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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 July 2014 (24.07.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/111962 A1

(51) International Patent Classification:
H05B 33/08 (2006.01) *H02J 9/00* (2006.01)

(21) International Application Number:
PCT/IT2013/000324

(22) International Filing Date:
18 November 2013 (18.11.2013)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
VI2013A000012 18 January 2013 (18.01.2013) IT

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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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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

(54) Title: LED LIGHT BULB WITH SUPPLEMENTED EMERGENCY LIGHTING FEATURES

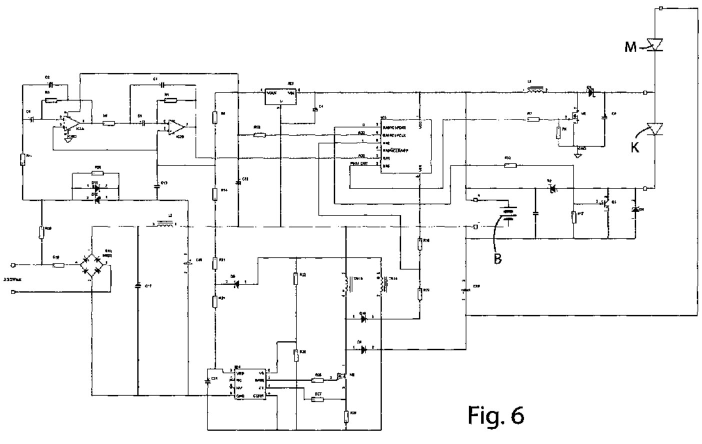

Fig. 6

(57) **Abstract**: A LED light bulb (LM) with supplemented emergency lighting features, comprising a light source (SL) placed inside a transparent diffusing bulb (BP) and constituted by a series of lighting LED diodes (K, M), a main high-frequency electronic switching power supply (AP), able to drive said series of LED diodes (K, M) with a continuous current, an emergency electronic power supply (AE), able to drive a subset of said LED diodes (K, M) when power supply is interrupted at the input of said main power supply (AP), a battery (B) and an electronic control circuit (G) for checking emergency lighting and battery (B) charging; the electronic control circuit (G) is able to detect, on a power line upstream of said light bulb (LM) and on which said light bulb (LM) is wired, at least one condition according to which the emergency lighting is activated, and is also able to distinguish said condition according to which the emergency lighting is activated from a switching off condition of said light bulb (LM) by means of a switch (SW) opening.

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LED LIGHT BULB WITH SUPPLEMENTED EMERGENCY LIGHTING FEATURES

The present invention generally relates to a LED light bulb with integrated emergency lighting features.

More particularly, the invention relates to a LED electronic light bulb with emergency functions, which includes a battery and an electronic circuit which is able to detect an emergency lighting condition (lack of AC power supply system) and which is able to recognize said condition from a simple opening of the light bulb switch caused by the lamp's switching off controlled by the user.

The light bulbs are constituted by lighting devices which include a light energy converter, a electric/electronic circuit for the power supply of the light source, a electrical/mechanical coupling system and a transparent protective casing.

Furthermore, the light bulbs have different formats according to the technical standards of the different light sources.

The light bulbs have a E27 or E14 screw connector and are designed to contain the tungsten filament, while the light tubes have a diameter of 26mm or 15mm and include low-pressure and gas-discharge indirect-emission fluorescent light sources.

The arrival of the solid state light sources (LED) has evolved the light bulbs and tubes, so as to replace the internal components of said bulbs and tubes, while preserving the external appearance; LED light bulbs were therefore born, with a high energy efficiency, in which the LEDs are driven by an integrated electronic ballast which is able to convert the 230V. AC main power supply in a suitable form for supplying the LED light sources.

LED light bulbs also allow for having new functions, such as the emergency lighting function, since, thanks to the efficiency and the small sizes of LEDs, space inside the bulbs is available to house batteries.

However, in order to maintain compatibility of the connection systems, it is not possible to automatically perform the emergency lighting function, because the connection systems have only two wires.

In particular, there is no possibility of adding a power supply wire, so that said wire is provided irrespective of the state of switch and without changing the known lamp holders and lighting plants.

An object of the present invention is therefore to obviate said drawbacks of the prior art and, in particular, to provide a LED lighting bulb with integrated emergency lighting function, which is able to automatically detect a condition of emergency lighting activation on the lighting plant where the LED lighting bulb is installed, irrespective of the state of switch.

Another object of the present invention is to provide a LED lighting bulb with integrated emergency lighting function, which can be used without changing the existing lamp holder and/or lighting plant.

A further object of the invention is to provide a LED lighting bulb with integrated emergency lighting function, which is able to control the emergency condition with very low energy consumption.

These and other objects are achieved by a LED lighting bulb with integrated emergency lighting function, according to the appended claim 1. Other detailed technical features, according to the invention, are contained in dependent claims.

Advantageously, the LED lighting bulb with integrated emergency lighting function, which is the object of the present invention, is automatically turned on so that:

- when 230V AC power is supplied to the lamp holder of the lighting bulb, said lighting bulb will light up fully and at the same time the integrated batteries are recharged;
- if the switch of one of the two power supply lines is turned off, the lighting bulb is off, the battery charging stops and a stand-by condition is obtained;
- if no voltage is obtained on the lamp holder electric circuit, upstream the switch, the lighting bulb is turned on in an emergency condition with low light and by using the batteries as energy source.

Further objects and advantages of the present invention will become clear from the following description, which refers to a preferred embodiment of the LED lighting bulb with integrated emergency lighting function, according to the present invention, and from the enclosed drawings, in which:

- figures 1, 2, 3 and 4 show a plurality of circuit diagrams of known lighting bulbs;

- figure 5 shows a block diagram of the LED lighting bulb with integrated emergency lighting function, according to the present invention;

- figure 6 shows a preferred embodiment of an electrical circuit used in the LED lighting bulb with integrated emergency lighting function, according to the present invention;

- figures 7 and 8 show two perspective views of the LED lighting bulb with integrated emergency lighting function, according to the present invention;
- figure 9 shows a top plan view of a heat sink provided on the LED lighting bulb, according to the invention;
- figure 10 shows a below plan view of the heat sink provided on the LED lighting bulb, as shown in figure 9, according to the invention;
- figure 11 shows an exploded view of the LED lighting bulb with integrated emergency lighting function, according to the present invention.

With reference to the enclosed figures 1-4, which show electrical circuits for supplying known lighting bulbs, figure 1 shows a power supply line for turning on the light bulb LM by interrupting the phase L by means of the power switch SW, figure 2 shows a power supply line for turning on the light bulb LM by interrupting the phase L by means of the power switch SW, with the parasitic capacitances CPC towards the other lines C of the electric plant which are subjected to the phase potential L, figure 3 shows a power supply line for turning on the light bulb LM by interrupting the neutral N by means of the power switch SW, while figure 4 shows a power supply line for turning on the light bulb LM by interrupting the neutral N by means of the power switch SW, with the parasitic capacitances CPN towards ground T.

With reference to the enclosed figures 5-11, the LED lighting bulb according to the present invention comprises:

- a light source SL, which is enclosed within a diffusing transparent body BP and which is constituted by lighting LED diodes, divided into two groups, so that K series-connected LED diodes belong to a first group and M series-connected LED diodes belong to a second group (with K equal to or different from M); the LED diodes are mounted on an aluminum plate CL which is fixed to a heat sink D; the LED diodes, not shown in the enclosed figures, are individually mounted on the aluminum plate CL (for example, by using the IMS technology) and, according to preferred embodiments, said LED diodes are 48 and each of them has a brightness of about 27 lumens and an electric power of about 210mW, thus obtaining about 1300 lumens and 10W;
- a main high-frequency switching electronic ballast AP, which is formed by the electrical components R19, BR1, C17, L3, C18, R21, R24, R22, R25, R26, R27, R28, C21, IC4, M2, D6, TR1, D9 and C19 and which controls the group of K+M LEDs with a steady current, by providing a total

electrical power of about 10W and a DC current of about 75mA;

- an emergency electronic ballast AE, which is able to control a subset of said K LED (for example consisting of K=6), when no power supply is detected at the input terminals of the main electronic ballast AP; the emergency electronic ballast AE is constituted by the electrical components R7, R9, M1, D1, L1 and C9 and is controlled by the microcontroller IC3;
- an electronic control circuit G for controlling the emergency conditions and the battery charging, which is constituted by the microcontroller IC3, the voltage regulator IC1, the switch and/or the charger Q1, R13, R17, D2, D3 and the amplifier IC2, R30, R31, D11, D12, R11, R3, C5, C2, R8, R4, C8, C3, C10, R6, R14 and C12;
- a battery B, which is constituted for example by a pair of NiCd or NiMH cells, able to deliver a nominal voltage of 2.4V with a total capacity of about 500mAh.

Practically, the emergency lighting bulb according to the invention, with respect to a known LED electronic lighting bulb, contains within a single structure a battery B and an electronic control circuit G, which is able to detect a condition of emergency lighting activation directly on the plant in which the lighting bulb is installed (such as the lack of AC power system on the plant); the lighting bulb according to the invention is also able to distinguish said condition from a simple opening of the switch connected to the lighting bulb (this action is simply caused by the user's action on the switch for turning off the lamp).

With reference to the enclosed figures from 1 to 4, when the switch SW of the circuit is closed, there is a 230V AC voltage at the ends of the two supply terminals of the light bulb LM; light bulb LM is thus normally on and the integrated battery B is recharged, while, when the switch SW of the circuit is opened, the light bulb LM turns off as a normal light bulb, but the internal electronic emergency lighting control circuit G is always able to control the power supply line to detect a 230V supply voltage upstream the switch SW.

All the embodiments shown in figures from 1 to 4 can occur, namely:

- switch SW is able to disconnect the phase line L in a circuit in which the two wires L, N are well isolated from other electric lines (typical embodiments are constituted by plugged table lamps or floor lamps, with the switch breaking the wire L); when the switch SW is open, a residual

AC supply voltage is measured to the supply terminals of the light bulb LM, which is coupled with the parasitic capacitance (few pF) of said switch SW. Said residual AC supply voltage is very low and is about a few tenths of Volts (fig. 1);

- switch SW is able to disconnect the phase line L in a circuit in which the two wires L, N are close to other electrical lines of a building (typical embodiments are constituted by ceiling or wall lamps which are directly wired in a civil electric plant, wherein the L terminal is disconnected from the switch SW, but the sectioned wire portion is settled in ducts and electrical conduits which are close to other wires connected to the electrical line L, at a voltage of 230 V AC); when the switch SW is open, the voltage which is measured at the terminals of the light bulb LM is the sum of the AC voltage coupled through the parasitic capacitance (few pF) of said switch SW and the voltage induced through the coupling parasitic capacitances CPC with respect to the electrical cables that are close to the disconnected portion. Said AC voltage, which is measured at the terminals of said light bulb LM when the switch SW is open, is between a few volts and a few tens of volts, on the basis of the parasitic couplings (fig. 2);

- the switch SW is able to disconnect the neutral wire N; therefore, the wire L, which has a voltage higher than 230V AC, is always connected to one of the two inputs of the light bulb LM and the parasitic capacitances towards ground CPN easily allow to couple a voltage of several volts at the terminals of the light bulb LM when the switch SW is open (figure 3-4).

In the above embodiments, the emergency lighting control circuit G, which is integrated into the light bulb LM and supplied by the battery B, thus consuming only a small fraction of the stored energy, is able to measure the residual AC voltage at the input terminals of the light bulb LM in order to switch off the supply circuits of the emergency lighting LEDs K and M.

Until a 230V AC voltage is measured upstream the switch SW, the light bulb LM is able to detect said voltage and keep the light off (as any known light bulb), while, as soon as there is no voltage upstream the switch SW, also the residual voltage at the input terminals of the light bulb LM is equal to zero and the emergency lighting control circuit G automatically turns on the emergency power supply AE, which in turn turns on the LEDs K with reduced luminous flux by using the energy stored in the battery B.

The operation goes on until the electronic control circuit G again detects the 230V AC supply voltage upstream the switch SW, when the emergency lighting function is inhibited by turning off the emergency power supply AE.

The electronic control circuit G which controls the supply condition upstream the switch SW uses a very small portion of the energy stored in the battery B, thus ensuring operation continuity of the light bulb LM in a stand-by mode (when the switch SW is open) for several months, for example by consuming half the available energy during a 3-months period.

The good operation of a light bulb LM which is turned on at least once every few days is thus ensured, since the internal battery B is recharged only when the light bulb LM is on.

When the emergency power supply AE is activated, the autonomous operation of the light bulb LM lasts for some hours; in this case, the initial brightness of the light bulb LM is high for allow the user to not perceive the brightness reduction with respect to the usual operation, while, subsequently, the brightness is gradually and automatically reduced, so as to maximize the battery life.

The electronic control circuit G is able to turn off the emergency light when the battery voltage falls below a minimum value, in order not to damage the battery (interrupt function).

Furthermore, the light bulb LM is designed by using inexpensive circuit solutions, whose portions have however a strong functional synergy.

With particular reference to the enclosed figure 6, the LED light bulb with integrated emergency lighting functions, which is the object of the present invention, operates as follows.

When a 230V AC voltage is supplied to the LED light bulb LM, said light bulb LM operates as a normal LED light bulb.

The main power supply AP converts the AC voltage to a 230V DC voltage of about 75mA at 140V, in order to turn on the LEDs K + M, which are all series-connected.

The driver IC4 gives a control signal at the GATE of the MOSFET M2, which, at a frequency of a few tens of KHz, periodically charge the inductor TR1A to transfer the energy to the capacitor C19, via the diode D9, and therefore to the plurality of LEDs K + M.

The driver IC4 adjusts the driving duty-cycle of the MOSFET M2, so as to keep constant at a predetermined value the peak current flowing through R28, which is measured through R27, thus indirectly regulating the current flowing through the LEDs K, M to a given prefixed value.

The auxiliary winding TR1B of the inductor generates, through D6 and R24, the power supply for the driver IC4, which, when turned on, is directly supplied from the rectified AC voltage, through R21.

The divider formed by R22 and R25 cuts down the maximum output voltage of the main power AP at a maximum value of about 200V when the plurality of LEDs K + M are disconnected.

Therefore, the main power supply AP advantageously gives power to the LEDs K + M and simultaneously provides a charging current to the battery B through the diode D2, which closes the circuit formed by the LEDs K + M on the common node of the electrical circuit (negative pole of the battery) through said battery B.

The battery B is thus directly across from the current which is supplied to the LEDs K + M, thus greatly reducing the total costs of the light bulb LM.

In particular, the battery charging function is obtained without added costs with respect to a known light bulb (for example, a current of 75mA flowing across the LEDs K + M allows to charge a battery B of 500mAh in less than 10 hours).

The power used for charging the battery B is about 200mW, corresponding to less than 2% of the power used for turning on the LEDs K + M in a normal operation mode of the light bulb LM and therefore the circuit of the present invention also allows to further obtain a high overall efficiency, thus having a negligible effect on the power consumption of the light bulb LM.

With regard to the charging circuit, the transistor Q1 is directly driven from the microcontroller IC3, which controls the operation of the light bulb LM.

The transistor Q1 is driven off when the battery B is charging.

When said charging is complete, the microcontroller IC3 turns on the transistor Q1, which in turn shunts the charging current of the battery B; therefore, the charge inhibition device, which is very simple and cheap (since it is obtained by using a single bipolar transistor Q1), also maintains a maximum efficiency, because the voltage drop, when Q1 is turned on, is reduced to the saturation voltage of the transistor Q1 itself (which is less than a hundred mV), thus obtaining an efficiency provision of the light bulb LM which is equal to the provision of a known light bulb without emergency functions, once the battery charging is carried out.

When the emergency lamp operates, the charging phase of the battery B is limited to the time strictly required by means of microcontroller IC3, which counts the emergency lighting time periods and send to the battery B the only amount of energy which has been expended during the time periods in which the light bulb LM is not supplied (when the switch SW is open); moreover, the microcontroller IC3 shall take due account of consumption in stand-by or during the emergency time periods, by appropriately weighting the consumption of battery B and, when the light bulb LM is again turned on through the switch SW, the battery B is charged only for the time necessary to restore the energy expended during the previous period.

The Zener diode D3, which shunts the battery B regardless of its state, advantageously allows the normal operation of the light bulb LM, even if the battery B is no longer able to ensure the emergency function; it is therefore provided a low cost component (such as the Zener diode D3), which automatically shunts the battery B in case of severe damage of said battery B, thus ensuring a smooth operation of the light bulb LM during the normal lighting time period, even if the battery B does not work at all.

The power supply AE used for the emergency function is based on a boost type DC/DC converter formed by M1, L1, D1 and C9.

Said converter is controlled by the microcontroller IC3 via the RA5 PWM output.

The microcontroller IC3 controls said output with a PWM signal, for example at a frequency of about 20÷30KHz, with a suitable duty-cycle, by raising the battery's voltage so as to obtain a driving current to drive the LEDs K of the LEDs K, M string (for example, according to preferred embodiments of the invention, K = 6 LEDs and LEDs K, M string = 48 LEDs).

It is thus possible to advantageously use as light sources only one portion of said LEDs K, M which are used during the ordinary operation; said LEDs belonging to said portion are driven at low current and inserted in the same circuit used for ordinary operations.

For example, the LEDs K could provide a total of 100lumen with a battery's energy consumption so as to allow an adequate autonomy of operation during the emergency lighting phase.

Thus, the light bulb LM would work during the emergency lighting phase with a luminous flux of approximately 10% of the nominal flow, thus maintaining a good luminous performance.

Therefore, according to the invention, a subset of the LEDs K, M which are provided in the light bulb LM are used for carrying out the emergency lighting function, without adding other lighting devices, and the LEDs driving circuit, when said LEDs are used for said emergency lighting function, is perfectly integrated into the lighting circuit and requires no additional switching devices to switch from a normal lighting phase to the emergency lighting phase.

The electrical circuit of the light bulb LM also allows the simultaneous and continuous operation of the main power supply AP and of the emergency power supply AE, without any risk of damage to electrical components or LEDs K, M, thereby simplifying the changeover transistors control and increasing the overall reliability of the circuit.

As already said, the microcontroller IC3 completely controls the operation of the boost converter for turning on the light bulb LM in emergency lighting conditions and simultaneously is able to continuously measure the battery's voltage.

In fact, as soon as the battery voltage reaches a minimum allowable value, the microcontroller IC3 reduces the duty cycle of the MOSFET M1 of a prefixed discrete quantity, thus reducing the brightness of a little, but, at the same time, causing an immediate increase of the battery voltage, since the absorbed current is lowered.

The light bulb LM is thus able to operate in emergency lighting conditions with a new lowered brightness level for a new time period of several tens of minutes and, when the battery's voltage again reaches the prefixed minimum value, the microcontroller IC3 again reduces the duty-cycle.

Said reduction process, which is carried out according to discrete steps, is repeated for N times until the residual light is very low.

Therefore, the light bulb LM is turned on in an emergency lighting state, albeit at very low brightness, for many hours, while using a battery B with a capacity which is not very high.

A further great advantage of the present invention is to turn on the light bulb LM in emergency lighting conditions, with reduced brightness, even when the battery B is very aged and the internal resistance is abnormally high.

The above technique is realized by exploiting the fact that the human eye responds according to a logarithmic way to the perceived luminous flux; for example, a luminous flux which is 500 times lower than an initial flow is perceived by the human eye only 6 times lower.

Furthermore, by also using the convergent series principle, it is possible to build the light source SL so that, when a limit condition for the battery B is reached, the current absorption and therefore approximately also the luminous flux are halved.

After 10 iterations, the perceived brightness is only 6 times lower, while the operation time can be up to 5 times longer.

The emergency lighting control electronic circuit G is controlled by the microcontroller IC3 which controls all the emergency light bulb LM functions.

In particular, the microcontroller IC3 controls the switching of the main power supply AP, which corresponds to the state of the switch SW, by means of the divider R23, R18 and the diode D10 (in particular, the microcontroller IC3, by using a HW internal interrupt device HW, which is connected to RA2, detects the voltage at the input of the main power supply AP at few tens of kHz, so as to detect the turning on of the light bulb LM in normal conditions), as well as the microcontroller IC3 controls the supply voltage AC when the switch SW is open, by means of the amplifier IC2.

The microcontroller IC3 has a very low power consumption and is directly supplied in parallel to the battery B and includes a battery voltage meter and a brown-out circuit, which inhibits the operation of the meter when the battery voltage falls below a predefined threshold value, thus preserving the battery B and reducing the current consumption to few μA.

The microcontroller IC3 also includes an analog/digital converter, which is connected to an internal multiplexer at the inputs RA1 and RA4.

The input RA1 allows to measure the supply voltage of the amplifier IC2, while the input RA4 measures the output voltage of said amplifier IC2.

The amplifier consists of the electrical components IC2, R30, R31, D11, D12, R11, R3, C5, C2, R8, R4, C8, C3, C10, R6, R14 and C12 and is a selective amplifier (a band-pass amplifier) at high-gain and tuned to the frequency of the AC power supply network (50-60Hz); it also constitutes the sensor of an emergency lighting condition.

The above mentioned amplifier processes the AC voltage at the power supply terminals of the light bulb LM, so as to obtain an AC signal to a mains frequency which is useful for having the microcontroller IC3 operations.

The microcontroller IC3 uses a digital filter algorithm running at the mains frequency so as to reject any noise at the terminals of the light bulb LM. Furthermore, the voltage regulator IC1 stabilizes the supply voltage of the amplifier IC2 in order to make the operation independent of the battery voltage.

Then, when the switch SW is open, the emergency lighting control circuit G is powered by the battery B.

The power consumption is very low (a few hundred of µA), as the microcontroller IC3 has “turning on” time periods which are spaced with “sleep” time periods, with time intervals of some tens of ms.

During operation, the microcontroller IC3 measures the output voltage of the amplifier at the input RA4, applies the digital filter and compare the measured value with a prefixed or pre-calculated threshold value to decide whether or not to activate the emergency power supply AE, by driving the MOSFET M1.

If the value of the AC signal, at the mains frequency, at the input (terminal) RA4 is lower than the prefixed threshold value, the microcontroller IC3 activates the MOSFET M1 at a suitable frequency and duty-cycle, by turning on the emergency light; if, on the contrary, the AC signal is higher than the prefixed threshold value, the emergency function is inhibited and the light bulb LM is off.

The threshold value for activating the emergency lighting condition can occur in two ways:

1) the threshold value is pre-set and it cannot be changed during operation (in this case, the threshold value is pre-set to a value which is higher, with a suitable range, than the background noise of the amplification circuits);
2) the threshold value is automatically determined by the light bulb LM in a self-adaptive way during its operation (in this case, the light bulb LM has a predetermined threshold value, but automatically adapts to the operating conditions of the electric plant where it is installed); this operation mode may be useful to handle cases of electric plants in which the levels of the measured AC power supply signal have a very wide dynamic range (for example, according to the enclosed fig. 1, the input AC mains voltage is very low, unlike the enclosed figures 2 and 4, where the AC voltage can be much higher).

If the light bulb LM operates with a self-adaptive threshold value, the light bulb LM has, as already mentioned, a predetermined first threshold value VL.

Then, as soon as the switch SW closes the circuit for the first time, the microcontroller IC3 measures the AC signal (voltage) at the input or terminal RA4 and, on the basis of the value of said measurement, the following actions are carried out:

- if the AC voltage is less than VL, an emergency lighting condition is detected and therefore the microcontroller IC3 turns on the light bulb LM in emergency lighting conditions, without changing the predetermined threshold value;
- if the AC voltage is between VL and a maximum value VH, the microcontroller IC3 sets a new threshold value which is equal to 2/3 of the measured value;
- if the AC voltage, according to a plurality of subsequent measurements, is always less than the threshold value which has been previously defined, the new threshold value is set as equal to the highest value among the 2/3 of the measured value and the probable minimum value.

Thus, the electrical immunity of the light bulb LM is improved, also ensuring that, even if a residual spurious AC voltage is provided (even with no power supply voltage of the electric plant) due to any interference of adjacent installations, the light bulb LM is able to correctly drive the emergency lighting function.

The light bulb LM according to the invention is also equipped with an emergency lighting condition inhibiting function (“rest-mode” function).

According to said function, the microcontroller IC3 scans, at the input RA2, the sequence of subsequent turning on of the light bulb LM (i.e. the sequence of subsequent opening and closing of the switch SW).

If the user turns on and off the light bulb LM consecutively and for a predetermined number of times (for example 4 times) within a total of ten seconds, the microcontroller IC3 understands said sequence as an emergency lighting inhibiting function and, starting from the last of the four switching off, the light bulb LM is in an inhibiting condition.

In this condition the light bulb LM can be uninstalled (and removed from the lamp holder) without the light bulb LM is switched on in emergency lighting condition, thus preserving the battery B; moreover, the microcontroller IC3 is in a condition of very low power consumption, thus preserving to the maximum the charging status of the battery B.

At the first subsequent closing of the switch SW (i.e. at the first switching on of the light bulb LM, which is again supplied by the 230V AC voltage), the inhibiting function is immediately removed and the light bulb LM restores its normal operation with the activation of the emergency lighting function.

The inhibiting function is convenient for the user for carrying the light bulbs LM, as well as for saving the battery B after production of the light bulb LM and before the sale and delivery of said light bulb LM to customers.

The enclosed figures from 7 to 11 show a possible embodiment of the light bulb LM with emergency functions according to the present invention.

The battery B placing and the shape of the aluminum heat sink D are provided so as to minimize the temperature of the battery B during operation, in order to ensure maximum life and to limit the battery's aging.

In particular, the shape of the aluminum heat sink D (shown in detail in the enclosed figures 9 and 10) is drawn so as to increase the dissipation of heat produced by the LEDs K, M which are mounted on the front plate CL and which are fixed on said plate by means of the fastening ring AF; specifically, the lateral cavities F are built for this purpose.

Furthermore, the battery's accumulators are backward and separated from the electronic circuit G by a disc made of insulating material or by a heat insulator EN (polyurethane foam or air-gel) and are thus housed in the most "cold" portion of the light bulb LM, below of which a plastic container CP, which is connected to the screw connector CV for inserting the light bulb LM in the lamp holder, is provided.

The electronic circuit G, which is usually separated into two parts, is inserted into a large cavity of the heat sink D and is electrically insulated by a plastic jacket IP.

The whole electronic circuit G is also incorporated into a silicone resin to make uniform the temperature of all the electrical components and to improve the overall electrical insulation and the reliability of the product.

From the above description, the characteristics of the LED light bulb with integrated emergency lighting functions, which is the object of the present invention, are clear as well as the related advantages are also clear.

Finally, it is also clear that many other technical variations may be made to the LED light bulb of the present invention, without departing from the scope of the appended claims, as well as it is clear that, according to the practical implementation of the invention, the materials, shapes and dimensions of the technical details which are shown in the enclosed drawings may be any according to requirements and that they can be replaced with other details which are technically equivalent.

CLAIMS

1. A LED light bulb (LM) with supplemented emergency lighting features, comprising a light source (SL) placed inside a transparent diffusing bulb (BP) and constituted by a series of lighting LED diodes (K, M), a main high-frequency electronic switching power supply (AP), able to drive said series of LED diodes (K, M) with a continuous current, an emergency electronic power supply (AE), able to drive a subset of said LED diodes (K, M) when power supply is interrupted at the input of said main power supply (AP), a battery (B) and an electronic control circuit (G) for checking emergency lighting and battery (B) charging, characterized in that said electronic control circuit (G) is able to detect, on a power line upstream of said light bulb (LM) and on which said light bulb (LM) is wired, at least one condition according to which the emergency lighting is activated and to distinguish said condition according to which the emergency lighting is activated from a switching off condition of said light bulb (LM) by means of a switch (SW) opening.

2. A light bulb (LM) according to claim 1, characterized in that, when said switch (SW) is closed, the light bulb (LM) is on and said battery (B) is being recharged, while, when said switch (SW) is open, the light bulb (LM) is turned off and said electronic control circuit (G) is able to check said power line, so that, when a supply voltage upstream of said light switch (SW) is detected, said control circuit (G) keeps off said emergency electronic power supply (AE).

3. A light bulb (LM) according to at least one of the previous claims, characterized in that, when said electronic control circuit (G) detects the lack of a power supply voltage upstream of said light switch (SW) and the lack of a residual potential at the input of said light bulb (LM), said electronic control circuit (G) automatically turns on said emergency electronic power supply (AE), which in turn switches on at least one first group (K) of LED diodes of said series of LED diodes (K, M), with a reduced luminous flux with respect to a luminous flux obtained with a supply voltage upstream of said light switch (SW), by using electric energy stored in the battery (B).

4. A light bulb (LM) according to at least one of the previous claims, characterized in that said LED diodes (K, M) are divided into two groups and, within each group, said LED diodes (K, M) are connected in series with each other and mounted insulated onto an aluminum plate (CL) that is

fixed to a heat sink (D) and that is placed inside said transparent diffusing bulb (BP).

5. A light bulb (LM) according to at least one of the previous claims, characterized in that said main electronic power supply (AP) provides electric power to said series of LED diodes (K, M) and, simultaneously, provides the charging electric current to said battery (B), said charging electric current being the supply current of said series of LED diodes (K, M).

6. A light bulb (LM) according to at least one of the previous claims, characterized in that, in conditions of emergency lighting, said light source (SL) is provided so that, at each achievement of a prefixed minimum value of the battery voltage (B), both the absorption current of said battery (B) and the luminous flux emitted from said light source (SL) are substantially halved, said prefixed minimum values of the battery voltage (B) being discrete and being provided in a predetermined number.

7. A light bulb (LM) according to at least one of the previous claims, characterized in that said emergency lighting condition is activated by means of a high gain selective amplifier, which is tuned to the frequency of the mains power supply and which controls the voltage at the power supply terminals of said light bulb (LM), by emitting a signal at the mains frequency, which is measured by a microcontroller (IC3) of said electronic control circuit (G) to turn on or turn off said emergency power supply (AE), depending on the fact that said signal is, respectively, less than or greater than a threshold value, said electronic control circuit (G) being supplied from said battery (B) when said light switch (SW) upstream of said light bulb (SW) is open.

8. A light bulb (LM) according to at least one of the previous claims, characterized in that said threshold value is pre-set and it cannot be changed during operation of said light bulb (LM).

9. A light bulb (LM) according to at least one of the previous claims, characterized in that said threshold value is automatically determined by the light bulb (LM) in a self-adaptive way during its operation, said light bulb (LM) having a predetermined threshold value (VL) which is automatically adapted to the operating conditions of the electric plant when the light bulb (LM) is installed.

10. A light bulb (LM) according to at least one of the previous claims, characterized in that said activation of the emergency lighting condition is

inhibited, for safely uninstalling said bulb (LM) from a lamp holder, when the light bulb (LM) is consecutively turned on and turned off, by means of said light switch (SW), for a predetermined number of times within a prefixed time, said inhibiting function being stopped at a first subsequent closing of said switch (SW) and consequently at a first subsequent turning on of said light bulb (LM).

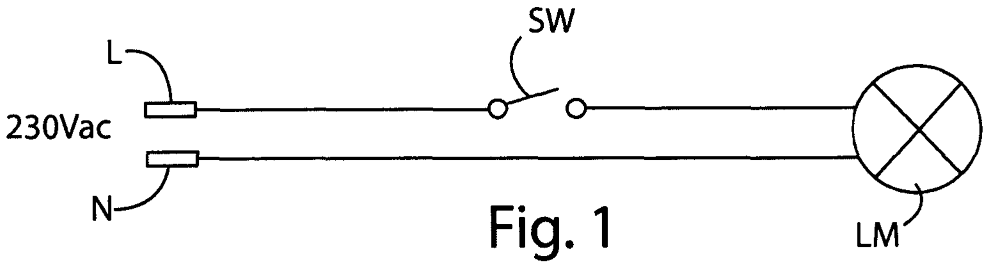

Fig. 1

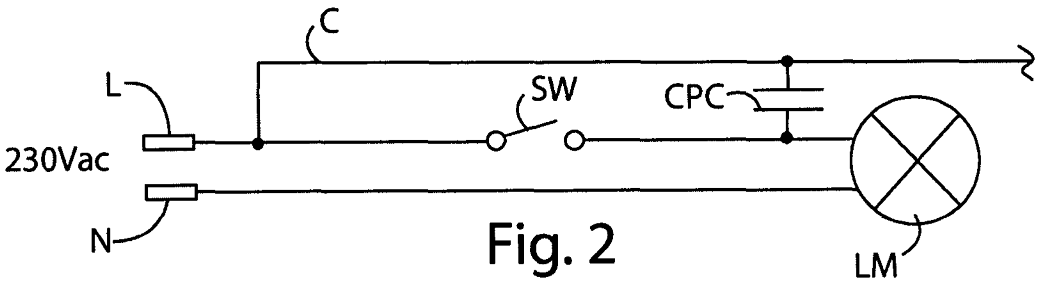

Fig. 2

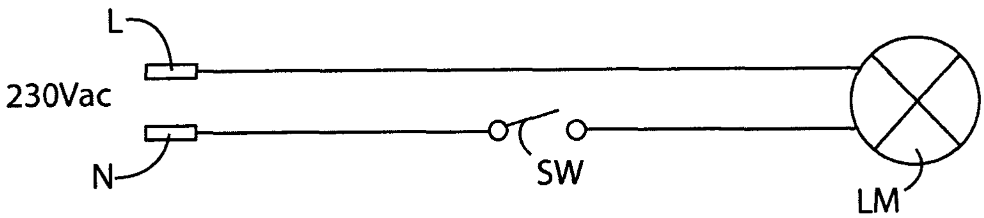

Fig. 3

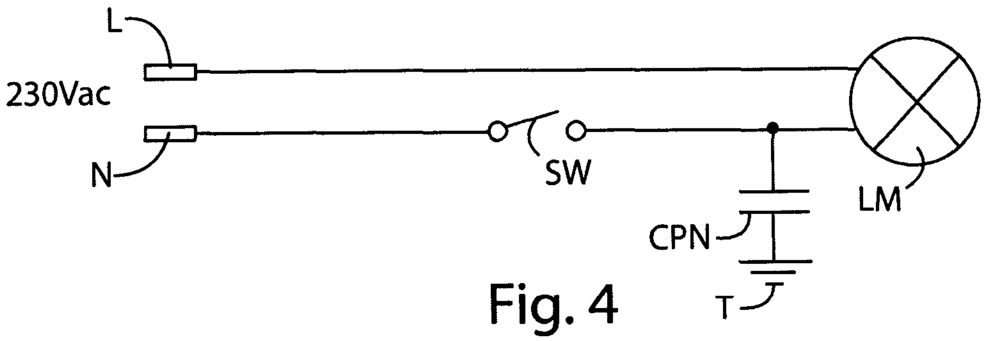

Fig. 4

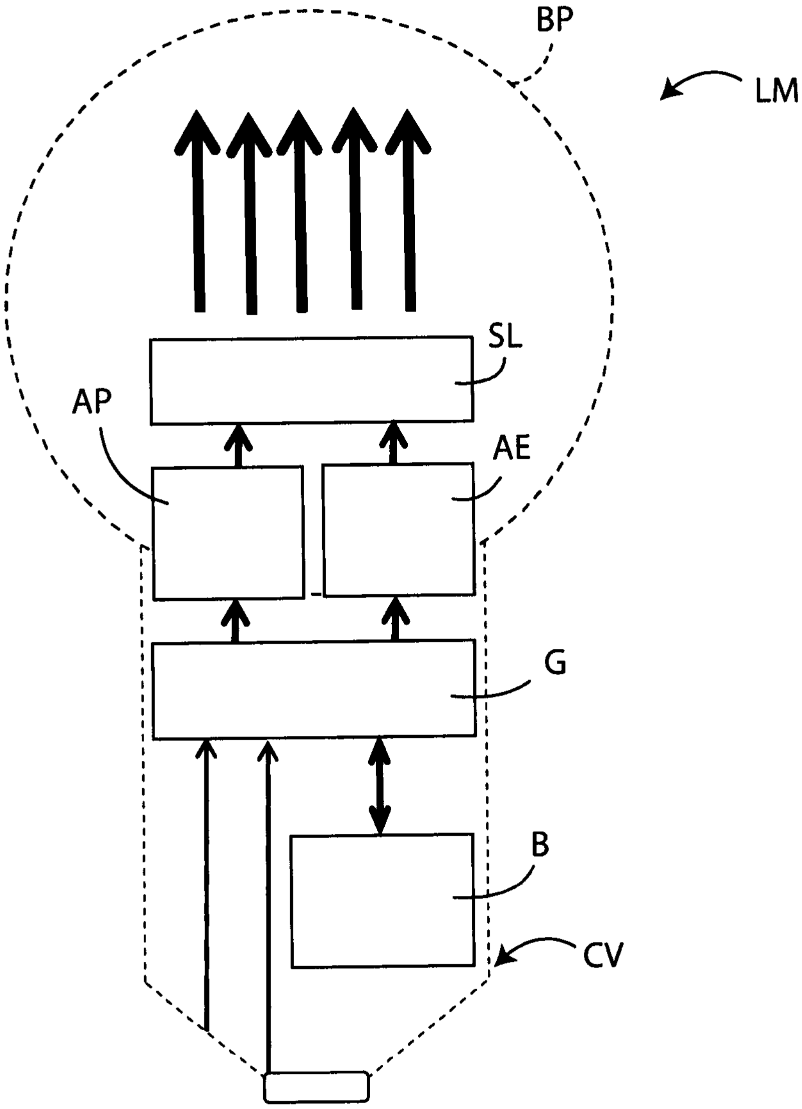

Fig. 5

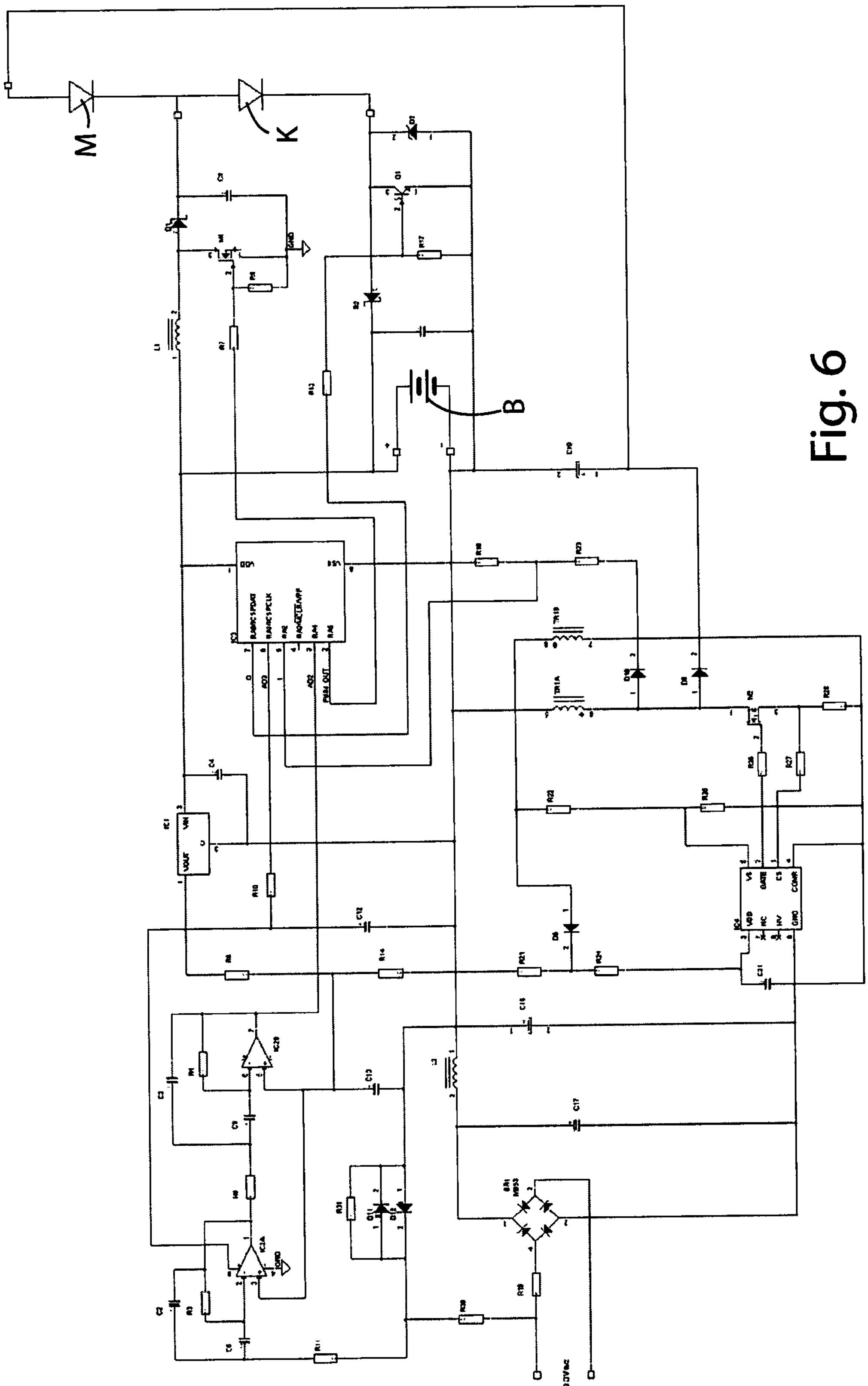

Fig. 6

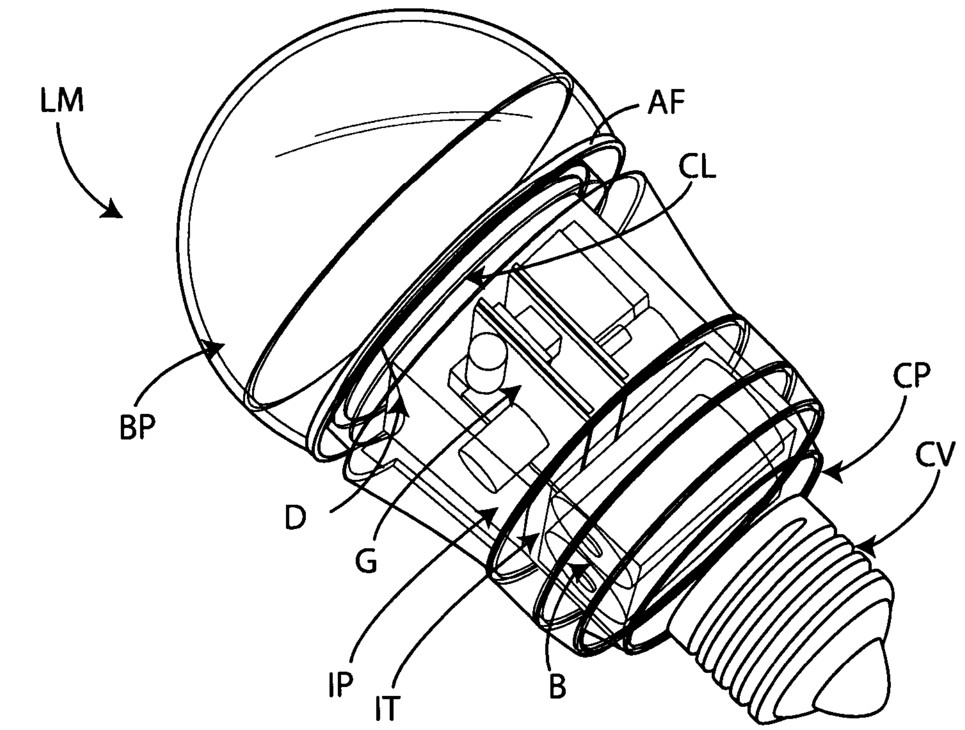

Fig. 7

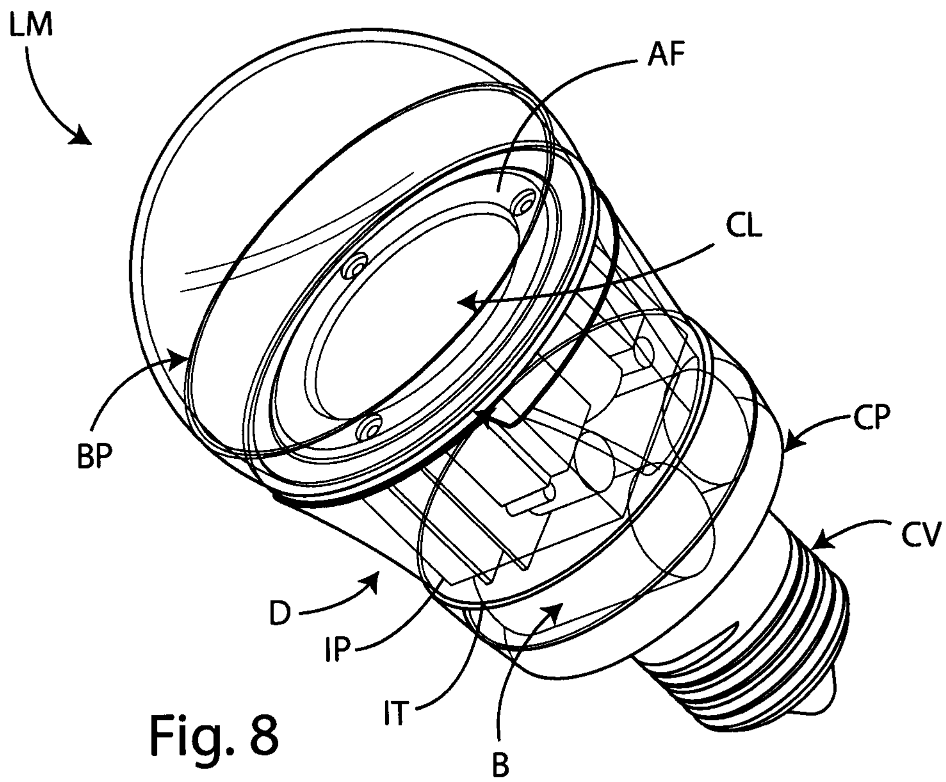

Fig. 8

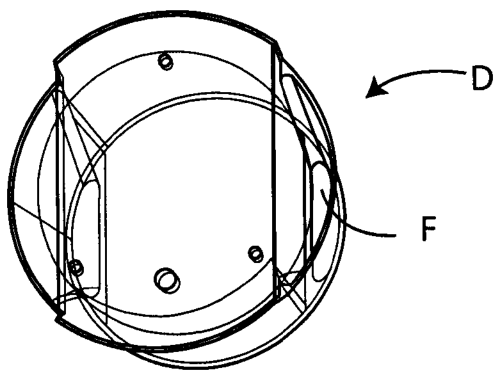

Fig. 9

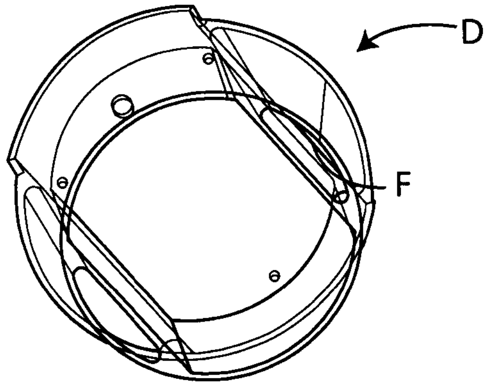

Fig. 10

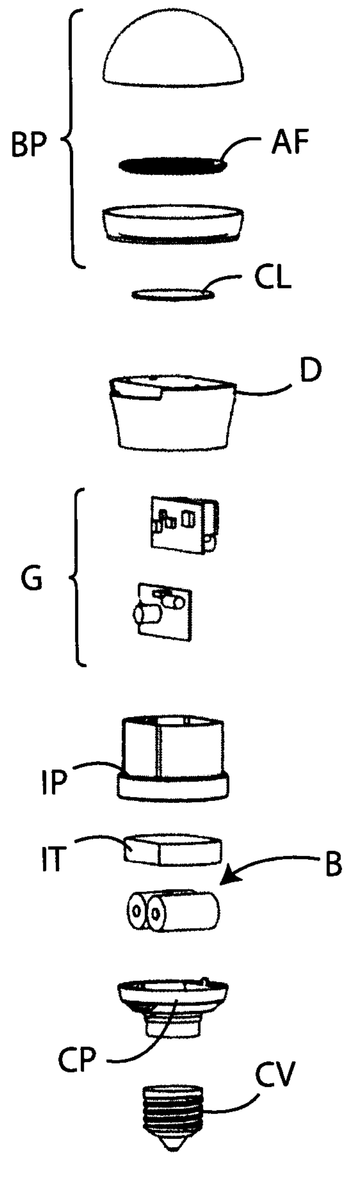

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2013/000324

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08 H02J9/00
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 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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/133649 A1 (KREINER BARRETT [US] ET AL) 9 June 2011 (2011-06-09) paragraph [0036] - paragraph [0037]	1-10
X	GB 2 447 495 A (WILLIAMS NICOLAS PAUL [GB]) 17 September 2008 (2008-09-17) page 5; figure 4 second to fourth paragraph; page 3	1-10
X	US 2011/109164 A1 (MOHAMMED SUHURA SHANAVAS [IN] ET AL) 12 May 2011 (2011-05-12) paragraph [0050] paragraph [0062]	1-10
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2014	27/02/2014

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2013/000324

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/141819 A1 (COJOCARY MOSE [IL]) 31 July 2003 (2003-07-31) paragraph [0021] - paragraph [0026]; figure 2 paragraph [0030] - paragraph [0034] -----	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IT2013/000324

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US 2003141819 A1	31-07-2003	NONE	