0028] As illustrated in FIG. 5(b), the lit color can be changed easily by changing the connection state of the rectification diode D51 with a switch S51. By using such a control circuit, the device can be used not only for electric decoration, but also for various applications such as switching display for "enter" and "do not enter" or switching display for "safe" and "dangerous" in road construction or the like, for example.

[0029] As illustrated in FIG. 5(c), rectification diodes D51 and D52 are connected in two different directions, and the diodes are respectively shorted by switches S51 and S52. By shorting both diodes with the switches, the light-emitting display device is driven by an AC voltage and is therefore lit orange. The device can also be lit red or green by shorting either one of the diodes.

[0030] FIG. 5(d) illustrates a circuit for controlling the luminescent color of the light-emitting display device using a control circuit of an active device. For example, T51 is a thyristor for controlling the positive half-cycle, T52 is a thyristor for controlling the negative half-cycle, C51 is a power supply part, C52 is a gate control part, and C53 is a control signal generation part. By using a timer circuit as a control signal generation part and controlling the conduction and non-conduction of each thyristor in accordance with the time, it is possible to control the lit color based on the time. For example, the device can be lit with any pattern such as orange blinking or a repeating pattern from orange to red, green, and then extinguished lights. Of course, by controlling the conduction angle of the half-cycles of different polarities of the AC voltage with the thyristors T51 and T52, the brightness of each light-emitting diode can be changed, and colors between red and green can also be changed continuously.

[0031] Further, by using a vibration or shaking detection circuit as a control signal generation part, it is possible to form an electric decoration device in which the luminescent color changes as vibration due to wind is detected. The control signal generation part may also be a temperature detection circuit, a humidity detection circuit, or an air pressure detection circuit.

[0032] A thyristor is used as an active device in the example described above, but an electrostatic induction thyristor, a gate turnoff thyristor (GTO), an insulated gate bipolar transistor (IGBT), a triac, or the like may also be used.

[0033] FIG. 6 illustrates an example in which one control circuit described above is coupled with the light-emitting display device illustrated in FIG. 4, wherein C61 is a control circuit. This control circuit is connected between the plug P41 connected to an AC 100 V commercial power supply and the light-emitting display device so that the luminescent color or emission intensity are controlled.

[0034] FIG. 7 illustrates an example in which the control circuit described above is incorporated into an AC 100 V relay connector. In FIG. 7(a), C71 is a control circuit part, P71 is a plug that can be plugged into an AC 100 V outlet, and P72 is a female plug into which an AC 100 V plug can be inserted. A relay connector is formed by P71, C71, and P72. In addition, P73 and U71 are the plug and light-emitting display device illustrated in FIG. 4. With such a configuration, it is possible to insert, remove, or replace a control circuit as necessary. For example, when the control circuit C71 is the circuit illustrated in FIG. 5(a), it is possible to change the luminescent color based on the manner in which P71 or P72 is connected.

[0035] In addition, it is also possible to use a plug socket

P75 into which a plurality of plugs can be inserted so as to connect a plurality of light-emitting display devices U71 and U72 to one control circuit part via plugs 73 and 74, as illustrated in FIG. 7(b), or to connect a relay connector having control circuit parts C71 and C72 with the same or different functions to a plurality of light-emitting display devices U71 and U72, as illustrated in FIG. 7(c).

[0036] Further, even when a control circuit is incorporated into each of a plurality of light-emitting display devices, it is also possible to systematically control all of the control circuits without newly using a signal line. In order to do so, a high-frequency thyristor control signal should be sent so as to be superimposed with AC 100 V, and a band-pass filter which detects specific high-frequency signals should be used as the control signal generation part of the light-emitting display device.

[0037] FIG. 8 illustrates a block connection diagram of the control circuits for the light-emitting display devices described above, wherein 81 is an AC 100 V power supply, 82 is a low-pass filter, 83 is a high-frequency control signal generation circuit, U81 to U86 are light-emitting display devices, and C81 to C86 are control circuits for the light-emitting display devices. The connections between each of the blocks are basically realized by only one pair of wires for transmitting a commercial AC voltage of 100 V.

[0038] In the control signal generation circuit 83, a high-frequency signal having a voltage of 1 to 10 V at a frequency of 1 kHz to 100 kHz, for example, is generated as a control signal and superimposed with a commercial AC voltage of 100 V. This high-frequency signal should be a high-frequency signal having a frequency which can be divided with a band-pass filter or a high-pass filter and an amplitude sufficiently smaller than the amplitude of the AC voltage for driving. The low-pass filter 82 is for preventing the occurrence of problems due to the leaking of the superimposed high-frequency signal to the power supply side 81. Superimposed high-frequency signals are detected by band-pass filters inside the control circuits C81 to C86, and the light-emitting states of the light-emitting display devices U81 to U86 are controlled by control circuits C81 to C86 such as those illustrated in FIG. 5(d).

[0039] One method of control using the control circuits C81 to C86 is to control the lighting, extinguishing, or blinking of each of the light-emitting display devices using six control signals f1 to f6 so that the control circuit C81 detects the control signal f1 and lights the light-emitting display device U81 and the control circuit C82 detects f2 and lights the light-emitting display device U82. In this case, a plurality of control signals may be generated simultaneously.

[0040] Another method of control using the control circuits C81 to C86 is to use two control signals f1 and f2 so that when the control circuits C81 to C86 detect the control signal f1, the positive half-cycle of the AC voltage is activated and the light-emitting display devices U81 to U86 are made to emit red light, and when the control signal f2 is detected, the negative half-cycle of the AC voltage is activated so that the light-emitting display devices are made to emit green light. By generating the control signals f1 and f2 simultaneously, the light-emitting display devices U81 and U86 emit orange light. The two control methods described above may also be combined.

[0041] FIG. 9 illustrates a mode in which a plurality of the light-emitting display devices of the present invention are connected in series. Each of D901 to D925 represents the light-emitting display device illustrated in FIG. 4, and 25 of these devices are connected in series. Symbol P91 is a plug connected to an AC 100 V commercial power supply, and P92 is a female plug into which an AC 100 V plug can be inserted.

[0042] With such a configuration, in comparison to the connection method illustrated in FIG. 4, one extra wire 91 is required, but exactly the required number of light-emitting display devices can be connected in series when executing this method. In this case, the respective light-emitting display devices are electrically connected in parallel.

[0043] It is sufficient for the current applied to the light-emitting diodes to be approximately 10 mA per chain, so even if 100 light-emitting display devices are connected, the total current is approximately 1 A, which eliminates the need for thick wiring. In addition, the trouble associated with wire connection can be reduced when laying out electric decoration.

[0044] To control the lighting state of each of the light-emitting display devices, the control circuit C91 is inserted, as illustrated in FIG. 9(b). By using a control method such as that illustrated in FIG. 8, the lighting state can be controlled in the same manner as when the devices are connected in parallel.

[0045] A combination of red and green was described above as the combination of the colors of the light-emitting diodes, but the luminescent colors are not limited to these colors, and various combinations such as red and blue or green and blue are possible. In addition, only an AC voltage was described as the driving power supply, but the device may also be driven by controlling the height or width of pulses having positive and negative polarities with active devices.

[0046]

[EFFECT OF THE INVENTION] With the present invention, a light-emitting display device which is compatible with a conventional electric bulb set, can be driven easily with AC 100V, can save electric power, has a long life, and does not newly require a signal line for control is obtained, and a control device capable of easily controlling the brightness or color of the emitted light of the light-emitting display device is also obtained.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 illustrates a basic unit of the light-emitting display device of the present invention.

FIG. 2 illustrates a light-emitting unit in which the basic units illustrated in FIG. 1 are connected in three-stage series.

FIG. 3 illustrates a case in which the light-emitting unit illustrated in FIG. 2 is resin-molded.

FIG. 4 illustrates a light-emitting display device in which 25 of the light-emitting units illustrated in FIG. 3 are connected in series, wherein the device is driven by AC 100 V in the same manner as in a conventional electric bulb set.

FIG. 5 illustrates a control circuit for controlling the luminescent light of the light-emitting display device of the present invention.

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