Jan. 14, 1964 W. J. KNOCHEL ET AL 3,118,086

ELECTROLUMINESCENT DEVICE WITH A BUILT-IN RESISTOR

Filed July 5, 1961

FIG. 1.

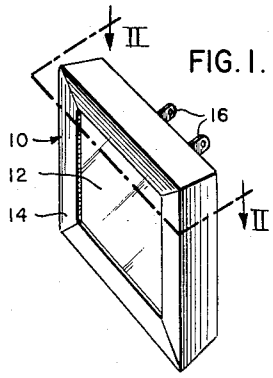


FIG. 2.

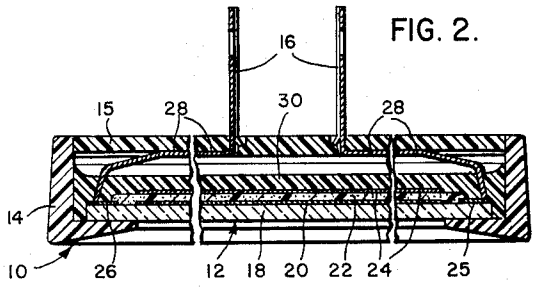


FIG. 3.

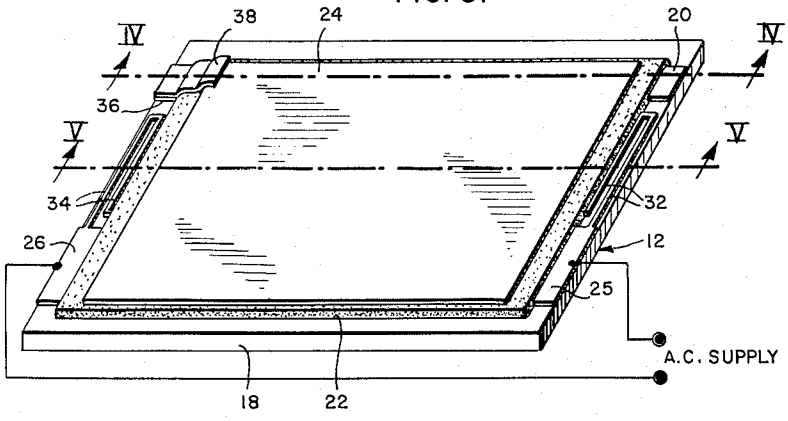


FIG. 4.

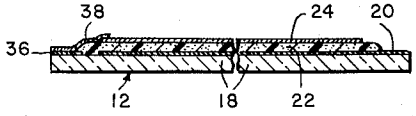


FIG. 5.

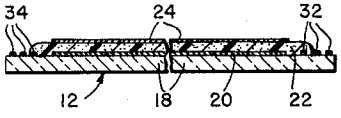
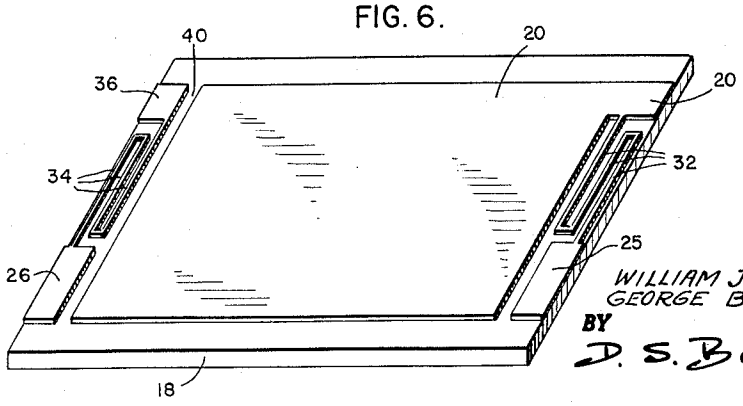


FIG. 6.



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ELECTROLUMINESCENT DEVICE WITH A BUILT-IN RESISTOR

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8 Claims. (Cl. 315—71)

This invention relates to electroluminescent devices and, more particularly, to an improved arc suppressing means for an electroluminescent lamp or the like.

The use of a current-limiting resistor to protect electrical apparatus from damage during transient overload conditions is well known. Such protection is especially important in electroluminescent devices insofar as destructive arcs and resultant puncturing of the thin electrodes and phosphor-dielectric layer therebetween can occur if the applied voltage exceeds the breakdown voltage of the layer. It has accordingly been found necessary to employ a limiting resistor in series with most electroluminescent devices to prevent damage from voltage and current surges, especially electroluminescent lamps which are designed to be operated directly from a convenient outlet.

Heretofore such limiting resistors were either inserted into the energizing circuit or made an integral part of the electroluminescent device, as shown in U.S. Patent Nos. 2,765,419 and 2,880,346, respectively. When included as an integral part of the device, the resistor in accordance with prior art practice comprised a suitable material that was admixed with the phosphor or constituted a separate sheet or layer that was placed between the phosphor layer and one of the electrodes, as disclosed in the latter of the above-cited patents.

While the prior art designs afforded the desired overload protection, they were not entirely satisfactory insofar as they required modification of the power supply circuit or the use of an additional element in the electroluminescent device—both of which are undesirable from a cost and engineering standpoint.

It is accordingly the general object of the present invention to provide a simple and inexpensive means for suppressing arcs in such devices as electroluminescent lamps that are susceptible to damage from current and voltage surges.

Another and more specific object is the provision of an integral current-limiting means for an electroluminescent device that can be fabricated and incorporated into the device with a minimum amount of labor and material.

Still another object is the provision of a component for an electroluminescent device wherein the limiting resistor and associated contact comprise a "printed circuit" component that is integral with one of the device electrodes.

The foregoing objects, and others which will become apparent as the description proceeds, are achieved by forming the resistor from the same material as one of the electrodes conventionally employed in electroluminescent devices. More specifically, a strip of predetermined width and length composed of the same material as the light-transmitting electrode is provided along at least one edge of the device and is connected to the aforesaid electrode to serve as a "built-in" limiting resistor. The contacts for connecting the device with a voltage source are also made from the same material thereby further simplifying the design and manufacture of the device.

A better understanding of the invention will be obtained by referring to the accompanying drawing, wherein:

FIGURE 1 is a perspective view on a reduced scale of a plug-in electroluminescent lighting unit which incorporates the present invention;

FIG. 2 is a cross-sectional view through the lighting unit along the line II—II of FIG. 1, in the direction of the arrows;

FIG. 3 is a pictorial view of the electroluminescent lamp component employed in the lighting unit shown in the preceding figures;

FIGS. 4 and 5 are cross-sectional views through the lamp component along the lines IV—IV and V—V, respectively, of FIG. 3, in the direction of the arrows; and

FIG. 6 is a pictorial view of the improved base-and-printed circuit component of this invention employed in the lamp embodiments shown in the preceding figures.

While the present invention can be advantageously employed in various types of electrical devices that are susceptible to damage from arcs caused by temporary overloads, it is especially adapted for use in conjunction with an electroluminescent lamp and has accordingly been so illustrated and will be so described.

With specific reference now to the drawings, in FIGS. 1 and 2 there is shown a lighting unit 10 which comprises an electroluminescent lamp 12 that is mounted in a frame 14 of suitable non-inflammable plastic or the like. As shown more particularly in FIG. 2, a pair of prongs 16 project from the back of the lighting unit to provide plug-in terminals for a convenience outlet. The prongs constitute the outer ends of generally L-shaped spring metal contactor members 28 which are rigidly anchored to and project through an insulating panel 15 of plastic or the like secured to the back of the frame 14. The inner ends of the contactor members are compressed by the back panel into pressure engagement with the bus bar areas or tabular contacts 25 and 26 of the electroluminescent lamp 12. A filling 30 of suitable thermosetting resin such as non-inflammable epoxy or the like is applied over the back and around the edges of the lamp 12, as illustrated in FIG. 2, thereby locking the lamp within the frame and sealing it off from the atmosphere. The inner ends of the contactor members 28 are embedded in and extend through the protective plastic filling and are thus permanently locked in positive electrical engagement with the lamp contacts. An electroluminescent lighting unit of this type adapted for use as a safety or night light is disclosed and claimed in copending application Serial No. 825,961 of W. J. Knochel et al., filed July 9, 1959, now U.S. Patent No. 3,056,898, assigned to the assignee of the present invention.

As shown in FIGS. 3 to 5 of the drawing, the electroluminescent lamp 12 is of the well-known glass-plastic construction wherein a nonconductive base member such as a glass base plate 18 is coated, in the order named, with a light-transmitting electrode 20, an electroluminescent phosphor-dielectric layer 22 and finally by a second electrode 24 of vaporized metal such as aluminum or the like in accordance with standard lamp-making practice. The light-transmitting electrode 20 comprises a thin layer of a suitable electrically-conductive material such as tin oxide or the like that is bonded to the glass base plate 18 and forms a substantially transparent film. Transparent conductive coatings of this type are used as heating elements for windshields and the like and can be fabricated by spraying the hot glass with a tin halide solution or by any of the other well-known techniques. Since the coating transmits visible radiations it can be broadly characterized as being "radiation-transmitting."

In accordance with the present invention, the desired current-limiting resistor comprises a narrow elongated strip 32 that is composed of the same material as and extends along one edge of the light-transmitting electrode 20, as shown in FIGS. 3 to 5 and most clearly in FIG. 6. The resistive strip accordingly constitutes what may be termed a "printed resistor" that is integral with and constitutes an extension of the light-transmitting electrode.

In order to provide an impedance of a sufficiently high value in the relatively small space available (the safety lamp 12 in the embodiment here shown is only 2" wide and 2½" long), the strip 32 is made very narrow in comparison to its length and preferably is of "non-linear" configuration. That is, it follows a tortuous path between the electrode 20 and the bus-bar contact 25 to which it is connected. As shown, the strip in the particular embodiment illustrated is of retroverted rectangular configuration and extends between one edge of the light-transmitting electrode 20 and the proximate edge of the glass base plate 18.

Even though a film of tin oxide approximately 2 to 3×10^{-6} inches thick, for example, has a resistance of around 65 ohms per square, it has been found that the desired value of resistance of at least 40,000 ohms can be obtained by making the strip 32 thin and long enough. The term "ohms per square" refers to the resistance measured between one electrode placed at the center of a circular segment of tin oxide film 1" in diameter and a group of twelve interconnected electrodes equally spaced around the periphery of the circle. As a specific example of a resistive strip suitable for use with the electroluminescent safety light 10 of the type here shown designed to operate on a 115–120 volt circuit, a retroverted strip of tin oxide of the type shown in FIG. 6 approximately 2 to 3×10^{-6} inches thick, 0.015 inch wide and 2$\frac{5}{16}$ inches in length (total) has a resistance in the order of 40,000 ohms and has given satisfactory results. It has been found that the impedance of the resistive strip can vary between about 18,000 to 55,000 ohms, depending upon the magnitude of the variations in the strip dimensions, particularly its thickness.

In order to insure that a sufficiently high resistance is placed in series with the lamp 12, a second resistive strip 34 is provided at the opposite edge of the base plate 18, as shown in FIGS. 3 to 6. In this case, however, the strip is electrically insulated from the light-transmitting electrode 20 by an opening or gap 40 in the conductive film that extends completely across the film.

In addition to the resistance strips 32 and 34, the associated bus bar contacts 25 and 26 are also preferably fabricated from the same conductive film used in making the light-transmitting electrode 20. As will be noted in FIG. 6, the contact-resistive strip networks 25—32 and 26—34, respectively, together with the glass base plate 18 and light-transmitting electrode 20 form what may be termed a "base-and-printed circuit component" for the electroluminescent lamp 12. The resistive strips and their associated contacts can be formed simultaneously with the light-transmitting electrode by silk screening the conductive material onto the glass base plate, or by depositing a continuous film on the plate and then removing preselected portions of the film to form the respective strips, electrode and contact elements.

To facilitate connecting the insulated bus-bar contact 26 to the metallic electrode 24, an integral auxiliary tabular contact 36 of generally rectangular configuration is provided at the end of the resistive strip 34 opposite the main contact 26, as shown most clearly in FIG. 6. After the phosphor-dielectric layer 22 and metallic electrode 24 have been formed, a conductive strap or jumper 38 such as a layer of silver paint or the like is applied over the auxiliary contact and the proximate portions of the phosphor-dielectric layer and metallic electrode, as indicated in FIGS. 3 and 4. The metallic electrode is thus connected to the exposed main contact 26 through the resistive strip 34 so that two "built-in" impedances are placed in series with the lamp 12.

As will be noted in FIGS. 3 to 5, the metallic electrode 24 is considerably smaller in area than the phosphor-dielectric layer 22 and the latter overlies the inwardly disposed portions of the contact-resistive strip networks. This avoids any possibility whatever of a short circuit occurring between the two electrodes. Moreover, since

the resistor and contact elements are extremely thin the protective filling 30 is proportionately thicker in these critical areas (see FIG. 2) thereby affording a greater degree of protection against vapor penetration.

While a generally rectangular retroverted strip configuration has been illustrated, it will be obvious that other "non-linear" or retroverted configurations such as a sawtooth or sinusoidal pattern can also be used. The same integral printed resistive strip-and-contact "circuit" can also be employed in ceramic type electroluminescent devices.

It will be appreciated from the foregoing that the objects of the invention have been achieved insofar as a limiting resistor and associated contact means have been provided which not only constitute an integral part of the electroluminescent device but which can be very conveniently and inexpensively fabricated from the same material as and simultaneously with one of the device electrodes.

While a preferred embodiment has been illustrated and described in detail, it will be understood that various modifications in the configuration and organization of parts may be made without departing from the spirit and scope of the invention.

We claim:

1. In an electroluminescent device having a pair of spaced electrodes, one of which comprises a layer of radiation-transmitting electrically-conductive material, the combination of a contact for connecting said radiation-transmitting electrode to a power supply, and current-limiting means connecting said radiation-transmitting electrode to said contact, said current-limiting means comprising an elongated strip of predetermined resistance that is electrically connected to and fabricated from the same material as the radiation-transmitting electrode.

2. The combination, in an electroluminescent device, of a radiation-transmitting electrode, a contact, and an interconnecting resistive strip as set forth in claim 1 wherein said resistive strip is of non-linear configuration and defines a tortuous path between said radiation-transmitting electrode and said contact.

3. The combination, in an electroluminescent device, of a radiation-transmitting electrode, a contact, and an interconnecting resistive strip as set forth in claim 1 wherein, said contact comprises a tabular element that is integral with and composed of the same material as said resistive strip, and said resistive strip comprises an integral part of said electrode.

4. The combination, in an electroluminescent device, of a radiation-transmitting electrode, a contact, and an interconnecting resistive strip as set forth in claim 1 wherein said radiation-transmitting electrode, resistive strip, and contact are supported by and are bonded to a non-conductive base member.

5. The combination, in an electroluminescent device, of a base member, a radiation-transmitting electrode, a contact, and an interconnecting resistive strip as set forth in claim 4 wherein said contact and resistive strip are located near and extend along an edge of said base member.

6. An electroluminescent device comprising, a base member, a light-transmitting electrode comprising a layer of electrically-conductive material on said base member, a layer containing an electroluminescent phosphor over said light-transmitting electrode, a second electrode comprising a layer of conductive material over said phosphor-containing layer, a resistive strip of predetermined length and width and a first contact located near an edge of said base member, a second contact located near another edge of said base member and electrically insulated from said light-transmitting electrode, and means electrically connecting said second contact to said second electrode, said first and second contacts and said resistive strip being fabricated from the same material as said light-transmitting electrode, and said first contact being electrically connected to said light-transmitting electrode by said resistive strip and together therewith comprising an integral

printed circuit extension of said light-transmitting electrode.

7. A component for an electroluminescent device or the like comprising, a base member of electrically-nonconductive material, a radiation-transmitting layer of electrically-conductive material on said base member, and a contact and interconnecting resistive strip integral with and composed of the same material as said radiation-transmitting layer, said contact and resistive strip being located between an edge of said radiation-transmitting layer and the proximate edge of said base member.

8. A component for an electroluminescent device or the like as set forth in claim 7 wherein, said base member comprises a glass plate, and said glass plate carries a

second contact-resistive strip network that is electrically insulated from said radiation-transmitting layer and located proximate another edge of said glass plate.

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