

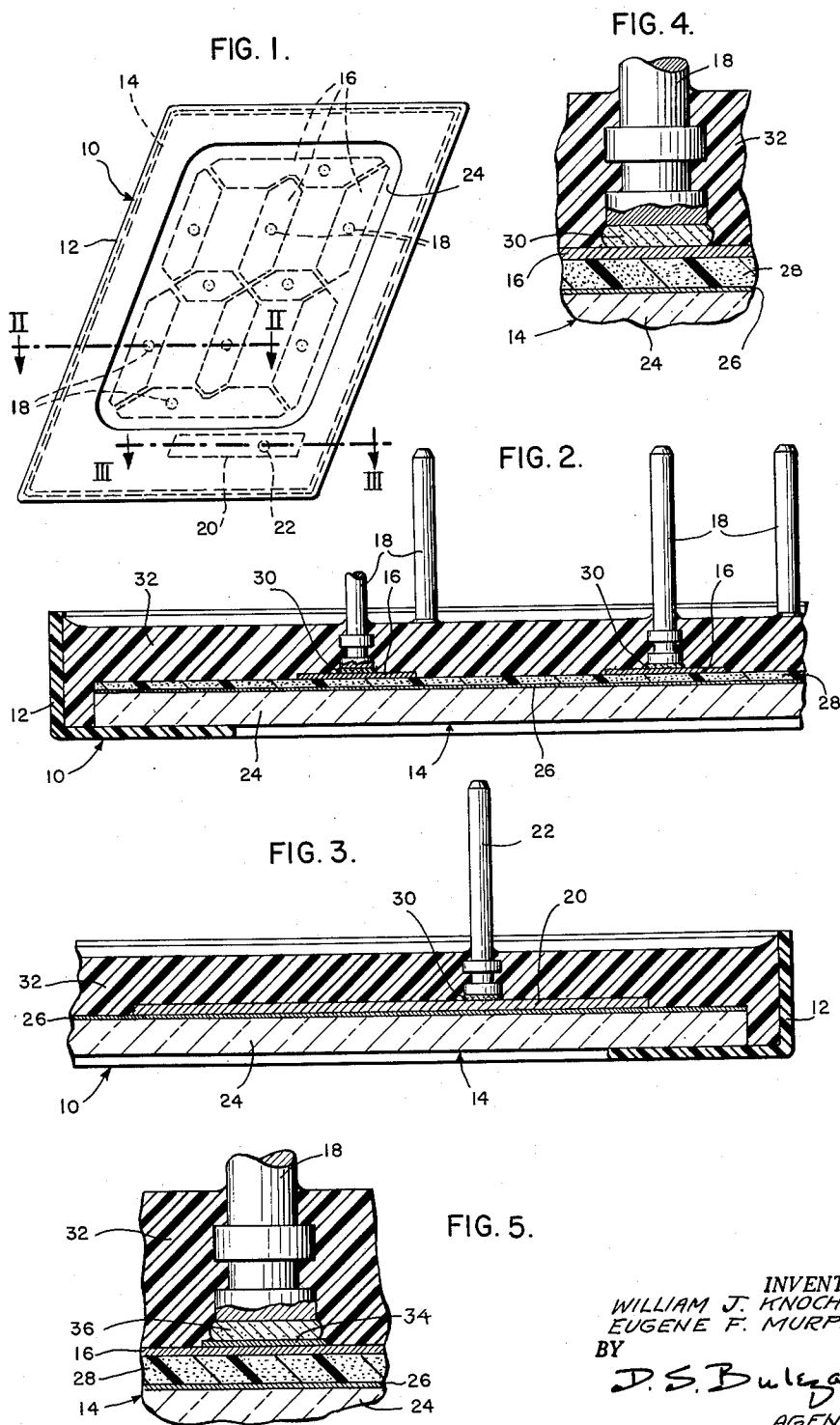
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ELECTROLUMINESCENT DEVICE AND TERMINAL MEANS THEREFOR

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3,133,221 ELECTROLUMINESCENT DEVICE AND TERMINAL MEANS THEREFOR

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This invention relates generally to electroluminescent lighting devices and, more particularly, to an improved terminal and electrical connection for such devices.

When fabricating electroluminescent lamps it is frequently necessary to attach the power leads or lead-in conductors directly to one or both of the lamp electrodes rather than to the usual bus bar or a reinforced edge portion of the electrode. This type connection is required in the so-called "segmented" lamps employed as display devices, for example, wherein a composite metal electrode consisting of a plurality of discrete segments is provided to enable preselected portions of the lamp to be lighted to form numerals, letters, etc. In devices of this character a separate lead-in conductor has to be fastened directly to each of the segments of the composite metal electrode. This direct electrode-to-conductor type of connection is also required in those cases where the dimensions of the lamp or light-emitting face thereof are such that there is no room for the usual bus bar area along one side of the lamp.

Satisfactory connections of the foregoing character are inherently very difficult to make insofar as a portion of the light-emitting area of the lamp is involved and the metal electrode is customarily formed by vapor deposition and is thus very thin and easily deformed or punctured. When this occurs variations in the applied electric field occur in the contact region resulting in an undesirable dark or bright spot thereat when the lamp is lighted.

Such connections are even more difficult to make in the case of "plastic" type lamps insofar as the phosphor-plastic dielectric layer must be sealed off from the atmosphere. Attempts to fasten the lead-in conductor directly to the metal electrode with commercially available hardenable plastic not only failed to eliminate the objectionable nonuniformity in brightness of the lighted lamp in the contact region but, in certain instances, even aggravated this condition. It is believed that the solvents and other fluid components of such hardenable plastics pass through the metal electrode, which is thin and rather porous, and react with the phosphor-plastic dielectric layer therebeneath in such a way as to drastically change its light-generating characteristics. Whatever the reason, the problem of unsightly variations in brightness at the point of contact remained.

Achieving the desired direct connection mechanically by means of spring-biased contactors has also been tried. Such contactors were anchored to the back of the lamp and located to make pressure contact with the various segments of the composite metal electrode. Apart from being costly this construction presented the additional problem in plastic type lamps of forming air-tight seals around the contactor members in order to prevent the ingress of water vapor and other gaseous impurities through the protective backing and subsequent deterioration of the phosphor.

In view of the foregoing, it is the general object of the present invention to provide an improved electroluminescent device which will overcome the foregoing and other deficiencies of the prior art structures.

Another and more specific object is the provision of

terminal means for an electroluminescent device which can be very conveniently and quickly attached directly to the lamp electrodes without damaging them.

Still another object is the provision of means for effecting a durable and positive electrical connection directly between a lead-in conductor and the metal electrode of a plastic type electroluminescent lamp without deleteriously affecting the performance quality of the lamp.

The foregoing objects, and others which will become obvious as the description proceeds, are achieved in accordance with this invention by effecting the electrical juncture of the electrode and lead-in conductor with a conductive cement or adhesive material which is pliable, and remains pliable even after the fabrication of the lamp has been completed, and then embedding both the interposed layer of pliable adhesive and the joined end of the conductor in a layer of cured plastic or the like. The pliable cement is thus held in place between and in intimate contact with the joined members thereby not only providing the desired positive and durable juncture thereof but serving as a sort of cushion which prevents the end of the conductor from deforming or puncturing the electrode during or after the fabrication of the lamp. Since it is tacky the adhesive material affords the additional advantage of holding the lead-in conductor in place until it is permanently fastened to the lamp by the layer of cured plastic. Rigid lead-in conductors of special configuration and specific formulation of adhesive material as well as an alternative form of juncture are also provided.

A better understanding of the invention will be obtained from the accompanying drawing wherein:

FIG. 1 is a front elevational view of an electroluminescent digital-display device incorporating the improved terminal and electrical connection of this invention;

FIG. 2 is a fragmentary cross-sectional view on an enlarged scale along the line II—II of FIG. 1, in the direction of the arrows;

FIG. 3 is a similar view along the line III—III of FIG. 1 in the direction of the arrows, illustrating the pin connection to the bus-bar portion of the light-transmitting electrode;

FIG. 4 is an enlarged view of the preferred form of electrical juncture between the pins and segments of the composite metal electrode shown in FIG. 2; and

FIG. 5 is a similar view of another form of juncture in accordance with the invention.

While the improved terminal and electrical connection of this invention can also be advantageously employed in ceramic type lamps, it is especially adapted for use in lamps of plastic construction and accordingly has been so illustrated and will be so described.

In FIG. 1 there is shown an electroluminescent digital-display device 10 consisting in general of a frame 12 containing an electroluminescent lamp 14 having a plurality of separately operable segments arranged in a preselected pattern, such as a split "figure 8" as in the case here shown.

As illustrated more particularly in FIG. 2, for each of the aforesaid lamp or illuminable segments there is provided a thin metallic electrode segment 16 of the same configuration, which electrode segments are electrically insulated from each other and together comprise a composite electrode. These electrode segments are connected in accordance with the present invention to lead-in conductors such as pins 18 by means of a thin layer 30 of pliable and electrically-conductive adhesive material. The joined end portions of the pins 18 and the layer 30 of conductive adhesive are both hermetically embedded

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in a rigid layer 32 of cured plastic, such as a hardenable epoxy resin or the like, that covers the back and sides of the lamp and, in the case of the plastic type lamp here shown, serves as a protective backing and a vapor barrier. Thus, when the display device 10 is plugged into a suitable socket, selected ones of the illuminable segments can be energized by means of a suitable switching arrangement to form any number from 0 to 9 in the well-known manner.

The electroluminescent lamp 14 is of plastic construction and, as shown in FIG. 2, comprises a light-transmitting base or substrate 24 over which are formed the customary light-transmitting electrode 26, phosphor-plastic dielectric layer 28, and the segments 16 of the composite metal electrode, in that order. A more detailed description of this type electroluminescent display device is given in U.S. Patent No. 2,922,993 issued to E. A. Sack, Jr. and owned by the present assignee.

As shown in FIG. 2, and more particularly in FIG. 4, the embedded end portions of the pins 18 are preferably enlarged and provided with flat end surfaces that are substantially parallel to and connected with the respective metal electrode segments 16 by means of the aforesaid layer 30 of conductive adhesive material.

While various adhesive materials may be employed, exceptionally good results have been obtained by using a mixture of carbon black, silver flake and an epoxy resin that is non-hardenable—that is, an epoxy resin which does not contain the usual solvents, hardeners, etc. and is therefore 100% solids. As a specific example of such a mixture, 6% by weight of carbon black or powdered graphite and 13% by weight of silver flake are admixed with 81% by weight of a suitable 100% solids epoxy resin such as epoxy ERL 3794 marketed by the Union Carbide Plastics Co. However, any commercially available conductive epoxy or plastic resin may be employed providing it does not contain solvents or any other fluid additives that would deleteriously react with the phosphor-plastic dielectric layer 28. In fact, satisfactory connections have been made with the aforesaid epoxy resin ERL 3794 without the aforesaid silver flake or graphite. This is rather surprising in view of the fact that epoxy resins without such additives are normally not electrically conductive. However, insofar as the pins 18 are firmly pressed against the metal electrode segments 16 to hold them in place until the protective coating or layer 32 of hardenable plastic is applied, it is believed that the layer 30 of non-hardenable epoxy is compressed and made so thin that it conducts the small currents involved. Whatever the reason, satisfactory lamps have been made and operated by using unmodified non-hardenable epoxy resin as the conductive adhesive material.

Since both the enlarged end portions of the pins 18 and the layer 30 of adhesive material are both hermetically embedded in the protective backing 32 of cured plastic, the adhesive material, even though pliable, is held in place between and in intimate contact with the pin and metal electrode surfaces. Thus, the occluded adhesive layer 30 not only effects a durable and positive electrical juncture of the aforesaid members but serves as a cushion, so to speak, that prevents the end of the pin from deforming or puncturing the thin metal electrode during or after the fabrication of the lamp. Because it is tacky the adhesive material 30 affords the additional advantage of keeping the pins 18 in place until they are permanently anchored to the back of the lamp by the rigid protective plastic layer 32.

A layer 30 of adhesive material is also desirably employed to connect the pin 22 to the light-transmitting electrode 26, or, as shown in FIG. 1 and more particularly in FIG. 3, to a much thicker bus bar 20 of silver paint or the like that overlies a part of the light-transmitting electrode that is remote from the light-emitting segments of the lamp.

In FIG. 5 there is shown another form of juncture

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wherein the carbon black, instead of being admixed with the adhesive material as in the above-described preferred embodiment, is applied to the metal electrode segment 16 separately to provide a layer 34 of carbon in the contact area. The layer of adhesive material 36 in this case is the same as that used in the aforesaid preferred embodiment except that it does not contain carbon black as an additive. The role played by the carbon black or graphite in preventing the occurrence of light or dark spots in the area of contact when the various segments are lighted is not known but optimum results are obtained when it is present and its use therefore, either in the form of a separate layer or as a constituent of the adhesive material, while not essential is desirable.

Comparative tests have shown that digital-display lamps fabricated in accordance with this invention do not show any signs of bright or dark spots in the contact area after thousands of hours of operation whereas control lamps having pins connected to the metal electrode segments with commercially available hardenable conductive epoxy resins developed unsightly dark areas after as little as 24 hours of operation.

If desired, metal straps of nickel, copper, etc. approximately 0.002" to 0.012" thick can be used as the lead-in conductors instead of the rigid pins 18 and 22 described above.

It will be apparent from the foregoing that the objects of the invention have been achieved by providing an improved terminal and electrical connection for electroluminescent devices, particularly those of plastic construction, wherein a very durable and positive juncture of the terminals and metal electrodes is achieved without affecting the performance quality of the lamp.

While several embodiments have been illustrated and described, it will be understood that various modifications may be made without departing from the spirit and scope of this invention.

We claim:

1. In an electroluminescent device having a light-emitting portion comprising a phosphor-plastic dielectric layer and a thin metal electrode that are protected from the atmosphere by a rigid overlying coating of cured plastic, terminal means for connecting said metal electrode to an electrical power source comprising;

a lead-in conductor having one end hermetically embedded in said protective plastic coating, and a thin layer of electrically-conductive adhesive material disposed between and electrically connecting the embedded end of said lead-in conductor with the underlying portion of said metal electrode,

said adhesive material consisting of a 100% solids mixture of electrically-conductive particles and a non-hardenable plastic resin that is inert with respect to said phosphor-plastic dielectric layer and is held between and in positive electrical contact with said lead-in conductor and metal electrode by said protective plastic coating.

2. Terminal and electrical connection means for a plastic type electroluminescent device as set forth in claim 1 wherein said non-hardenable adhesive material consists essentially of a 100% solids mixture of silver flake and epoxy resin.

3. Terminal and electrical connection means for a plastic type electroluminescent device as set forth in claim 1 wherein said non-hardenable adhesive material consists essentially of a 100% solids mixture of the following constituents in approximately the indicated percent by weight:

Constituent:	Percent by weight
Carbon black -----	6
Silver flake -----	13
Epoxy resin -----	81

4. In an electroluminescent device having a light-emitting portion which includes a phosphor-plastic dielectric

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layer and a superimposed thin metal electrode that are protected from the atmosphere by a rigid overlying layer of cured plastic, means for connecting said metal electrode to an electrical power source comprising;

a lead-in conductor having one end hermetically embedded in said rigid protective plastic layer and disposed proximate said metal electrode, 5
a thin layer of powdered graphite over the portion of said metal electrode underlying the embedded end of said lead-in conductor, 10
and a thin layer of electrically-conductive adhesive material disposed between said layer of powdered graphite and the embedded end of said lead-in conductor, 15
said adhesive material consisting of an unmodified non-hardenable plastic resin that is inert with respect to said phosphor-plastic dielectric layer and is held in place between and in positive electrical contact with said layer of graphite and the embedded end of said lead-in conductor by the rigid protective plastic layer. 20

5. In an electroluminescent display device having a plurality of separately energizable segments each comprising a light-transmitting electrode, a thin metal electrode, an electroluminescent phosphor disposed between said electrodes, and a rigid layer of insulating material that overlies each of the metal electrodes and constitutes the back of said device, terminal means for electrically and

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separately connecting each of said metal electrodes and the associated segments of the device with an electrical power source comprising;

a metal contactor pin hermetically anchored in and extending through and rearwardly of a portion of said rigid insulating layer that overlies one of said metal electrodes so that the latter is disposed proximate the inner end of said pin, and

a layer of non-hardenable unmodified plastic resin located between and electrically connecting the inner end of said pin and the underlying portion of said metal electrode,

said connecting layer of non-hardenable plastic resin being held in place between said metal electrode and the end of said pin by said rigid layer of insulating material and thereby providing a protective shock-absorbing cushion between said pin and the thin metal electrode.

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