(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 January 2011 (13.01.2011)

PCT

(10) International Publication Number
WO 2011/004021 A1

(51) International Patent Classification:
H05B 37/02 (2006.01) *H05B 33/08* (2006.01)

(21) International Application Number:
PCT/EP2010/059932

(22) International Filing Date:
9 July 2010 (09.07.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0911937.1 9 July 2009 (09.07.2009) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK,

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(54) Title: DRIVER FOR LIGHT-EMITTING DIODES

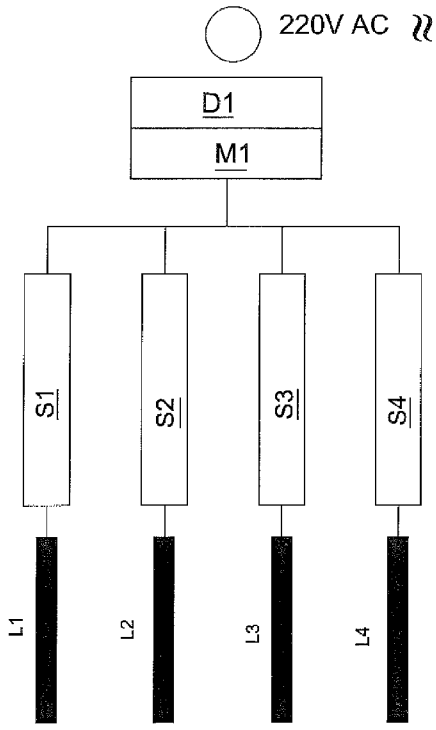


FIG. 3

(57) Abstract: According to the invention, a lighting apparatus is provided having a dimmer module. The dimmer module has an input device with a plurality of positions, each position for regulating the light to a predetermined brightness. The input device may be e.g. a turning knob with a potentiometer. The dimmer module further comprises a rectifier for rectifying an alternating voltage in accordance to a position of the input device. The lighting apparatus has a master module which interprets brightness control information of the dimmer. The master modules outputs a supply voltage as well as a brightness control voltage a direct current voltage in accordance of the position of the input device. A first slave module is provided for receiving the supply direct current voltage as well as the brightness control voltage. The first slave module provides a current through a first plurality of serially connected light-emitting diodes, the strength of current depending on the brightness control voltage direct current voltage. At least one of the light-emitting diodes emits light of a first colour and at least one of the light-emitting diodes emits light of a second colour.

WO 2011/004021 A1

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

Driver for light-emitting diodes

The invention relates to a driver of light-emitting diodes. Artificial light in rooms often leads to an unpleasant impression of the light. Light bulbs and fluorescent tubes emit light that make objects and the skin of humans look pale. It is known that light-emitting diodes may be used to emphasize the colours of objects, e.g. fruits in convenience stores.

The data sheet "Triac Dimmable Offline LED Driver, LM 3445" of National Semiconductor of March 23, 2009 shows a master-slave configuration to drive a plurality of LED's. However, these configurations require many components and the power losses are high.

Accordingly, it is desired to provide a lighting apparatus for LED's with less components and ensuring a lower power consumption.

According to the invention, a lighting apparatus for lighting a room is provided comprising a brightness level control device comprising an input device. The input device is expediently provided for regulating the light of the lighting apparatus to a predetermined brightness level. The input device may be an input device with a plurality of positions. Each position may indicate a predetermined brightness of the light of the lighting apparatus. The brightness level control device is provided for varying the root mean square (RMS) of an input alternating current (AC) voltage. This AC voltage may have e.g. 230V or 110V RMS. The variation is expediently in accordance to the regulation provided by the input device.

The variation may be in accordance to the position of the input device. A rectifier rectifies the output voltage of the brightness level control device.

The brightness level control device may be a brightness level control device module.

A master module is provided for filtering the rectified voltage to a LED supply voltage and for outputting a brightness level control signal to control the brightness of LED's. A first slave module receives the LED supply voltage and the brightness level control signal, the first slave module comprises a plurality of LED's being supplied by the LED supply voltage, whereby the brightness of the light-emitting diodes (LED's) is in accordance to the brightness level control signal.

The second slave module is also driven by the master module. Thus, a modular assembly is provided, in which a plurality of slaves may be driven by one master module. This makes it possible to keep the slaves small because most of the control circuitry is centralized at the master, which may be placed independently of the position of the LED's.

The lighting apparatus enables to provide a master-slave concept that requires only limited components. The master module comprises a filter to filter the rectified voltage. Such filters usually have a plurality of inductors and capacitors to remove inductive and capacitive parts of the signals. Usually, these components are large and generate power losses. By centralising the filtering functions in the master, the number of components is reduced and, at the same time, the power losses are reduced. Thus, the lighting

apparatus requires less space and generates less heat than known systems.

In an embodiment, the plurality of LED's in the first slave module is serially connected respectively the plurality of LED's in the second slave module is serially connected. The serial connection makes it possible to drive the LED's by the same current which reduces the complexity of the slave modules.

In a preferred embodiment, at least one of the light-emitting diodes of the first slave module emits light of a first colour and at least one of the light-emitting diodes of the first slave module emits light of a second colour.

Even though the light-emitting diodes (LED's) emit different colours, the same current flows through the diodes. The characteristics of LED of different colours generally differ. If the current through the LED's changes, the brightness level of the LED of the first colour differs from that of the LED of a second colour. Accordingly, the colour impression of the light emitted by the lightning apparatus changes with its brightness level. The colours of the LED's may be selected such that the colour change is according to the desired colour impression.

In a further embodiment the characteristics of the plurality of light-emitting diodes of the first slave module equals the characteristics of the second light-emitting diodes of the second slave module. Thus, the same brightness level control signal may be used to control the brightness of the LED's of both slave modules.

If the master module is placed at the slave module, cables between master modules and slave modules are short to reduce losses. Generally, the brightness level control device, e.g. a dimmer, is placed at the wall. The master module may be installed where a light source was installed before without the need to change the cables between the dimmer and the master module. The light source may be removed and the master can be installed using the same cables that run from the ceiling to the dimmer.

In a further embodiment, the lighting apparatus comprises a further master module for receiving the rectified voltage and for outputting a further brightness control signal in accordance to the regulation of the input device, preferably in accordance to the position of the input device.

A third slave module is provided for receiving the further brightness control signal and the rectified voltage output by the further master module, the third slave module for providing a current through a third plurality of serially-connected light-emitting diodes, the strength of current depending on the further brightness control signal. At least one of the light-emitting diodes emits light of a third colour and at least one of the light-emitting diodes emits light of a fourth colour.

To provide light with another colour, a second master module may be provided. This second master module drives slave modules for driving the LED's of different colours.

The LED's driven by one of the slave modules may be a string of nine to twenty-one LED's being combined by placing them as

close as possible together. The LED's produce a light that is well mixed and as homogeneous as possible.

The LED module formed by these LED's is preferably arranged in a lighting apparatus, particularly preferably such that the LED's are not visible. The actual lighting of the room is done via reflections from walls and ceilings. The lighting apparatus may be mounted in short distance to an object to be illuminated, because the light source is not visible to the user and does not damage the object due to the low power consumption resulting in less heat creation.

In an embodiment, lenses are provided to change the angle of the emitted light cone. The lighting apparatus may be realized in form of bars or in radial form as retrofit in existing lamps.

The light may be used to produce scenes in housing spaces in analogy to stage lighting. The atmosphere, the time of day and the location is identifiable by the light. The light fits to the scene and supports the general impression of the location. Different scenes are provided by the choice of modules. By combining different modules, atmospheres may be created. The modules may be adapted for lighting e.g. paintings and statues in museums.

Embodiments will now be described with reference to the accompanying drawings.

Figure 1 shows a schematic of a first embodiment of a lighting apparatus.

Figure 2 shows a cross-section of two modules of lightemitting diodes of the lighting apparatus of Figure 1.

Figure 3 shows a schematic of a second embodiment of a lighting apparatus.

Figure 4 shows details of the schematic of the lighting apparatus of Figure 1.

Figure 5 shows further details of the schematic of the lighting apparatus of Figure 1.

Figure 6 illustrates the change of brightness levels during dimming.

Figur 7 illustrates a view on a lighting LED string being switched on.

Figure 1 shows a schematic of a first embodiment of a lighting apparatus. The lighting apparatus 1 comprises a first master module M1 and a second master module M2. The first master module M1 is connected to a first bar 2 or slave module comprising a first set of light-emitting diodes (LED's) L1 and a second set of light-emitting diodes (LED's) L2. The bar 2 further comprises a first slave controller S1 and a second slave controller S2. The first set of LED's L1 comprises nine LED's, which are arranged in a row and are electrically serially connected. The slave controller provides a constant current that flows through all of the nine LED's.

The second slave controller S2 drives the second set of serially connected LED's L2 by providing a constant current to flow through the nine LED's of the set L2.

A second bar 3 or slave module is provided comprising a third slave controller S3, a third set of LED's L3, a fourth slave controller S4 and a fourth set of LED's L4. The third slave controller S3 controls the third set of LED's L3 and the fourth slave controller S4 controls the fourth set of LED's L4. The third slave controller S3 and the fourth slave controller S4 are connected to the first master controller M1.

The lighting apparatus is installed in a room. The first bar 2 and the second bar 3 are mounted vertically or horizontally at least 20 cm away from ceilings or walls. The LED's are expediently arranged to radiate towards the ceiling or wall. Particularly, the lighting apparatus may be configured for providing indirect lighting of a room. A dimmer is provided at a convenient location such that a user may dim the light by actuating the dimmer, e.g. by moving the dimmer.

The master modules M1 and M2 are mounted at the ceiling or wall where the cables from dimmer come out. The masters may be covered by housings, which are similar to these of conventional luminaries.

A cable with four wires connects the first master M1 with the first bar 2 and the second bar 3. Equally a second cable having four wires connects the second master M2 with the third bar and the fourth bar.

The output signals of the master controller M1 to the slave controllers S1, S2, S3 and S4 are a driving voltage for constant current (VBUCK_Slave), a driving voltage for control electronics (VCC_Master), ground (GND_Slave) and brightness level control voltage (DIM_slave).

The master module M1 receives the brightness level control information from a dimmer and forwards the brightness level control information to the slave controller S1, S2, S3 and S4. The brightness level control information defines the amount of current to flow through the respective set of LED's. Each set L1, L2, L3 and L4 comprises LED's of different colours. The colours may be green, red, yellow, orange, blue or white. White LED's may be constructed as blue LED's, being covered by a yellow coating to emit light which appears to be white.

As LED's of different colours have different current-brightness - characteristics, a reduction of the current through the LED's may result in different rates of change for different LED's. E.g. if the current is reduced by 10 %, the brightness of a LED of a first colour may reduce by 12% while the brightness of an LED of a second colour may decrease by 15 %.

Different sets of LED's, e.g. sets of LED's of one slave module or of different slave modules - particularly sets of LED's which are arranged at corresponding positions relative to the master module - may correspond to each other in number of LED's, colour of LED's, current-brightness-characteristics of the LED's and/or relative arrangement of the LED's. Thereby, it may be insured that the two sets have equal characteristics even when the current provided to the two

different sets changes. Inhomogeneties in the light emitted by the lighting apparatus may be avoided in this way when the current flowing through the sets of LED's is varied. Also,

Figure 2 shows a cross section of the first set of LED's L1 and the second set of LED's L2. The first set of LED's L1 comprises a part 14 which is part of the housing for the set of LED's L1. In this part 14, a holder 12 is inserted to hold the LED 10. When being switched on, the LED emits a light producing a light beam in the upper part of Figure 2 in form of a light cone 16.

The third set of LED's is similarly constructed in a part 15 of the housing 15, the third set of LED's having a holder 14 for the LED 11, which form a light cone 17. The light cones 16 and 17 overlap. Thus, the light of the cones 16 and 17 is mixed.

Figure 3 shows a second embodiment of a lighting apparatus 1. The lighting apparatus 1 comprises an AC voltage source 30 providing an AC voltage of effectively 220 V. This voltage is fed to a dimmer D1. This voltage is fed to the master M1 that produces a DC (direct current) voltage and a brightness level control voltage. This brightness level control voltage depends on the dimmer position and is used to control the slave controllers S1, S2, S3 and S4. The slave controllers S1, S2, S3 and S4 each provide a constant current for the set of LED's L1, L2, L3 and L4, respectively. The first slave controller S1 and the first set of LED's L1 are arranged at a first bar for a first slave module, the second slave controller S2 and the second set of LED's L2 are arranged at a second bar for a second slave module. The third bar or third slave module holds the third slave controller S3 and

the third set of LED's L3 and the fourth bar or fourth slave module holds the fourth slave controller S4 and the fourth set of LED's L4.

Figure 4 illustrates details of a dimmer D1 and the master controller M1. It is provided a triac dimmer 40, an AC voltage supply 42, a bridge circuit 43, an external series pass regulator 44, an LED driver IC 45, a valley fill circuit 46, a first filter 47, an output filter 48, and an output vcc driver 49.

The AC voltage supply 42 is the connection to the power supply network installed in the house. The dimmer D1 is a standard dimmer having a knob KN1 or a lever to turn or lift a potentiometer position. The positions of the knob KN1 are illustrated by the dashes around the knob KN1. The knob KN1 or a lever may be turned by a human user to control the brightness level of the light. One terminal of the dimmer D1 is connected to one end of a cable CA1 and one terminal of the dimmer D2 is connected to one end of a cable CA2.

The bridge circuit 43 receives the respective other ends of the cables CA1 and CA2 and transfers the AC voltage to a rectified voltage VBR1. The bridge circuit 43 is also called rectifier 43. Two examples of waveforms output by the bridge circuit 43 are shown. The first one shows the voltage if the dimmer knob is in its maximum position, while the second one shows the voltage VBR1 if the knob is in a position to adjust the brightness to half of the maximum brightness. This type of dimming is called phase control (PFC).

The valley fill circuit 46 provides voltage supply for the LED's, in particular for the LED strings. The valley fill

circuit 46 comprises a diode D3 together with the capacitor C10 to allow the voltage Vbuck_slave to stay high during the time when VBR1 varies. A network of passive elements C7, D4, D8, R8, C9 and D9 add passive power factor control to the circuit to suppress flicker. The valley fill circuit 46 also provides a filter function to keep the voltage Vbuck_slave stable. Alternatively or additionally, the valley fill circuit may prevent a feedback of noise to the AC voltage supply 42.

The external series pass regulator 44 comprises a first resistor R2, a first diode D1, a transistor Q1 and a second resistor R5. The external series pass regulator 44 translates the rectified voltage VBR1 to a voltage that can be sensed by the BRLD pin of the LED driver circuit 45. The LED driver circuit 45 is a LM 3445 LED driver circuit of National Semiconductor. The LED driver circuit 45 has inputs BRLD, FLTR1, COFF, FTRL2, ISNS, the voltage supply inputs VCC and GND and the outputs ASNS, and gate and an input/output DIM.

The LED driver circuit 45 detects the voltage at the pin BRLD, which corresponds to the duty cycle of the dimmer. At the output ASNS, a voltage between 0V and 4V is output corresponding to the duty cycle of the dimmer. The resistor R1 and the capacitor C3 form a filter that helps that the output voltage at the pin ASNS stays stable. The voltage at the input FLTR1 is input to a brightness level control decoder in the LED driver circuit 45. The brightness level control decoder outputs a voltage at the pin DIM. The pin DIM is connected to an output DIM_slave of the master controller M1. The voltage output of the brightness level control decoder is basically a comparison between the voltage at the pin FLTR1 and a 5,86 Hz saw tooth wave having a minimum of 1

V and a maximum of 3 V. This output voltage is not only fed to the pin DIM but is also fed via a Schmitt-trigger to an output driver of the LED driver circuit 45 which drives the output GATE.

The output signals of the master controller M1 are VBUCK_Slave, VCC_Master, GND_Slave and DIM_slave.

Figure 5 illustrates details of the slave controller S1 and of the slave controller S2. The slave controller S1 respectively S2 receive the signals have the inputs VBUCK, VCC, DIM and GND. VBUCK is connected to VBUCK_Slave of M1, VCC to VCC_Master of M1, GND to GND_Slave of M1 and DIM to DIM_slave M1. Thus, the slave controllers S1 and S2 are connected in parallel.

The slave controller S1 comprises an LED driver circuit 51, an input voltage filter 52, an input brightness level control filter 53, a buck regulation stage 54 and an LED string 55.

The inputs VBUCK and the input GND are connected to the outputs VBuck_slave and GND_slave. They receive the power supply for the buck regulation stage 54. The input VCC is connected to the output VCC_slave and to the input of the input voltage filter 52, which comprises a zener diode D2, a resistor R10 and a capacitor C5. These components are connected serially such that the anode of the diode D2 is connected to VCC, the cathode of the diode D2 is connected to a first terminal of the resistor R10 and a second terminal of resistor R10 is connected to a first plate of capacitor C5 of which the second plate is connected to ground.

The first plate of capacitor C5 is also connected to the input FLTR1 and VCC pins of the LED driver circuit 51 which is of the same type as the LED driver circuit 54 of Figure 4. The pins ASNS, BLDR and GLD of the LED driver circuit 51 are connected to ground.

The input dimmer filter 53 comprises a resistor and a capacitor, which are connected serially. The input brightness level control filter 53 is a low path filter of which the output is connected to the input DIM of LED driver circuit 51.

The buck regulation stage 54 comprises a series connection of a diode D10, an adapter L5, a transistor Q2 and a resistor R3 between VBUCK and ground. The gate of transistor Q2 is connected to the gate pin of LED driver 51, whereas the connection node between resistor R3 and transistor Q2 is connected to the input ISNS of the LED driver circuit 51.

The connection node between the drain of transistor Q2 and the inductor L5 is connected to a first terminal of inductor L2, of which the second terminal is connected to a basis of a transistor Q3. The buck regulation stage 54 further comprises a resistor R4, a capacitor C11 and a capacitor C12. The first terminals of the resistor R4 and of the capacitor C12 are connected to VBUCK. The second terminal of resistor R4 is connected to the emitter of transistor Q3. The collector of transistor Q3 is connected to the first plate of capacitor C11 and the input COFF of LED driver 51. The second terminal of capacitor C12 is connected to the basis of transistor Q3.

The voltage over capacitor C12 is called VLED. This voltage is applied to the terminals of the LED string 55. The LED

string 55 comprises 9 LED's L1 to L9. Of course, different numbers of LED's are possible. Nine to twenty-one LED's have proven to be particularly advantageous, if a desired colour impression with desired dimming properties should be provided. The anode of LED L1 is connected to VBUCK, whereas the cathode of LED L9 is connected to the second terminal of capacitor C12. The anode of LED L2 is connected to the cathode of LED L1, the anode of LED L3 is connected to the cathode of LED L2 and so on.

The LED driver circuit 51 is connected as a slave. By applying a high voltage at the inputs FLTR1 and low voltages at the pins BLDR and ASNS, the angle-detect circuit and the brightness level control decoder of the LED driver circuit 51 are switched off.

Instead, the LED driver circuit uses the voltage at the DIM input to control the brightness of the LED's 55. This is done by driving the gate of transistor Q2 via the output pin GATE to maintain a constant current through the LED string 55. Current ramps up through the inductor L2 and the LED string when the transistor Q2 switches on. At the resistor R3 this current is sensed and compared to a reference voltage at FLTR2. If this sensed voltage is equal to the reference voltage, transistor Q2 is turned off and diode D10 conducts a current through the inductor L2, L5 and the LED's 55. Capacitor C12 eliminates most of the ramp current ripple in the inductor. Resistor R4, capacitor C10 and transistor Q3 provide a linear current ramp that senses a constant off-time of a given output voltage.

The LED's L1 to L9 are serially connected which means that the same current flows through each of the LED's L1 to L9.

The LED's L1 to L9 do not have the same characteristics because they emit light of different colours. For example, LED L1 emits an orange light, whereas the LED L2 emits green light. Despite of this, it is possible to arrange these LED's in one single string. The characteristics of the LED's are to be configured such that the desired colour lighting is realized. Accordingly, a reduction of the current results in different brightness levels of the diode L1 and resp. diode L2. If the brightness level position of the dimmer is changed, one of the LED's L1 to L10 may change the brightness by 40 % while another LED may change the brightness only by 30 %. The combination of LED's having different colours leads to different brightnesses for the different colours. These characteristics are used to change the impression of the colour together with the brightness. For example a light that should reproduce a sunset should appear yellow at high brightness and bright red at low brightness. This characteristic is provided by the combination of the LED's.

An existing lighting apparatus having a bulb may be replaced by the described lighting apparatus by the following steps. The bulb is connected with one terminal to one terminal of the AC voltage source 42 and with the other terminal with one terminal of the Triac dimmer D1 via the cables CA1 and CA2. These cables run from the dimmer close to the door to the ceiling where the lamb bulb is placed. After disconnecting the bulb from the cables CA1 to CA2 at the ceiling, the rectifier 43 is connected to the cables CA1 and CA2.

Thus to replace an existing lamp bulb by a inventive lighting apparatus, there is no need to install new cables from the door to the ceiling. Further, the losses over the cables CA1 and CA2 are low because a relatively high voltage and a low

current is used to transfer the power from the dimmer to the rectifier.

A prototype according to the embodiments of Figures 4 and 5 was built and worked.

As the slave controllers S1 and S2 are connected in parallel, the valley fill circuit 46 is shared by both slaves. Thus, the number of components is reduced. Accordingly, a single valley fill circuit may be provided for a plurality of slaves.

Fig. 6 illustrates characteristics of 3 LED's having different colours. The brightness L is drawn in dependence of the current through the LED's. The left LED is orange, the LED in the middle is yellow and the right LED is red. The brightness of the emitted light of all LED's increases with increasing current. However, the degree of increase differs. At a first predetermined current I1, the brightness of the orange LED is higher than the brightness of the red LED, which is brighter than the yellow LED. Accordingly, a current I1 flowing through a string of these LED's gives an impression of a mainly red colour.

However, at a second current I2 that is higher than I1, the lightness of the orange LED is higher than the lightness of the yellow LED. The lightness of the yellow LED is larger than the lightness of the red LED. Accordingly, the light emitted by a string of these three LED's gives a main impression of yellow.

Figure 7 shows an embodiment of an LED string 75, illustrating a view on the lighting LED string being switched

on. Eleven light-emitting diodes (LED's) 10 to 20 are arranged in a row. Each of the LED's 10 to 20 is fixed in a holder 2 and emits a light cone, which is indicated by a circle 3 around the holder 2. In the holder 2 of each LED, a character indicates the colour of the emitted light. The first LED 10, the sixth LED 15 and the last LED 20 emit orange light. The second LED 11 and the tenth LED 19 emit yellow light, whereas the third LED 12, the fifth LED 14, the seventh LED 16 and the ninth LED 18 emit red light each. The fourth LED 13 emits white light. The fourth LED 13 is a blue LED having a yellow covering such that the emitted light appears to be white.

The lighting apparatus emits a light that gives an impression of a sunrise. A light of a natural sunrise is mainly characterized by a wavelength that is close to orange. Thus, the orange LED's are placed at the outer positions of LED row. Thus, an observer cannot differentiate between the colours of the inner LED's. He may not see the red light of LED 12, but a light being a mixture of the red colour with colours of the other LED's 11, 13, 14 and so on. The orange LED's 10 and 19 are placed at the outer positions because an observer would recognize that the colour of the outer LED is not close to the predominant colour.

The light of the LED row 1 is preferably reflected by walls and ceiling of the room. The reflections ensure that the light of the LED's 10 to 19 is mixed several times, in particular before the light impinges on an object which is to be illuminated.

Claims

1. Lighting apparatus (1) for lighting a room, comprising:
- an interface (CA1, CA2) for receiving an alternating current (AC) voltage from a brightness level control device (Dl), the brightness level control device (Dl) comprising an input device (KN1) for regulating the light of the lighting apparatus (l) to a predetermined brightness, the brightness level control device (Dl) being provided for varying the root mean square (RMS) of an input alternating current (AC) voltage in accordance to the regulation provided by the input device (KN1);
- a rectifier (42) for rectifying an output voltage received at the interface (CA1, CA2);
- a master module (44,45,46,47,48) for filtering the rectified voltage (VBR1) to a LED supply voltage (VBUCK) and for outputting a brightness control signal (DIM) to control the brightness of LED's (55);
- a first slave module (S1) for receiving the LED supply voltage (Vbuck) and the brightness control signal (DIM), the first slave module (S1) comprising a plurality of LED's (55) being supplied by the LED supply voltage (Vbuck), the brightness of the LED's being in accordance to the brightness control signal (DIM),
- a second slave module (S2) for receiving the LED supply voltage (Vbuck) and the brightness control signal (DIM), the second slave module comprising a plurality of LED's being supplied by the LED supply voltage (Vbuck), the brightness of the LED's being in accordance to the brightness control signal (DIM).

2. Lighting apparatus according to claim 1,

whereby the plurality of LED's (55) in the first slave module (S1) are serially connected and the plurality of LED's in the second slave module (S2) are serially connected.

3. Lighting apparatus according to claim 2, whereby at least one of the LED's (55) of the first slave module (S1) emits light of a first colour and at least one of the LED's of the first slave module (S1) emits (55) light of a second colour.

4. Lighting apparatus according to any of claims 1 to 3, whereby the characteristics of the plurality of LED's (55) of the first slave module (S1) equals the characteristics of the plurality of LED's (55) of the second slave module (S2).

5. Lighting apparatus according to one of the claims 1 to 4, whereby the master module (M1) is placed at the slave modules (S1, S2).

6. Lighting apparatus according to one of claims 4 to 5,
- a further master module (M2) for filtering the rectified voltage to a further LED supply voltage and for outputting a further brightness control signal in accordance to the regulation of the input device of the brightness level control device,
- a third slave module for receiving the further LED supply voltage and further the brightness control voltage output by the further master module, the third slave module being configured to provide a current through a third plurality of serially connected LED's, the strength of current depending on the brightness control signal,

whereby at least one of the LED's emits light of a third colour and at least one of the LED's emits light of a fourth colour.

7. Lighting apparatus according to one of claims 1 to 6, further
comprising:
the brightness level control device (D1) comprising the input device (KN1) for regulating the light of the lighting apparatus to a predetermined brightness, the brightness level control device module being provided for varying the root mean square (RMS) of the input alternating current (AC) voltage in accordance to the regulation of the input device;
whereby an output of the brightness level control device (D1) is connected to the interface.

8. Lighting apparatus according to one of claims 1 to 7, wherein the input device is an input device (KN1) with a plurality of positions, wherein each position is provided for regulating the light of the lighting apparatus (1) to a predetermined brightness, wherein the brightness level control device (D1) varies the root mean square (RMS) of the input alternating current voltage in accordance to the position of the input device.

9. Lighting apparatus substantially as described herein with reference to, and as illustrated in, the accompanying drawings.

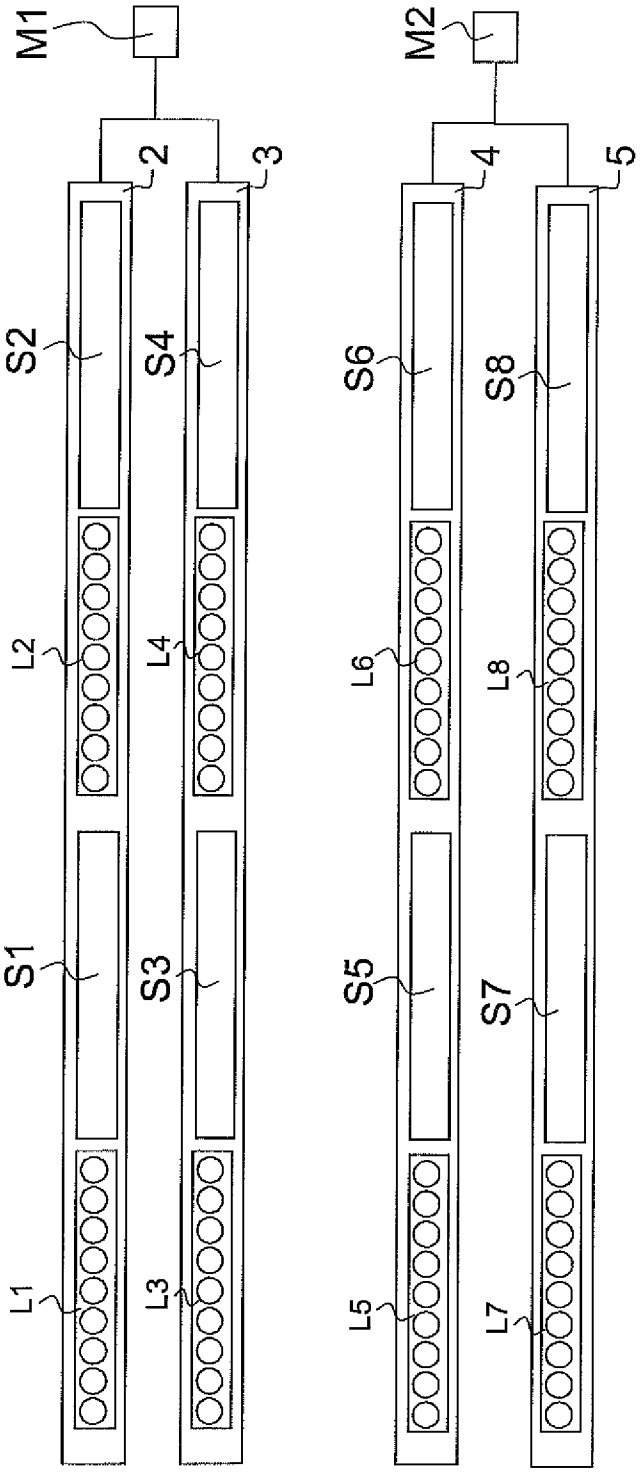


FIG. 1

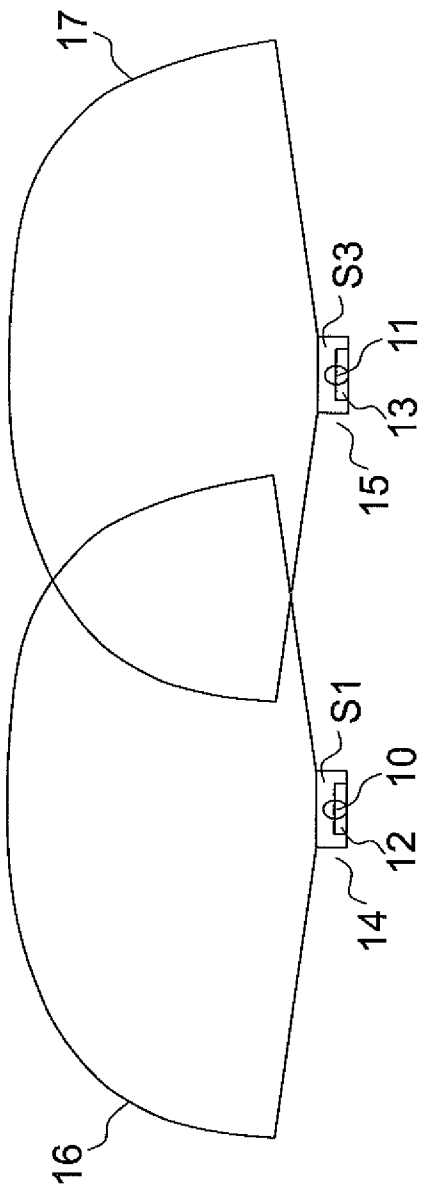


FIG. 2

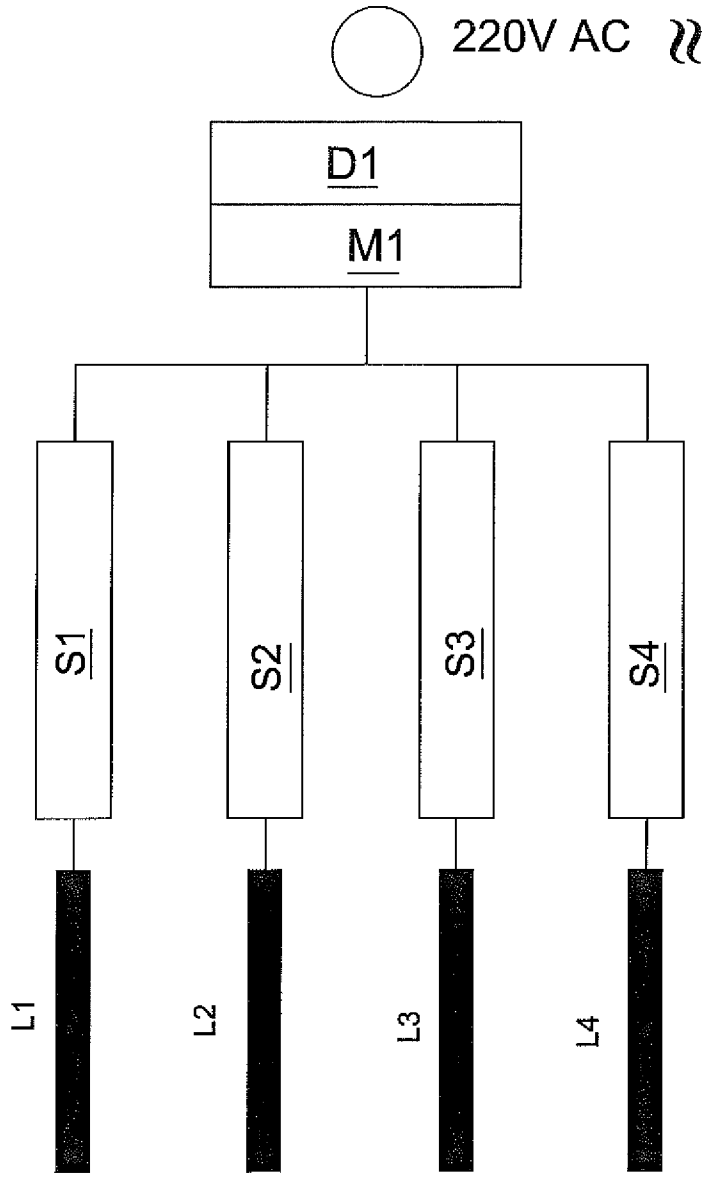
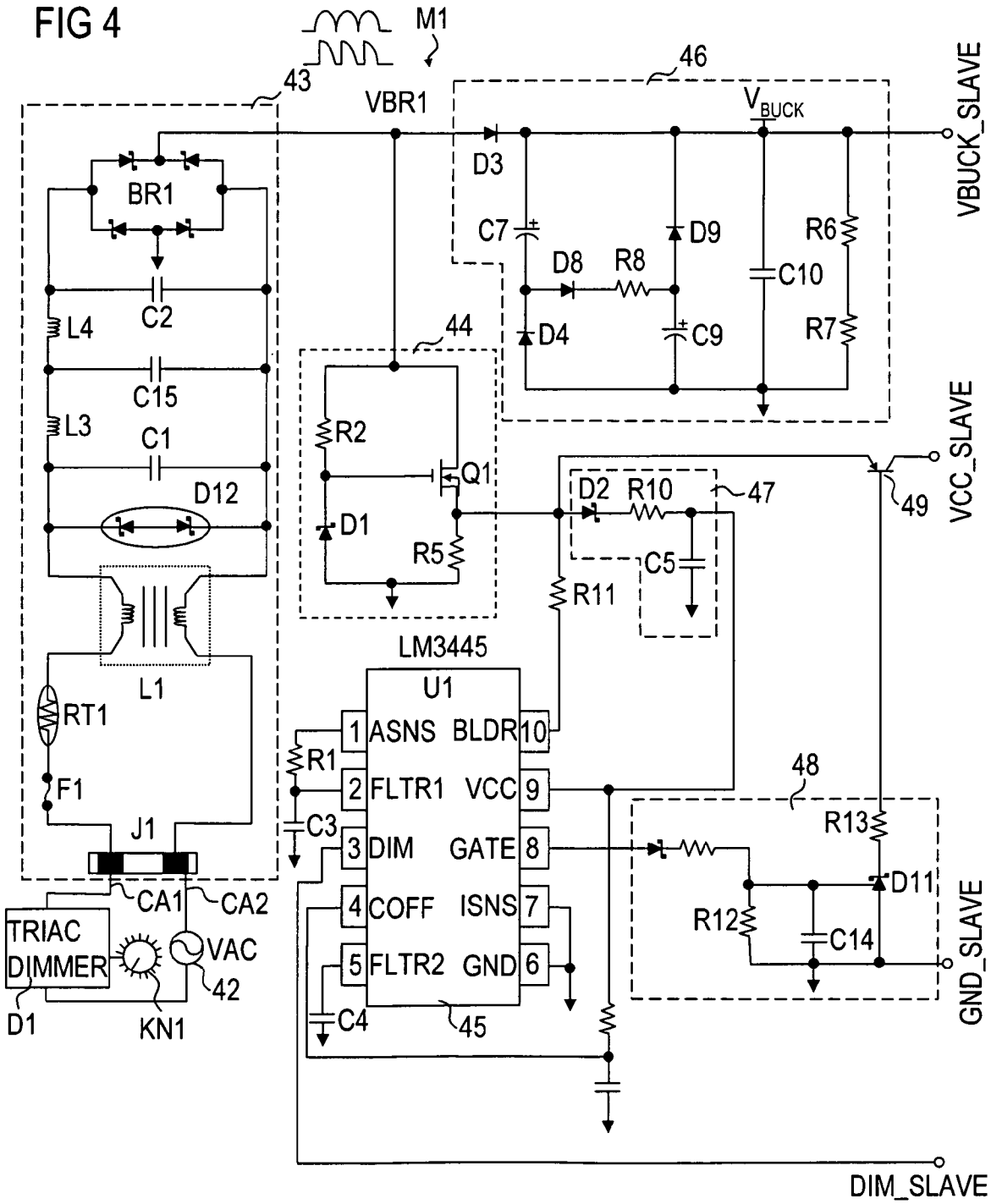


FIG. 3

FIG 4


M1
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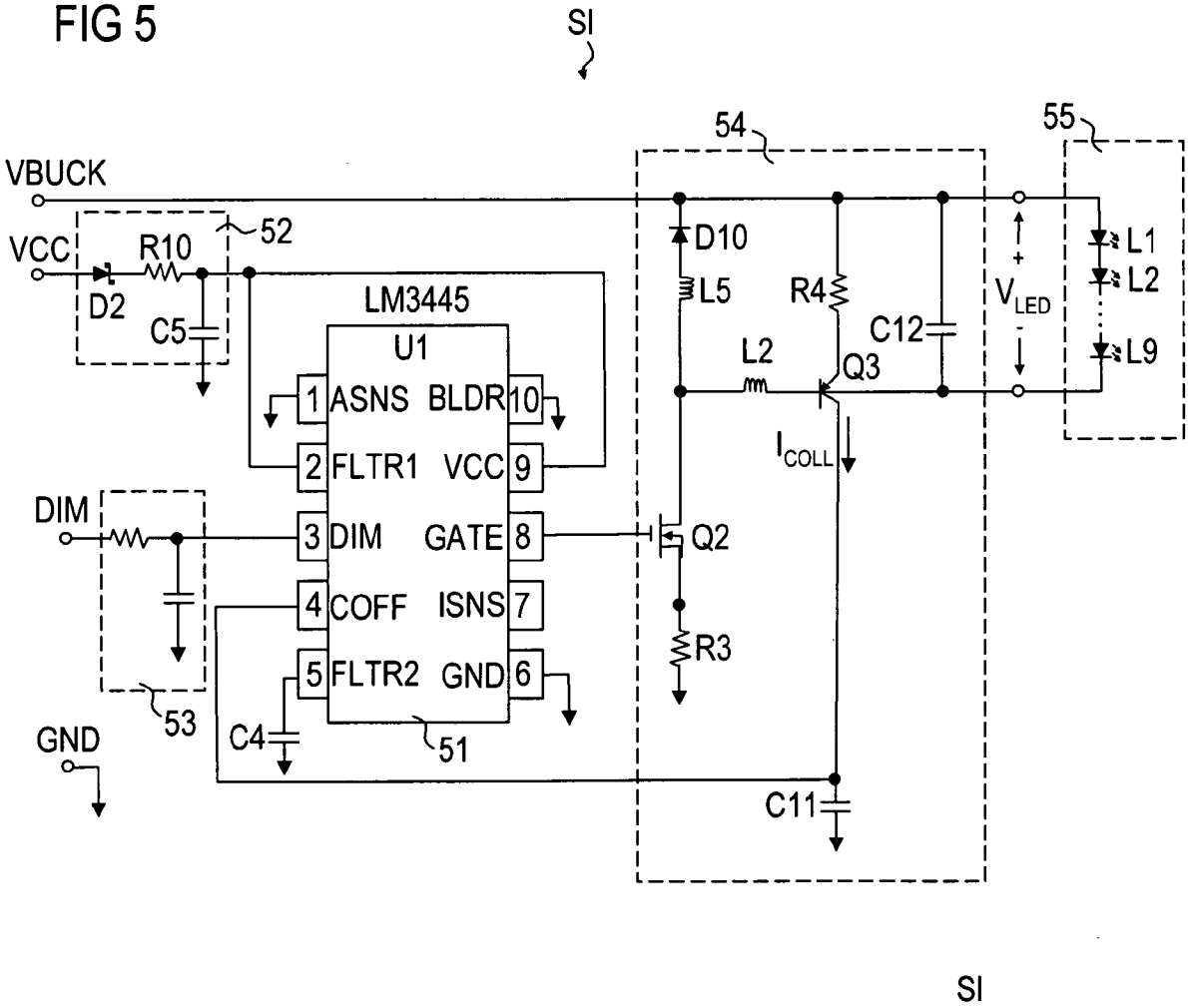
46
VBR1
V_{BUCK}
VBUCK_SLAVE
D3
BR1
C7
D9
R6
D8
R8
C10
C2
L4
D4
C9
R7
44
C15
L3
C1
R2
Q1
D12
D2
R10
47
49
VCC_SLAVE
D1
R5
C5
R11
LM3445
U1
L1
RT1
1 ASNS BLDR 10
R1
F1
2 FLTR1 VCC 9
48
J1
C3
3 DIM GATE 8
R13
CA1
CA2
4 COFF ISNS 7
D11
TRIAC DIMMER
VAC
R12
C14
5 FLTR2 GND 6
42
D1
KN1
C4
45
GND_SLAVE
DIM_SLAVE

FIG 5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55
VBUCK
VCC
R10
52
D2
C5
LM3445
U1
1 ASNS BLDR 10
2 FLTR1 VCC 9
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4 COFF ISNS 7
5 FLTR2 GND 6
DIM
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GND
C4
51
D10
L5
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Q3
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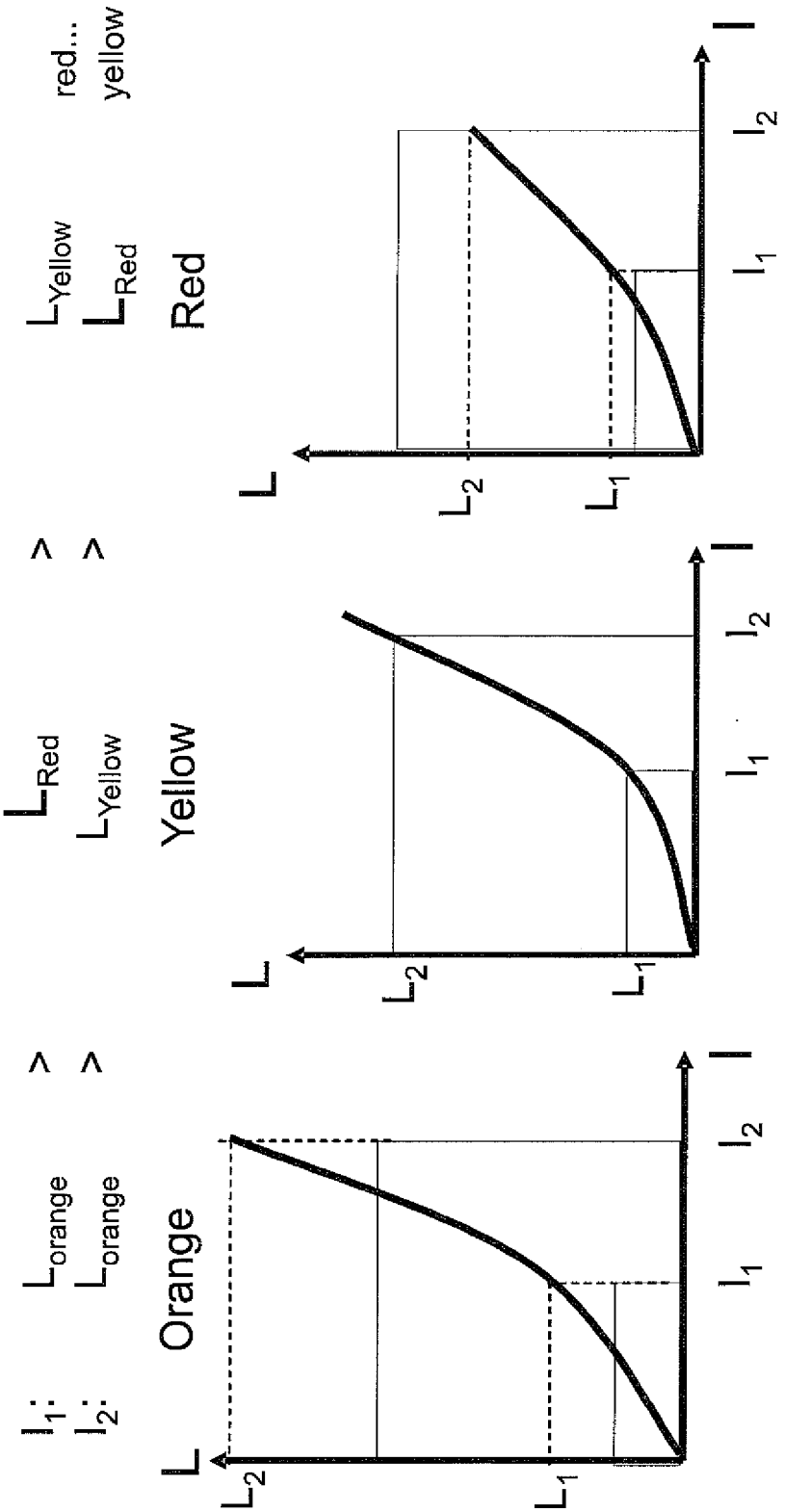
Q2
R3
C11
V_{LED}
L1
L2
L9
SI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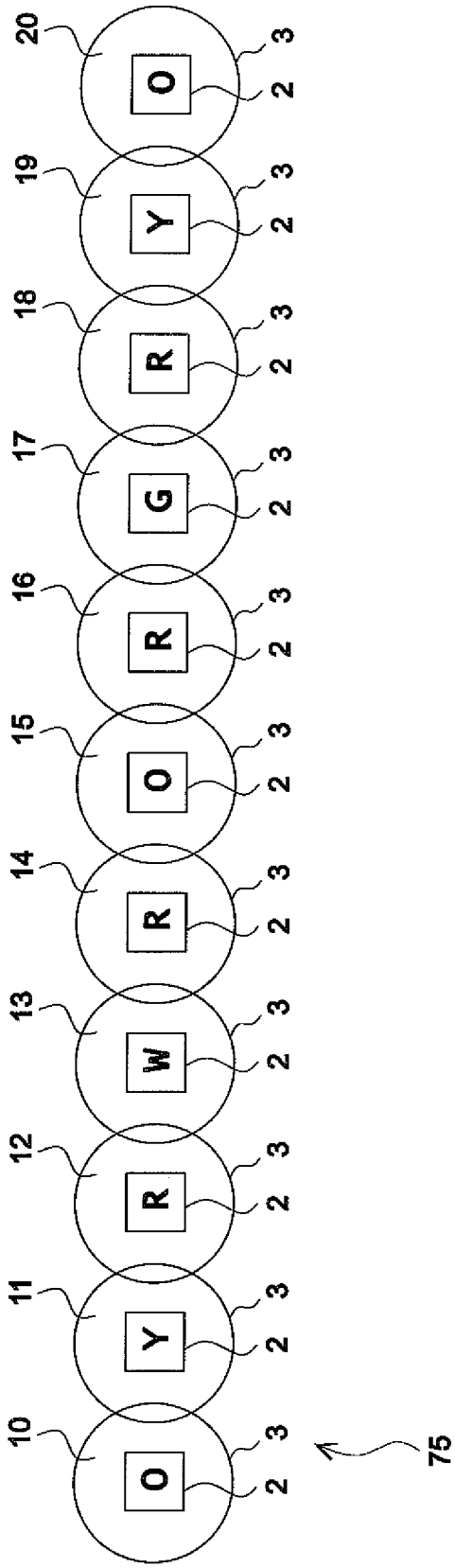
I2:
Lorange
Lorange
Orange
L
L2
L1
I
I2
I1
>
LRed
LYellow
Yellow
LYellow
LRed
Red
red...
yellow

FIG. 6


20
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19
Y
3
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18
R
3
2
17
G
3
2
16
R
3
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15
O
3
2
14
R
3
2
13
W
3
2
12
R
3
2
11
Y
3
2
10
O
3
2
75

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/059932

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B37/02 H05B33/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B G05B H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/174473 A1 (MORGAN FREDERICK M [US] ET AL) 11 August 2005 (2005-08-11) page 1, paragraph 12 - page 2, paragraph 25; figures 1, 2, 3, 15, 16a, 16b, 17, 24a, 25e, 28-30 page 5, paragraph 165 - page 9, paragraph 210 page 15, paragraph 272 page 16, paragraph 292-293 page 18, paragraph 310 page 20, paragraph 330 page 21, paragraph 334-335	1-9
A	US 4 418 333 A (SCHWARZBACH RICHARD J [US] ET AL) 29 November 1983 (1983-11-29) * abstract; figure 1	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 2010	04/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Fax: (+31–70) 340–3016	Brosa, Anna-Maria

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/059932

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005174473 A1	11-08-2005	NONE	
US 4418333 A	29-11-1983	EP 0069470 A1	12-01-1983