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H05B 33/08 (2006.01)

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WO 2002/096162 A1	**JP 2006236709 A**
US 7449839 B1	**US 20080247205 A1**
US 20080224623 A1	**US 20080157686 A1**
US 20060208667 A1	**US 20020158590 A1**

(58) Field of Search:
INT CL **F21K, H05B**
Other: **WPI. EPODOC**

(54) Title of the Invention: **LED lamps**
Abstract Title: **A soft start mains LED lamp with LED chain and capacitor**

(57) An electric lamp (10 in Fig 3) comprises: an LED unit 18 having a chain of LEDs connected in series via an electrical circuit 70 to AC mains lighting outlet supply terminals 48. The electrical circuit comprises: a mains rectifier D1; at least one resistive element R1,R2 to drop the voltage to the LED chain; and a capacitor C1 for smoothing the dropped voltage to the LED chain 18. The resistor R1 and capacitor C1 in combination can provide a soft start and slow dim-to-off, suppress flickering in triac dimmer driven LED units, and suppress fast transient spikes on the mains. The circuit may include a positive temperature coefficient thermistor R1, full wave rectification D1, a further chain of LEDs with opposite polarity, and means 84 to sense the rectified voltage and control the charge and discharge of the capacitor C1. The lamp may be connected to a dimmer, may be pear shaped or strip light shaped, and may have a diffuser with partial internal reflectances to increase the apparent size of the source of light and the angles of light irradiation.

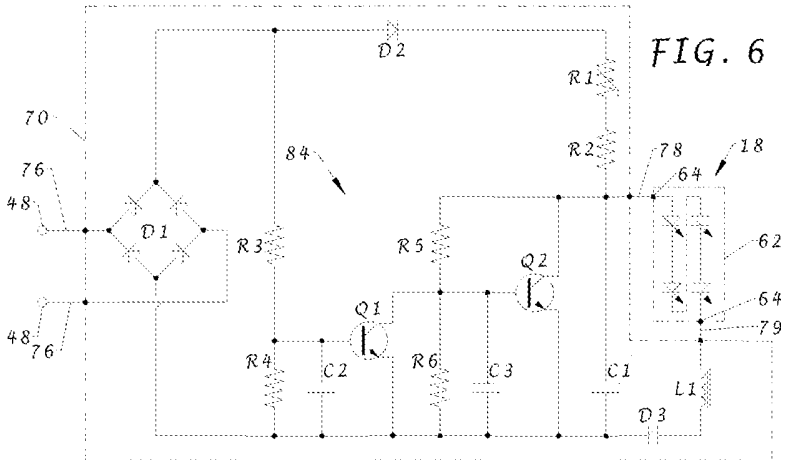

FIG. 6

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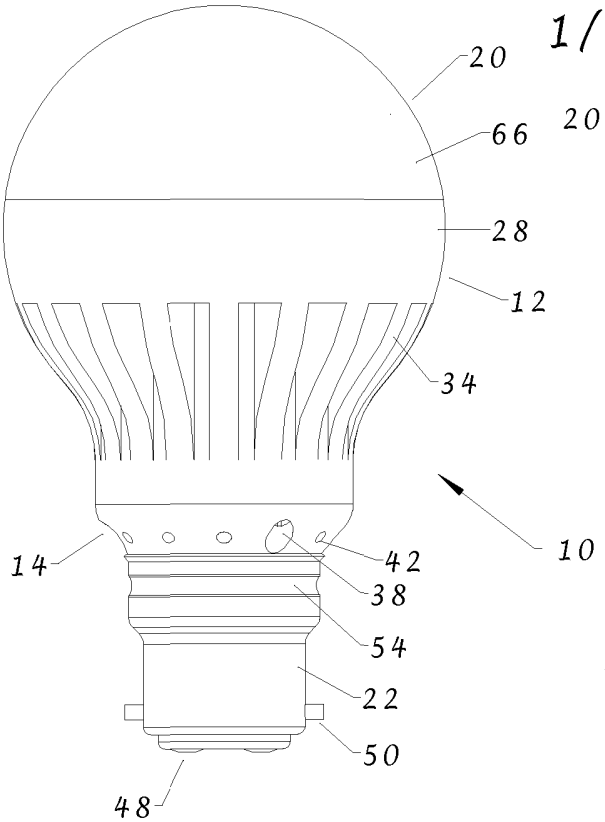
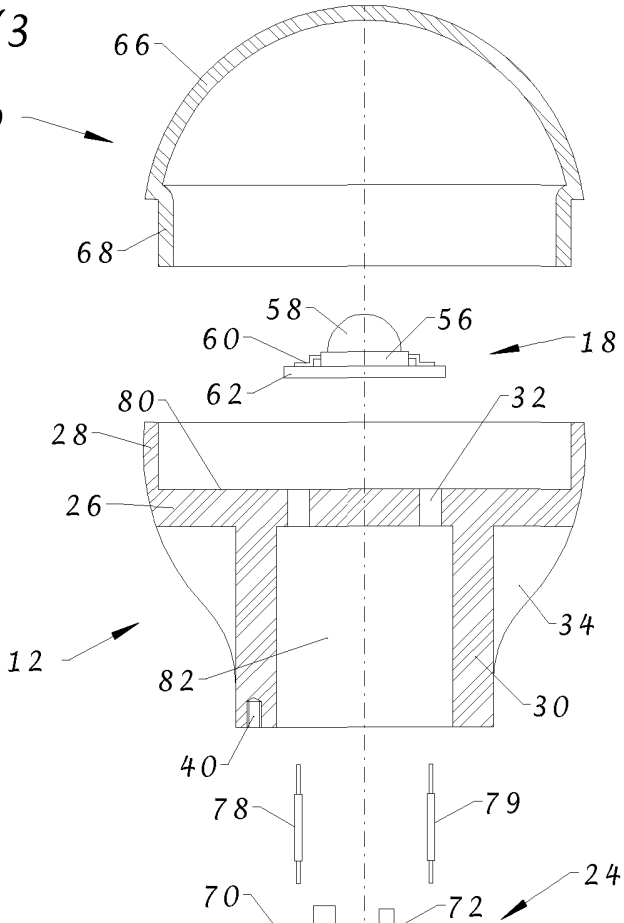


FIG. 1



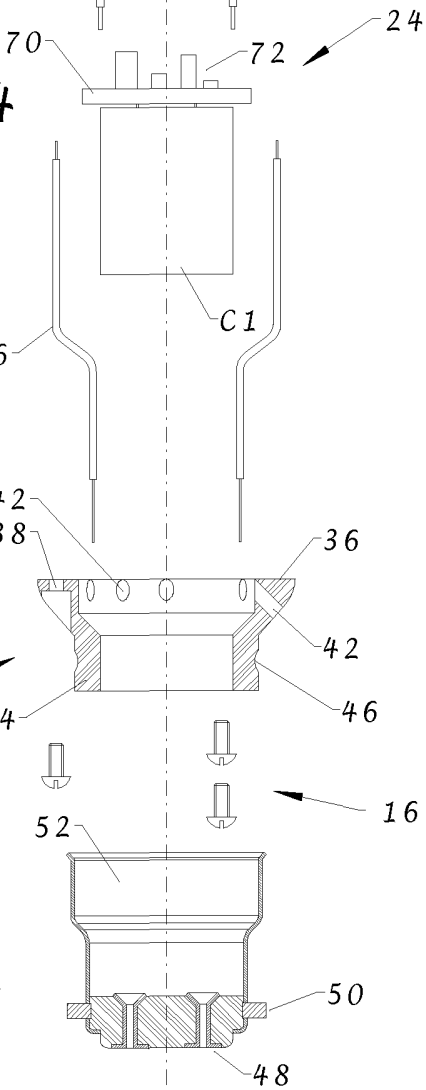
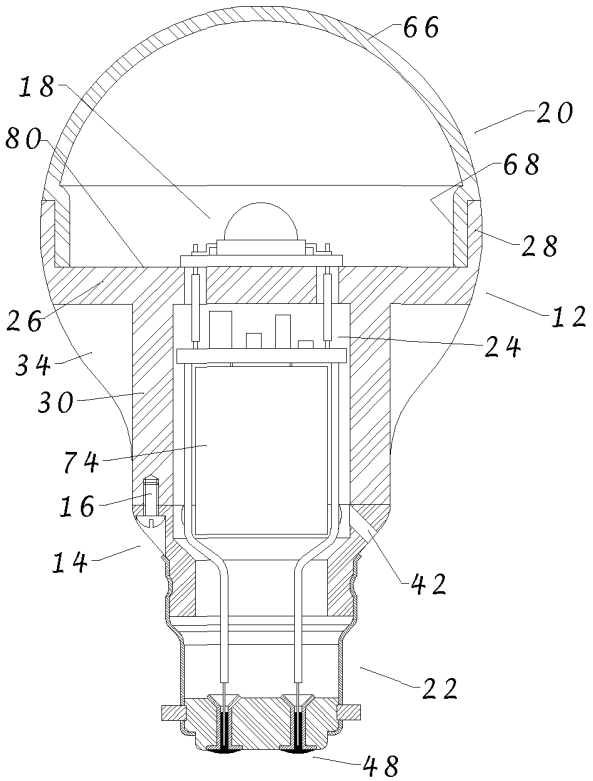


FIG. 4

10

FIG. 3



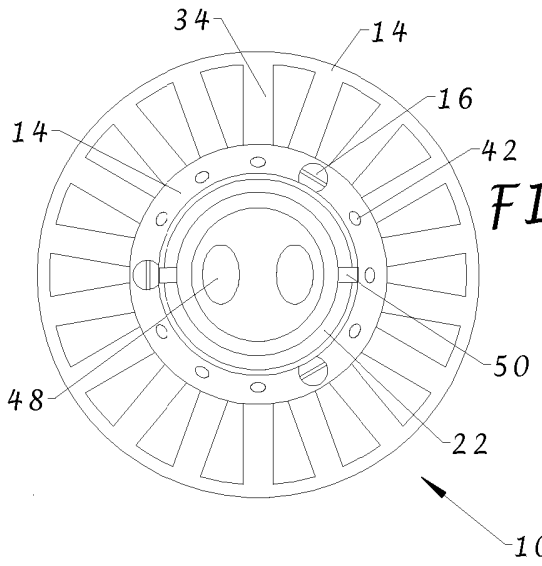


FIG. 2

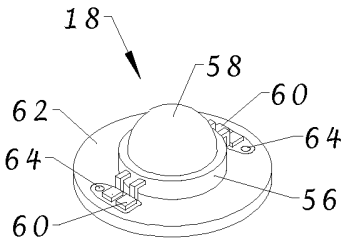


FIG. 5

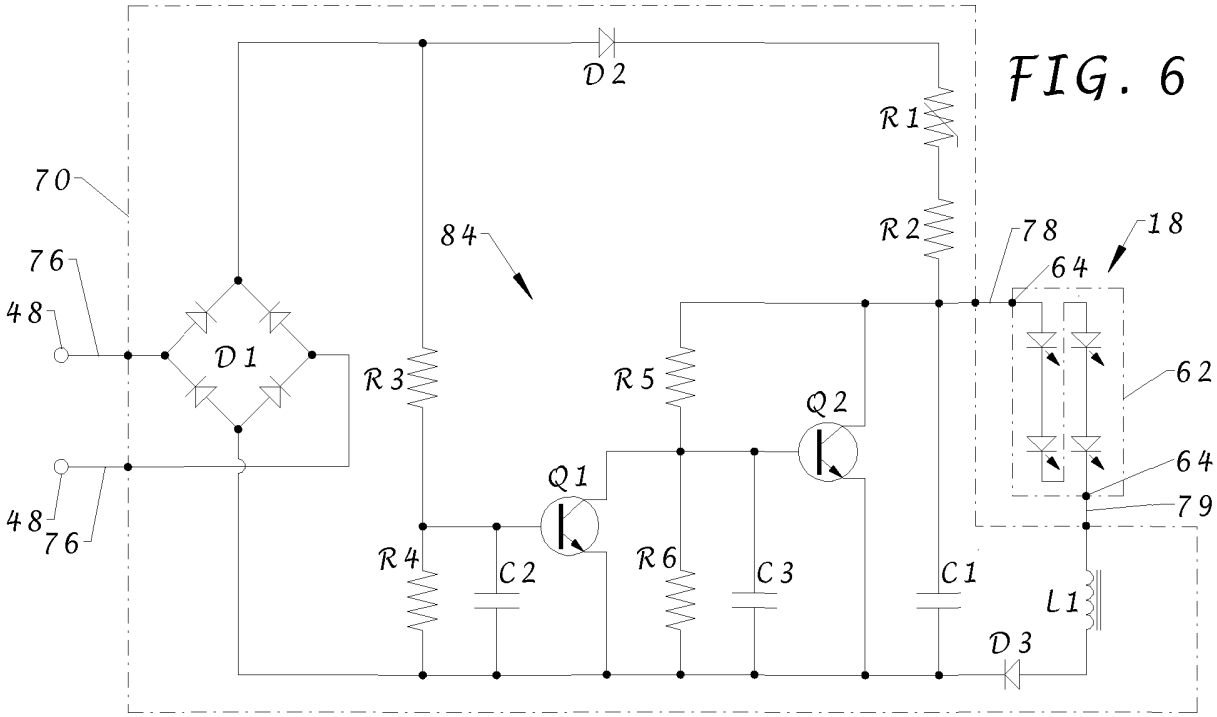


FIG. 6

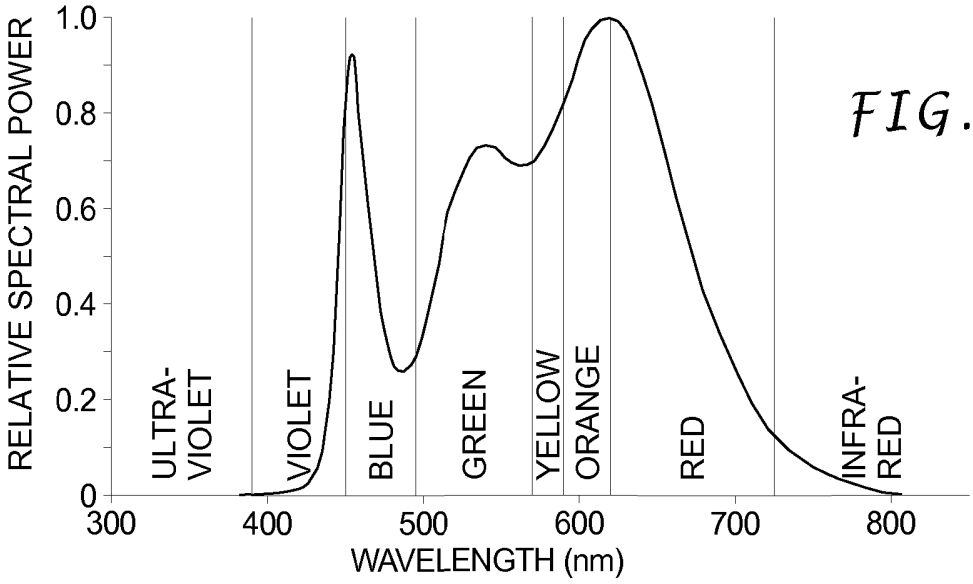


FIG. 7

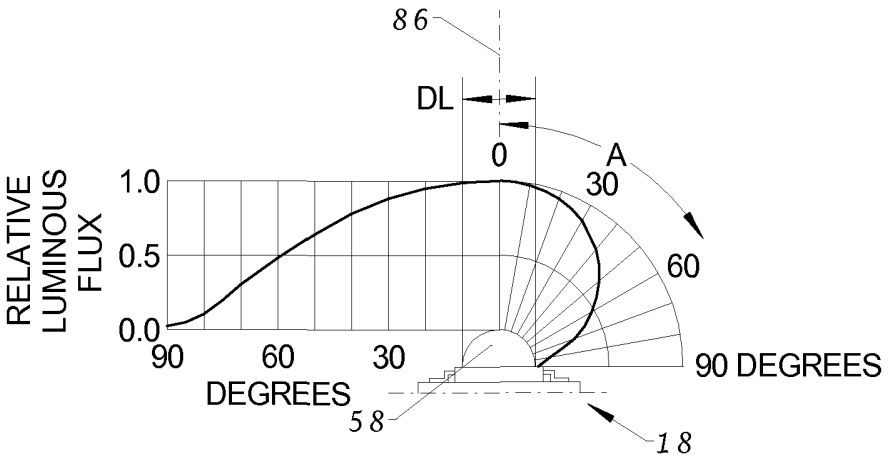


FIG. 8

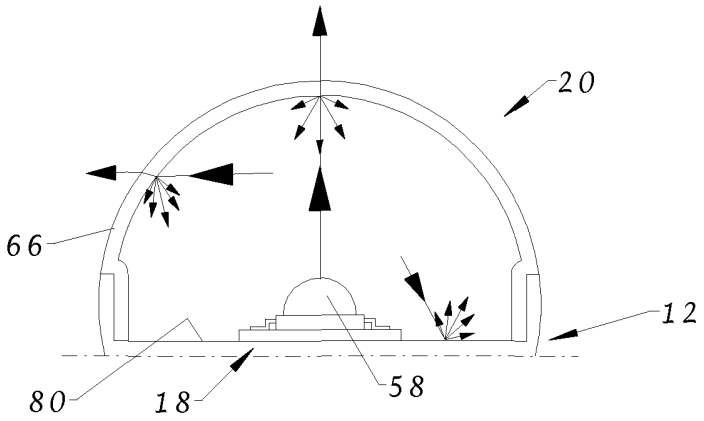


FIG. 9

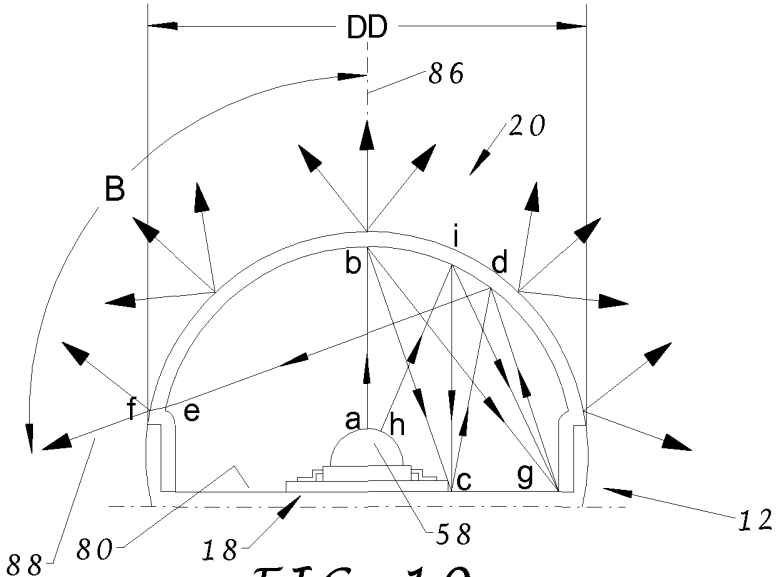


FIG. 10

TITLE

LED lamps

DESCRIPTION

This invention relates to light-emitting diode (LED) lamps.

LED devices having a single diode junction have been known for many years and used as, for example, indicator lights. Their advantages include high efficiency and long life. Traditionally, however, disadvantages have included low light output, a narrow view half-angle and a restricted range of colours. More recently, LED units have been manufactured with a large number of diode junctions formed on a single substrate and connected in series. Obviously, this increases the potential light output. Also, different junctions can be designed to produce different colours, thus affecting the overall colour of light produced by the LED unit. Furthermore, LED units have been manufactured with two chains of series-connected LEDs of opposite polarities connected between the LED unit's input terminals, so that the LED unit can be connected to AC mains electricity directly or through a series dropping resistor to adjust the AC voltage applied as the LED unit.

Examples of LED units that are intended to be driven by mains electricity and that have been placed on the market are the Acriche AN3200 and Acriche AN3220 manufactured by Seoul Semiconductor. They are designed to require an input voltage of about 95V and 195V AC, respectively, to draw an optimum current of 40mA and 20mA, respectively, and to produce a luminous flux in both cases typically of 150 lumens. These LED units are intended to be connected to the mains supply in series with a dropping resistor depending on the supplied voltage, for example depending on whether the mains voltage is nominally 100V or 110V for the AN3200, and depending on whether the mains voltage is nominally 220V or 230V for the AN3220. The difference between the supplied mains voltage and the require LED unit voltage also readily enables other circuit components to included to provide protection against variations in the mains voltage and excessive temperature of the LED unit.

LEDs have a very fast response time. This can be an advantage in some circumstances. However, many people would prefer a slower response time more akin to a conventional tungsten filament light bulb, which typically takes about one half second to come up to full brightness and two seconds to dim to off.

An LED unit such as the AN3200 or AN3220 can be connected to the mains via a conventional triac dimmer circuit. However, with some designs of triac dimmer circuit the LED unit does not come on and go off smoothly. In particular, at low settings, the circuit can hunt so that the LED unit flickers sporadically at less than mains frequency. For example, when the dimmer setting is progressively increased from fully off, instead of coming up gradually from off, the LED unit changes from an off state to a flickering state and then to a low state in which is light output of the LED unit is greater than would be desired. At the least, this is annoying. Furthermore, although it has multitudinous other applications, this invention was originally conceived in connection with the provision of lighting for chickens in a chicken barn so as to simulate the daily cycle of daytime and night time, in which the level of light is gradually increased by a dimmer circuit during the simulated dawn and gradually decreased during the simulated dusk. The flickering effect, if an LED unit were employed, rather than a conventional tungsten filament light bulb, would have an adverse effect on the chicken's egg productivity and/or growth and/or temperament.

An aim of the present invention, or at least of specific embodiments of it, is to provide an electric lamp using an LED unit which preferably can be used as a direct replacement for a conventional tungsten filament light bulb, which has a response time which is more akin to that of a tungsten filament light bulb, and which does not suffer from the flickering effect when used in conjunction with a dimmer circuit.

In accordance with the present invention, there is provided an electric lamp comprising: an LED unit comprising a chain of LEDs connected in series between a pair of LED terminals; a connector having a pair of supply terminals for connecting the lamp to an AC mains lighting outlet; and an electrical circuit connecting the supply terminals to the LED terminals. The electrical circuit comprises: a rectifier for rectifying the mains voltage to produce a rectified voltage; at least one resistive element for dropping the rectified voltage that is supplied to the LED terminals; and a capacitor for smoothing the dropped voltage that is supplied to the LED terminals. Therefore, the rectifier enables the capacitor to store energy for more than one mains cycle, and the resistive element and capacitor in combination can be used to provide a soft start and slow dim-to-off for the lamp. Furthermore, it has been found that this arrangement can obviate or at least substantially suppress the flickering phenomenon discussed above. Moreover, the resistive element and capacitor can effectively suppress fast transient spikes on the mains.

The capacitor is preferably of sufficient capacitance to produce a significant turn-on delay, upon sudden application of full mains voltage to the supply terminals, before the dropped

voltage applied to the LED terminals rises to its maximum. The turn-on delay is preferably at least one fifth of a second and more preferably about half a second. The capacitor is also preferably of sufficient capacitance to produce a significant turn-off delay, upon sudden removal of full mains voltage from the supply terminals, before the dropped voltage applied to the LED terminals falls to substantially zero. The turn-off delay is preferably at least one half of a second and more preferably about two seconds.

The electrical circuit preferably includes means for sensing the rectified voltage and for controlling the charging and discharging of the capacitor in dependence upon the sensed voltage.

The resistive element(s) preferably include at least one positive temperature coefficient thermistor to protect the lamp from excessive temperature or current.

The rectifier is preferably arranged to provide full-wave rectification of the mains voltage so that the LED unit is driven for both halves of the mains cycle.

Although they may remain unused, the LED unit may comprise a further chain of LEDs connected in series between a pair of LED terminals with opposite polarity to the first-mentioned chain of LEDs.

The lamp may further include a body, with the LED unit being mounted on a heat-sinking portion of the body at or adjacent one end of the body, the connector being mounted on the body at or adjacent an opposite end of the body, and the electrical circuit, or at least the bulk of the electrical circuit, being disposed within a cavity provided by the body between the opposite ends thereof.

A specific embodiment of the present invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a side view of an electric lamp;

Figure 2 is an underplan view of the lamp;

Figure 3 is a sectioned side view of the lamp;

Figure 4 is an exploded sectioned side view of the lamp;

Figure 5 is an isometric view of an LED unit of the lamp;

Figure 6 is a circuit diagram of the lamp;

Figure 7 is a graph of relative spectral power against wavelength for the light produced by the lamp;

Figure 8 is shows a radiation pattern of the beam produced by the LED unit;

Figure 9 is a ray diagram illustrating reflections and transmissions at a diffuser and reflector of the lamp; and

Figure 10 is a diagram illustrating the light produced by the lamp.

Referring to Figures 1 to 5 of the drawings, an LED lamp 10 comprises front and rear body portions 12,14 secured together by three screws 16, an LED unit 18, a domed diffuser 20, a connector cap 22 and electrical circuitry 24 connecting the LED unit 18 to the connector cap 22.

The front body portion 12 is moulded from a white opaque plastics material having a matt surface so that it diffusely reflects incident light. The front body portion 12 has a circular wall 26 of a diameter of, for example, 60 mm. A cylindrical wall 28 projects forwardly from the periphery of the circular wall 26. A further cylindrical wall 30 of smaller diameter than the front cylindrical wall 28 projects rearwardly from the circular wall 28. A pair of holes 32 are formed in the circular wall 26 within the internal diameter of the rear cylindrical wall 30. A plurality of heat-radiating fins 34 beneath the circular wall 28 radiate from the rear cylindrical wall 30.

The rear body portion 14 is moulded from plastics material and is generally annular. The front face 36 of the rear body portion 14 is flat, and three holes 38 are provided, through which, upon assembly of the lamp 10, the screws 16 are passed into engagement with three screw-threaded holes 40 in the rear of the rear cylindrical wall 30 of the front body portion 12. A plurality of ventilation holes 42 are spaced apart around the rear body portion 14. The rear end of the rear body portion 14 is formed as a cylindrical spigot 44 with a external crimping groove 46.

The connector cap 22 is of conventional design and in the drawing is shown as a 'BC' or 'B22' cap, but other designs of cap 22 may alternatively be employed. The cap 22 has a pair of terminals 48, and a pair of bayonet pins 50. Upon assembly of the lamp 10, the spigot 44 of

the rear body portion 14 is fitted into the mouth 52 of the cap 22, and the cap is then crimped in the region 54 into the crimping groove 46 of the rear body portion 14.

The LED unit 18 has a disc-shaped heat-sinking base 56 onto which a semi-spherical lens 58 is formed. A large number of LEDs (not shown) are formed on the base 66 under the lens 58. The LEDs are series connected between a pair of solder pads 60. The LED unit 18 is attached by its solder pads 60 to a small printed circuit board 62. A thermally conducting paste may be applied between the base 56 of the LED unit 18 and the printed circuit board 62. The printed circuit board has two holes 64 for connection to the electrical circuitry 24. An example of the LED unit 18 is the Acriche AN3220 manufactured by Seoul Semiconductor.

The diffuser 20 is moulded from translucent plastics material which has optical transmission and reflection characteristics that will be described in more detail below. The diffuser 20 has the form of a dome with a generally uniform wall thickness. A main portion 66 of the diffuser 20 is part-spherical, being slightly less than a hemisphere, and having an external radius of, for example, about 30 mm. At the rear edge of the main portion 66, a connecting portion 68 is provided in the form of a cylindrical skirt having a external diameter which is about the same as the internal diameter of the front cylindrical wall 28 of the front body portion 12.

The electrical circuitry 24 comprises: a printed circuit board 70 on which are mounted a number of components 72 including a large capacitor C1; a pair of wires 76 for connecting the printed circuit board 70 to the terminals 48 of the connector cap 22; and a pair of wires 78,79 for connecting the printed circuit board 70 to the LED unit 18.

During assembly of the lamp 10: the connector cap 22 is crimped to the rear body portion 14; the ends of the wires 76 are soldered to the connecting cap terminals 48 and to the printed circuit board 70; and the wires 78 are soldered to the printed circuit board 70. Also, the printed circuit board 62 of the LED unit 18 is bonded to the centre of the front face 80 of the circular wall 26 of the front body portion 12, using a thermally-conductive adhesive, with the holes 64 of the LED circuit board 62 aligned with the holes 32 through the circular wall 26 of the front body portion 12. The electrical circuitry 24 is then inserted in the cavity 82 formed by the rear cylindrical wall 30 of the front body portion 12, and the front ends of the wires 78 are guided through the holes 32 in the wall 26 and through the holes 64 in the LED circuit board 62. The screws 16 are then used to secure the front and rear body portions 12,14 together. The front ends of the wires 78 are then soldered to the LED circuit board 62. The diffuser 20 is then

fitted to the front body portion 12 using a suitable adhesive, with the skirt 68 being fitted inside the front cylindrical wall 28 of the front body portion 12.

Referring now to Figure 6, the wires 76 from the connector cap terminals 48 are connected to the AC inputs of a rectifier bridge D1 on the printed circuit board 70. The positive output from the bridge D1 feeds via a diode D2, positive temperature coefficient thermistor R1, resistor R2 and one of the wires 78 to the LED unit 18. From the LED unit 18, the return path is via the other wire 79, a choke L1 and a diode D3 to the negative output of the bridge D1. The large capacitor C1 is connected between the wire 78 and the negative output of the bridge D1. The charging and discharging of the capacitor C1 is controlled by a sub-circuit 84 fed from the positive output of the bridge D1 and comprising resistors R3,R4, capacitor C2, transistor Q1, resistors R5,R6, capacitor C3 and transistor Q2.

In operation, when full mains voltage is initially suddenly applied to the cap terminals 48, substantially full, full-wave-rectified mains voltage is applied to the series connection of the thermistor R1, resistor R2, LED unit 18 and choke L1. However, the large capacitor C1 is initially discharged. Therefore, the voltage applied to the LED unit 18 rises progressively from zero as the large capacitor C1 charges. The charging of the large capacitor C1 is moderated by the sub-circuit 84 in which transistor Q1 progressively turns on, and in which transistor Q2 immediately turns on but is then progressively turned off by transistor Q1. The values of the circuit components are chosen so that the turn-on time of the LED unit 18 is about 0.5 seconds, so that the LED unit 18 emulates a standard tungsten light bulb being switched on.

In operation of the lamp 10 in its steady 'on' state, transistor Q1 is on, but the resistance of resistor R5 is high so that negligible current flows through transistor Q1, and transistor Q2 is off. The thermistor R1 and resistor R2 serve to drop the voltage applied to the LED unit 18 to a suitable value, and the large capacitor C1 is charged and smoothes the voltage applied to the LED unit 18. The thermistor R1 regulates the supply to the LED unit 18 by increasing its resistance if the lamp 10 becomes too hot or if the current through the thermistor R1 becomes too high, for example due to prolonged over-voltage applied to the cap terminals 48. The capacitor C1 and choke L1 also serve to protect the LED unit 18 from any fast transient spikes.

When the supply to the connector cap terminals 48 is suddenly switched off, the large capacitor C1 is initially fully charged and progressively discharges through the LED unit 18. The discharging of the large capacitor C1 is assisted by the sub-circuit 84 in a controlled manner, in which transistor Q1 progressively turns off, and in which is transistor Q2 is

progressively turned on by transistor Q1 before finally turning off. The values of the circuit components are chosen so that the turn-off time of the LED unit 18 is about 2 seconds, so that the LED unit emulates a standard tungsten light bulb being turned off.

If an LED unit such as the unit 18 were connected to a triac dimmer rather than directly to the mains, with some designs of triac dimmer the LED unit would not come on and go off smoothly. In particular, at low settings, the circuit can hunt so that the LED unit would flicker sporadically at less than mains frequency. For example, when the dimmer setting is progressively increased from fully off, the LED unit changes from an off state to a flickering state and then to a low state in which is light output of the LED unit is greater than would be desired. However, with the circuit of Figure 6, and particularly the large capacitor C1, this flickering phenomenon can be avoided and, with progressive increase of the dimmer setting, the light output of the LED unit 18 progressively increases from zero to full without any flickering or significant step changes in the light output form the LED unit 18.

In an example of the circuit of Figure 6 designed to operate with a nominal mains voltage of 230V AC, the LED unit 18 may be provided by an Acriche AN3220 manufactured by Seoul Semiconductor, which draws a current of about 20mA at an applied voltage of about 195V. Example values of the other circuit components are: thermistor R1, 300 Ohms cold; resistor R2, 500 Ohms; resistor R3, 300 kOhms; resistor R4, 20 kOhms; resistor R5, 300 kOhms; resistor R6, 1 kOhm; capacitor C1, 220 microF; capacitor C2, 4.7 microF; capacitor C3, 47 microF; and choke L1, 68 microH. It should be noted that the Acriche 3220 contains two chains of LEDs of opposite polarities connected between its terminal tags 60, and that with the circuit of Figure 6, only one of those chains of LEDs is driven.

Figure 7 shows the relative spectral power of the light produced by the lamp 10 when employing an Acriche AN3220 for the LED unit 18 and a non-tinted diffuser 20. It is to be noted that the relative spectral power of ultra-violet light is substantially zero, and that the relative spectral power of infrared light is very low and decreases to substantially zero at 800 nm.

Figure 8 shows the light radiation pattern from the bare LED unit 18, both in polar form to the right and in Cartesian form to the left. It will be noted that the direction of maximum luminous flux coincides with the primary axis 86 of the LED unit 18. Also, the relative luminous flux falls to 50% at an angle A of about 55 to 60 degrees. At an angle of 90 degrees the relative luminous flux has fallen to substantially zero. In the case of the Ariche AN3220, the diameter DL of the lens 58 is relatively small, being 10 mm. It will be appreciated

that the apparent area of the lens 58 of the LED unit 18, when viewed on the primary axis 86, is ¼pi DL^2, or 79mm^2. The domed diffuser 20 and the reflective nature of the front face 80 of the circular wall 26 of the front body portion 12 serve to increase the apparent area of the source of light and also to increase the angles at which the relative luminous flux has fallen to 50% and substantially to zero, as will now be described.

Referring to Figure 9, the diffuser 20 is moulded or treated so that the transmission coefficient for light incident on its inner surface is about 70%, the reflection coefficient is about 30%, and the absorption coefficient is a close to zero as possible. The reflection is diffuse and may be Lambertian reflection or, as shown in Figure 9, hazy reflection in which the maximum of reflected power is in the specular direction, but nevertheless with a significant amount of scattering. Also, the front body portion 12 is moulded or treated so that the reflection coefficient for light incident on the surface 80 is as close as possible to 100%. Again, the reflection is diffuse and may be Lambertian reflection or hazy reflection. As a result of the partial reflectance of the diffuser 20 and the reflectance of the surface 80, the inside of the domed diffuser 20 fills with light travelling in all directions, and as each ray of light impinges on the inner surface of the main portion 66 of the diffuser 20, only about 70% of its radiant power is transmitted through the diffuser 20 to the outside.

In a prototype, it was found that the angle B at which the relative luminous flux falls to 50% of the luminous flux in the direction of the axis 86 was about 100 degrees. This compares with about 55 to 60 degrees for the bare LED unit 18. An example of a ray transmitted from the lamp 10 at an angle B of 100 degrees to the primary axis 86 is indicated by the reference numeral 88 in Figure 10. Examples of ray paths leading to the ray 88 are also shown in Figure 10, taking the paths abcdef, abgdef, hicdef, higdef. It will also be appreciated that the diameter DD of the diffuser, being slightly less than 60 mm, is almost six times greater than the diameter DL of the lens 58, and therefore that the apparent area of the of the diffuser 20, when viewed on the primary axis 86, is almost thirty-six times the apparent area of the lens 58. The overall effect of the diffuser 20 and reflective surface 80 is to increase the view angle of the LED unit 18 and to increase the apparent area of the light source whilst avoiding any excessive 'hot-spot' effect.

It will be appreciated that many modifications and developments may be made to the embodiment of the invention described above. For example, although the described embodiment of the invention generally resembles a pear-shaped light bulb, the invention may also be applied to a lamp resembling a strip light, employing an LED unit in which the LED junctions are

arranged in a line rather than being concentrated in a spot. In this case, the reflective surface of the heat sink may be rectangular having a length slightly greater than the length of the LED unit, with the LED unit being mounted along the longitudinal centre-line of the reflective surface, and the diffuser may be part-circularly cylindrical, for example generally semi-circularly cylindrical, of similar length to the reflective surface and with its axis approximately coinciding with the line of LED junctions.

It should be noted that the embodiment of the invention has been described above purely by way of example and that many other modifications and developments may be made thereto within the scope of the present invention.

CLAIMS

(The reference numerals in the claims are not intended to limit the scope of the claims.)

1. An electric lamp (10) comprising:
an LED unit (18) comprising a chain of LEDs connected in series between a pair of LED terminals (64);
a connector (22) having a pair of supply terminals (48) for connecting the lamp to an AC mains lighting outlet; and
an electrical circuit (24) connecting the supply terminals to the LED terminals;
wherein the electrical circuit comprises:
a rectifier (D1) for rectifying the mains voltage to produce a rectified voltage;
at least one resistive element (R1,R2) for dropping the rectified voltage that is supplied to the LED terminals; and
a capacitor (C1) for smoothing the dropped voltage that is supplied to the LED terminals.

2. A lamp as claimed in claim 1, wherein the capacitor is of sufficient capacitance to produce a significant turn-on delay, upon sudden application of full mains voltage to the supply terminals, before the dropped voltage applied to the LED terminals rises to its maximum.

3. A lamp as claimed in claim 2, wherein the electrical circuit is arranged such that the turn-on delay is at least one fifth of a second.

4. A lamp as claimed in any preceding claim, wherein the capacitor is of sufficient capacitance to produce a significant turn-off delay, upon sudden removal of full mains voltage from the supply terminals, before the dropped voltage applied to the LED terminals falls to substantially zero.

5. A lamp as claimed in claim 4, wherein the electrical circuit is arranged such that the turn-off delay is at least one half of a second.

6. A lamp as claimed in any preceding claim, wherein the electrical circuit includes means (R3-R6,C2,C3,Q1,Q2) for sensing the rectified voltage and for controlling the charging and discharging of the capacitor in dependence upon the sensed voltage.

7. A lamp as claimed in any preceding claim, wherein the resistive element(s) include at least one positive temperature coefficient thermistor (R1).

8. A lamp as claimed in any preceding claim, wherein the rectifier is arranged to provide full-wave rectification of the mains voltage.

9. A lamp as claimed in any preceding claim, wherein the LED unit comprises a further chain of LEDs connected in series between a pair of LED terminals with opposite polarity to the first-mentioned chain of LEDs.

10. A lamp as claimed in any preceding claim, further including a body (12,14), the LED unit being mounted on a heat-sinking portion (26) of the body at or adjacent one end of the body, the connector being mounted on the body at or adjacent an opposite end of the body, and the electrical circuit, or at least the bulk of the electrical circuit, being disposed within a cavity (82) provided by the body between the opposite ends thereof.

11. An electric lamp substantially as described with reference to the drawings.

Application No: GB0900068.8 **Examiner:** Mr Bernard Peat

Claims searched: 1-10 **Date of search:** 9 July 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-10	WO2006/046207 A1 (KONINKL PHILIPS ELECTRONICS) See Fig 6, rectifier 22, resistor R7, capacitor C2, LEDs 26
X	1-5,7-10	WO2008/136685 A1 (LEDLIGHT GROUP) See Fig 1, claims 1, 2, and 6, page 5 lines 7-8.
X	1-5,7-10	US2006/0208667 A1 (THOR) See Figs 3 and 4, paragraph 91.
X	1-5,7-10	JP2006236709 A (MATSUSHITA) See Abstract and Fig 3.
X	1-5,7-10	US7449839 B1 (CHEN) See Abstract and Fig 3.
X	1-5,7-10	US2002/0158590 A1 (SAITO) See Abstract, Fig 6, paragraphs 91-92.
X	1-5,7-10	WO02/096162 A1 (KONINKL PHILIPS ELECTRONICS) See Figs 1 & 3, page 3 lines 16-28.
X	1-5,7-10	US2008/0157686 A1 (CHUNG) See paragraph 6, Figs 6 and 8.
X	1-5,7-10	US2008/0224623 A1 (YU) See Fig 1 and paragraph 13.
X	1-5,7-10	US2008/0247205 A1 (WU) See Abstract and Fig 5.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if	P	Document published on or after the declared priority date but

	combined with one or more other documents of same category.		before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

F21K; H05B

The following online and other databases have been used in the preparation of this search report

WPI. EPODOC

International Classification:

Subclass	Subgroup	Valid From
H05B	0033/08	01/01/2006