

Lighting Device

The present invention relates to a lighting device with at least one socket into which a lighting means can be inserted. The socket has electronic terminals to supply the lighting means, wherein an electric or electronic ballast which guarantees a suitable electric supply to a fluorescent bulb is provided in the lighting device.

In the state of the art, it is known that lighting devices in the form of bulb holders have electric or electronic ballasts, such as transformers, for example, in order to provide a suitable voltage for light bulbs, including halogen bulbs.

In the same way, it is known in the state of the art that provided in lighting devices are conventional or electronic ballasts that allow an ignition of the fluorescent bulb and allow flicker-free operation of the same by means of a high frequency alternating voltage.

Furthermore known in the state of the art is the use of LEDs (light-emitting diodes) as lighting means. Thus for example in DE 10 2004 044 166 B4 an explosion-protected luminaire with light-emitting diodes as the light source is disclosed wherein the light-emitting diodes are supplied by a suitable electronic ballast.

Also known from the state of the art are applications in which interchangeability of fluorescent bulbs or light bulbs with lighting means having LEDs is made possible.

For example, lighting means are known that essentially have the form of a light bulb and that are inserted into a conventional light bulb holder but in which light is produced by means of LEDs. In bulbs of this kind, a ballast is provided in the lighting means itself for this purpose.

Furthermore known from DE 299 00 320 U1 is an LED lighting means (light-emitting diode lighting means) with which a fluorescent bulb can be replaced, wherein the LED lighting means is supplied via a cable set with which the plug-in socket can be connected to an on-board voltage source of a motor vehicle so that in the LED lighting means it is necessary only to provide a diode that can prevent destruction of the light-emitting diodes in the event of an erroneous mix-up of the polarity when inserting the LED lighting means into the plug-in socket. The LED lighting means can furthermore have a switching means with which the light-emitting diodes can be switched on or off individually, in pairs, or in groups.

The object of the present invention is to improve a lighting device of the description to the effect that a simple changeover, for example between fluorescent bulb and an LED lighting means

with a number of LEDs, is possible without the necessity of electrical or mechanical adjustments to the lighting device.

This object is solved by means of the features of Patent Claim 1.

According to the invention, a corresponding LED lighting means can, without mechanical or electrical adjustments or without electronic adjustments, as the case may be, be inserted into the lighting device which otherwise, with the electric or electronic ballast, is suitable for one or more fluorescent bulbs. This means the lighting device can selectively be used with fluorescent bulbs or with a corresponding LED lighting means without further measures on the ballast or the wiring and without switching through the use of a switching device or the like.

Used in lieu thereof are a corresponding number of LEDs that are connected in series and whose current value essentially corresponds to a bulb current during operation of the lighting device with fluorescent bulb or fluorescent bulbs.

In the case of electronic ballasts for fluorescent bulbs the input alternating voltage is rectified and, by means of a step-up converter, converted to a regulated direct voltage (so-called intermediate circuit voltage).

This conversion is necessary in order to achieve a correction of the power factor as called for in the standards (EN 61000) and consequently virtually sinusoidal current consumption out of the supply grid.

The ballast has a transistor half bridge and an LC series resonator wherein the fluorescent bulb is connected in parallel to the capacitor in the LC series resonator.

With such a transistor half bridge in differential mode, the above-mentioned intermediate circuit voltage is converted into square wave voltage with a constant frequency. Today's customary switching frequencies in modern electronic ballasts lie in the range from 20 kHz to 60 kHz. As the result of this corresponding arrangement, a system with constant voltage and constant frequency becomes a system with constant current, wherein this corresponds to the principle of a Boucherot circuit.

All of the ballast's components or switching circuits, as the case may be, mentioned in the preceding are used to operate the fluorescent bulb or fluorescent bulbs. In order also to be able to use in a simple way a corresponding LED lighting means with a ballast such as described in

the preceding, the LED lighting means can have a bridge rectifier, or such a bridge rectifier can be allocated to the LED lighting means.

In this connection it should be observed that a fluorescent bulb that has not yet been ignited has a high ohmic resistance in the range of several 100 k Ω . The corresponding LC resonator consequently first runs in open circuit operation so that the voltage on the capacitor of the resonator rises until the point that the fluorescent bulb has ignited and the resonator subsequently is loaded with a resistance in the order of several 100 Ω . This resistance depends on the bulb type. In order to achieve a correspondingly high starting voltage, during the starting phase a switching frequency of the transistor half bridge mentioned above is changed until it is close to a resonant frequency. Once the fluorescent bulb has ignited, this frequency is kept constant and the bulb current becomes a virtually constant value regardless of the bulb type.

According to the invention, the series resonator is already loaded in such a starting phase during the use of LED lighting means, so that no high voltages arise on the corresponding capacitor of the resonator and the resonator immediately acts as a current source. This is implemented in a simple manner in that the voltage on this capacitor of the resonator is rectified with the mentioned bridge rectifier and this direct voltage is directly loaded with the corresponding number of serially-connected LEDs. To achieve this, preferably diodes that are, with regard to their reverse recovery times, adjusted to the switching frequency of the ballast are used for the bridge rectifier.

The corresponding current value of the LEDs is thereby essentially equal to the bulb current during operation with one or more fluorescent bulbs. The ballast for fluorescent bulbs of the type 18W/T8 or 36W/T8, as the case may be, delivers a bulb current of from 300 mA to 320 mA. Such a value lends itself to the operation of high power LEDs.

With the corresponding number of LEDs, in this way the voltage of the capacitor can be adjusted in such a way that it roughly corresponds to the operating voltage of a fluorescent bulb.

Various component defects are possible in the LEDs. In order to be able to take such defects into consideration in the lighting device according to the invention, a thyristor clamp circuit between LEDs and bridge rectifier can be allocated as a protective circuit to the LED lighting means. Such a thyristor clamp circuit is also called a thyristor crowbar.

Possible component defects in the LEDs are a melt down and consequently a short circuit of the LED or the LED becoming high impedance, for example, due to a break in the bonding wires.

As already explained above, the ballast behaves like a constant current source in a relatively large load range. As a rule, the short circuit of one or more of the serially-connected LEDs is not critical. A break to an LED simultaneously means a break in the entire load circuit in the corresponding resonator. The result is a rise in the output voltage of the ballast up to a level of several 100 V_{eff}. In modern ballasts, this high voltage is switched off within several 100 ms or less. In order to prevent such a high voltage, the ballast is short circuited by the LED lighting means or its allocated thyristor clamp circuit, as the case may be, in the event of a break in the load circuit. This is achieved as a result of the thyristor clamp circuit, also called a thyristor crowbar circuit, constantly monitoring the rectified output voltage and, should the level reach a specified, maximum voltage threshold, igniting the thyristor of the clamp circuit and consequently short circuiting the ballast.

In order to be able to replace the fluorescent bulb with a corresponding LED lighting means in a simple manner, not only electrically or electronically, as the case may be, this LED lighting means can be formed as an LED module that can be inserted into the lighting device with the corresponding socket in place of one or also more fluorescent bulbs. Such an LED module contains, for example, the bridge rectifier and the thyristor clamp circuit as a protective circuit.

According to the invention it is therefore possible to install a corresponding lighting device, wherein at the time of installation it is still left open whether later a fluorescent bulb or an LED lighting means will be used. Retrofitting of the lighting device with regard to mechanical systems or with regard to the electrical supply is not necessary. Instead it is possible to insert a corresponding LED module in the place of one or more fluorescent bulbs, wherein in this connection it is also possible to develop the lighting device such that it is explosion-protected.

As already explained, the lighting device in a preferred embodiment is executed so as to be explosion-protected. The corresponding ballast can be encapsulated so that it is not in contact with a possibly explosive environment. Furthermore, due to the modular and compact arrangement, heat dissipation can be improved so that the lighting device as a whole does not exceed a certain temperature. The corresponding LED lighting means, particularly as an LED module, can also be compact and can itself also be equipped so as to be explosion-protected. I.e., lighting device and/or lighting means can be formed with Ex-e, Ex-d or Ex-m protection.

In particular, the LED lighting means can have terminals that correspond to those of a fluorescent bulb so that the fluorescent bulb as well as the LED lighting means can alternatively be inserted into the same holders. For this purpose, the LED lighting means is advantageously

possibly formed with terminals that correspond, in their arrangement on the LED lighting means and in their form, to those of fluorescent bulbs.

The lighting device has, for example, a base body for holding the lighting means in place and a transparent or translucent cover that can be placed on to the base body and that covers the lighting means. By means of the cover, the lighting means can furthermore be shielded from a possibly explosive atmosphere.

In an embodiment, the lighting device can have sockets to seat at least two different fluorescent bulbs that are arranged parallel to each other or one another, as the case may be. Alternatively the corresponding LED lighting means or module, as the case may be, can be inserted into these sockets. The lighting device can be supplied with alternating voltage. However a supply with direct voltage is also possible.

The LED lighting means can, similarly to the fluorescent bulb, also be locked into the corresponding socket with its terminals after insertion into the corresponding socket. For this purpose, a locking mechanism can be allocated to each socket.

For simple adjustment and development of the corresponding terminals, particularly in the form of male contacts, pin housings for holding the terminals or male contacts can be arranged, one on each end of the LED lighting means or module, as the case may be.

In the following, an advantageous embodiment of the invention is explained using the included figures.

Shown are:

Figure 1 A lighting device according to the invention in an isometric view seen diagonally from above with accompanying lighting means;

Figure 2 The lighting device according to the invention in an isometric view seen diagonally from below with fluorescent bulbs as lighting means;

Figure 3 The lighting device according to the invention in an isometric view seen diagonally from below with an LED lighting means;

Figure 4 A schematic view of the ballast with fluorescent bulbs;

Figure 5 A schematic view of the ballast with an LED lighting means;

Figure 6 A schematic view of the sockets on the mounting flange of the lighting device according to the invention;

Figure 7 A schematic diagram of an LED lighting means with further systems;

Figure 8 A schematic diagram of an electronic ballast with fluorescent bulb; and

Figure 9 A schematic diagram of a bridge rectifier with clamp circuit for supplying a number of LEDs.

Shown in Figure 1 is a luminaire 1 that consists of a lighting device 2 into which a lighting means 3, 4 can be inserted. Provided as lighting means are alternatively fluorescent bulbs 3 or an LED lighting means 4. The lighting device 2 consists of a base body 5, which advantageously has mounting means in order to be mounted to a wall or ceiling, and of a transparent or translucent cover 6, which can be detachably mounted to the base body 5. The luminaire 1 is formed so as to be explosion-protected, which means particularly the base body 5 and the cover 6 are developed in such a way that the electrics and the electronics contained in the base body 5 and the lighting means 3, 4 inserted therein are shielded by the cover 6, so that the luminaire 1 can also be used in potentially explosive ambient conditions.

The base body 5 has electric supply terminals 11 that can be connected via a supply line to an alternating current source. The electric supply terminals 11 are developed so as to be explosion-protected.

If the cover 6 is removed from the base body 5, an insertion or replacement of the lighting means 3, 4 can take place. For this purpose, the base body has, in the area of its end sides in the longitudinal direction L, mounting flanges 9, 10 that extend in the latitudinal direction B. The fluorescent bulbs 3 or the LED lighting means 4, as the case may be, can be inserted into the mounting flanges 9, 10 from below in the height direction H.

For this purpose, the fluorescent bulbs 3 have on each of their ends in the longitudinal direction L terminals 8, each of which consists of two male contacts.

The LED lighting means 4 accordingly has correspondingly developed terminals 12, 13, 14 and 15 provided on each of the end sides 16, 17 in the longitudinal direction L of the LED lighting means 4. The distances between the two terminals 12, 13 on the end side 16 and between the two terminals 14, 15 on the end side 17 correspond to the distances between each particular contact 18, 19 provided on each of the mounting flanges 9, 10 and the centre of the LED

lighting means 4 in the longitudinal direction. The contacts 18, 19 can be formed as only seats for the male contacts of the terminals 8, 12, 13, 14, 15.

Consequently two fluorescent bulbs or tubes 3 can be replaced by the LED lighting means 4. This has the advantage that the integral LED lighting means 4 is likewise provided in the interspace, which would normally be present between the fluorescent bulbs 3, as a result of which a multitude of LEDs 22 can be uniformly distributed across the LED lighting means 4 and consequently a higher light output can be achieved.

Shown in Figure 2 are two fluorescent bulbs 3 which are inserted into the base body 5 of the lighting device 2.

The fluorescent bulbs 3 are either mounted into the contacts 18, 19 of the mounting flanges 9, 10 by insertion and twisting or by other suitable mounting means.

After the fluorescent bulbs 3 have been removed, the LED lighting means 4 can be inserted into the same contacts 18, 19 of the mounting flanges 9, 10, as shown in Figure 3. After the terminals 12, 13, 14, 15 of the LED lighting means 4 have been inserted into the same contacts 18, 19, the electric supply of the contacts 18, 19 must then be adjusted in such a way that the LED lighting means 4 can be operated instead of the fluorescent bulbs 3. For this purpose, it is expedient if it is automatically determined whether a fluorescent bulb 3 or an LED lighting means 4 has been inserted. On the one hand, this can be done by an electronic ballast 20 that, by the application of an electric test voltage or of a test current, determines if an LED lighting means 4 or fluorescent bulbs 3 are inserted. In particular, this is determined by using the fact that the electric resistance of the LEDs 22 in the LED lighting means 4 differs from that of the fluorescent bulbs 3. The automatic determination can also be made by using the fact that some of the terminals 12, 13, 14, 15 of the LED lighting means 4 are provided only for mounting but are not conducting electricity.

On the other hand, determination of whether a fluorescent bulb 3 or an LED lighting means 4 is inserted into the lighting device 2 can also be made by using the fact that the presence of the LED lighting means 4 is determined by activation of a switch which is pressed down by a suitable geometry of the LED lighting means 4, for example, by a projection. On the other hand, the presence of an LED lighting means 4 can also be determined by a proximity sensor that determines the presence of the LED lighting means 4 particularly in the normally free interspace between the fluorescent bulbs 3. Finally, the presence of the LED lighting means 4 can also be determined by providing a magnetic sensor in the base body 5 and a corresponding magnetic

element in the LED lighting means 4. The electronic ballast 20 is shown by way of example in Figures 4 and 5, wherein the electronic ballast is integrally installed in the base body 5 of the lighting device 2.

Shown in Figure 4 is the operation of two fluorescent bulbs 3 by means of the electronic ballast 20 and in Figure 5 the operation of an LED lighting means 4.

Shown in Figure 6 is a schematic top view onto a mounting flange 9 of the base body 5 of the lighting device 2, wherein the electronic ballast 20 is provided in the upper area in the height direction H. The electronic ballast 20 is preferably sunk in the base body 5. The mounting flange 9 has two contacts 18, 19 that are suitable for holding the terminals 8, 12, 13, 14, 15 of the fluorescent bulbs 3 or the LED lighting means 4. The contacts 18, 19 are particularly only slit-like recesses 23 into which the two male contacts of the respective terminals 8, 12, 13, 14, 15 can be inserted. The terminals 8, 12, 13, 14, 15 can be mounted in the contacts 18, 19. In particular, this can be done by twisting the terminals 8, 12, 13, 14, 15 or the contacts 18, 19. On the other hand, however, embodiments are also possible in which engagement of the terminals 8, 12, 13, 14, 15 in sockets is provided.

Alternatively, the fluorescent bulbs 3 can also be mounted by being screwed in, while the LED lighting means 4 is mounted by other mounting means with regard to the base body 5.

Figure 7 shows a schematic diagram of a corresponding LED lighting means 4 in the form of an LED module. In the depicted embodiment, the LED lighting means 4 comprises two printed circuit boards, arranged in parallel and with a corresponding number of LEDs 22. One end of each printed circuit board is allocated an electronic circuit comprising bridge rectifier and protective circuit in the form of a thyristor clamp circuit 24, 25. The LED lighting means 4 furthermore has pin housings 26 and 27, one on each of two ends, that are correspondingly connectable to the contacts of the lighting device. The pin housings 26, 27 can be formed with corresponding male contacts similar to the fluorescent bulbs.

As a result of the use of the electronic circuit 24, 25, it is furthermore guaranteed that LED modules that are rotated by 180° can also be operated in the luminaire because corresponding bridge circuits are provided. There is likewise the possibility that instead of one printed circuit board, for example, two or also more are arranged one behind the other and each parallel to the other(s).

Figure 8 shows a schematic diagram of a corresponding ballast 20. In particular, this serves to operate a fluorescent bulb 28 in the embodiment as shown in Figure 8. However, according to

the invention this ballast can also be used without further measures in order to operate a corresponding LED lighting means.

The electronic ballast serves to rectify an input alternating voltage and, by means of a step-up converter, to convert it to a regulated direct voltage, so-called intermediate circuit voltage. The corresponding control circuit 29 is used to do this in the known manner.

By means of a transistor half-bridge 30, after the start of the fluorescent bulb 28 the intermediate circuit voltage is chopped in differential mode with a constant switching frequency in a certain frequency range and fed to an LC series resonator 31. The corresponding fluorescent bulb 28 is connected in parallel to a capacitor of the resonator 31.

In this way, a system with constant voltage and constant frequency becomes a system with constant current corresponding to the principle of a Boucherot circuit.

If the fluorescent bulb 28 is replaced with a corresponding LED lighting means, see Figure 9, it has, in addition to the individual serially-connected LEDs 22, a bridge rectifier 32 and a protective circuit in the form of a thyristor clamp circuit 33. Bridge rectifier and protective circuit are contained in an electronic circuit 24 or 25, as the case may be, see also Figure 7, which are part of the corresponding LED lighting means or module, as the case may be.

The corresponding terminals are used to connect to the ballast in accordance with Figure 8, see also Figures 7 or 4 and 5, as the case may be.

In the case of the use of the ballast for a fluorescent bulb, the corresponding LC resonator 31 according to Figure 8 runs in open circuit operation as long as the fluorescent bulb has not yet ignited and consequently has a high ohmic resistance. I.e., the voltage on the capacitor of the resonator increases until the fluorescent bulb ignites and subsequently loads the resonator. In this process the corresponding resistance drops depending on the bulb type of the fluorescent bulb.

In order to achieve a required high starting voltage, during the starting phase the switching frequency of the half bridge 30, see Figure 8, is changed until it is close to the resonant frequency. Once the bulb 28 has ignited, the frequency is kept constant and the bulb current is at a virtually constant level, regardless of the bulb type.

In order already to load the resonator 31 according to Figure 8 during the starting phase in such a way that no high voltages occur on the capacitor of the resonator and that the resonator

immediately acts as a current source, the corresponding circuit of the LED lighting means has a bridge rectifier 32. This consists of four in particular high performance diodes, i.e., the diodes have a relatively high speed so that a corresponding direct voltage of the resonator as a current source is loaded directly with a number of the serially-connected LEDs 22.

In this connection it must be observed that a current value of the LEDs 22 according to Figure 9 is equal to the bulb current during operation of the fluorescent bulb 28 according to Figure 8. Provided here is, for example, a bulb current for a fluorescent bulb of the type 18W/T8 or 36W/T8 300 mA to 320 mA, as the case may be, which level lends itself to the operation of high performance LEDs ($> 1\text{W}$). By means of a corresponding number of LEDs 22, the voltage of the capacitor of the resonator can be adjusted in such a way that it roughly corresponds to the operating voltage of the fluorescent bulb 28 according to Figure 8.

The circuit 24 or 25, as the case may be, allocated to the LED lighting means furthermore has the protective circuit 33. This serves the compensation of possible component defects of the LEDs 22.

The ballast behaves like a constant current source in a relatively large load range. The short circuit of one or more of the serially-connected LEDs 22 according to Figure 9 is therefore not critical. A break in an LED simultaneously means a break in the entire load circuit in the corresponding resonator 31, see Figure 8. The result is a rise in the output voltage of the ballast up to a level of several 100 Veff. In modern ballasts, such high voltages are switched off within several 100 ms or less.

In order to prevent such high voltages, further measures in the LED lighting means are advantageous, see the protective circuit 33 in the form of a thyristor clamp circuit or crowbar circuit.

The ballast is short circuited by means of the protective circuit when there is a break in the load circuit. The protective circuit continuously monitors the rectified output voltage of the ballast. Upon the achievement of a specified maximum voltage source, a corresponding thyristor of the protective circuit ignites and the ballast is short circuited.

According to the invention, according to the preceding description it is possible that in a lighting device, for example, one fluorescent bulb can be replaced with an LED lighting means with a number of LEDs without mechanical or electronic changes in the construction. Such a replacement can also be made after the installation of the lighting device. Additional measures are not required.

Claims

1. Lighting device (2) with at least one contact (18, 19) into which a lighting means (3, 4) can be inserted, wherein the contact (18, 19) has electric terminals for the supply to the lighting means (3, 4) and wherein provided in the lighting device (2) is an electric or electronic ballast (20) that guarantees a suitable electric supply to a fluorescent bulb (3) or light bulb, **characterised in that** the ballast (20) can be used for a number of serially-connected LEDs (22) of an LED lighting means (4), wherein a current value of the number of LEDs essentially corresponds to a bulb current during operation of the lighting device (2) with fluorescent bulb (3).
2. Lighting device according to Claim 1, wherein the ballast (20) has a rectifier (21), a step-up converter, a transistor half-bridge (30) and an LC series resonator (31), and the fluorescent bulb (28) is connected in parallel to the capacitor of the LC step-up converter (31).
3. Lighting device according to Claim 1 or 2, wherein a bridge rectifier (32) is allocated to the LED lighting means (4).
4. Lighting device according to one of the preceding claims, **characterised in that** a thyristor clamp circuit is allocated as a protective circuit (33) to the LED lighting means (4) between LEDs (22) and bridge rectifier (32).
5. Lighting device according to one of the preceding claims, **characterised in that** the bridge rectifier (32) has four diodes that are, with regard to their reverse recovery times, adjusted to the switching frequency of the ballast (20).
6. Lighting device according to one of the preceding claims, **characterised in that** the LED lighting means (4) is developed as an LED module in which bridge rectifier (32) and thyristor clamp circuit (33) are contained, particularly in a parallel arrangement.
7. Lighting device according to one of the preceding claims, wherein the lighting device (2) is formed so as to be explosion-protected.
8. Lighting device according to one of the preceding claims, wherein the LED lighting means (4) has terminals (12, 13, 14, 15) that correspond to those of a fluorescent bulb (3), wherein

the fluorescent bulbs (3) as well as the LED lighting means (4) can alternatively be inserted into the same contacts (18, 19).

9. Lighting device according to one of the preceding claims, wherein the lighting device (2) has a base body (5) for holding the lighting means (3, 4) as well as a transparent or translucent cover (6) that is placed on to the base body (5) and that covers the lighting means (3, 4).
10. Lighting device according to one of the preceding claims, wherein the lighting device has contacts (18, 19) for holding at least two different fluorescent bulbs (3) arranged in parallel and wherein the LED lighting means (4) can alternatively be inserted into said contacts.
11. Lighting device according to one of the preceding claims, wherein the lighting device (2) is designed to be supplied with alternating voltage.
12. Lighting device according to one of the preceding claims, wherein pin housings (26, 27) for provision of terminals and particularly male contacts are arranged one on each end of the LED lighting means (4).
13. Lighting device according to one of the preceding claims, wherein each contact (18, 19) of the lighting device has a locking mechanism for locking the terminals or male contacts, as the case may be, inserted into the respective socket.