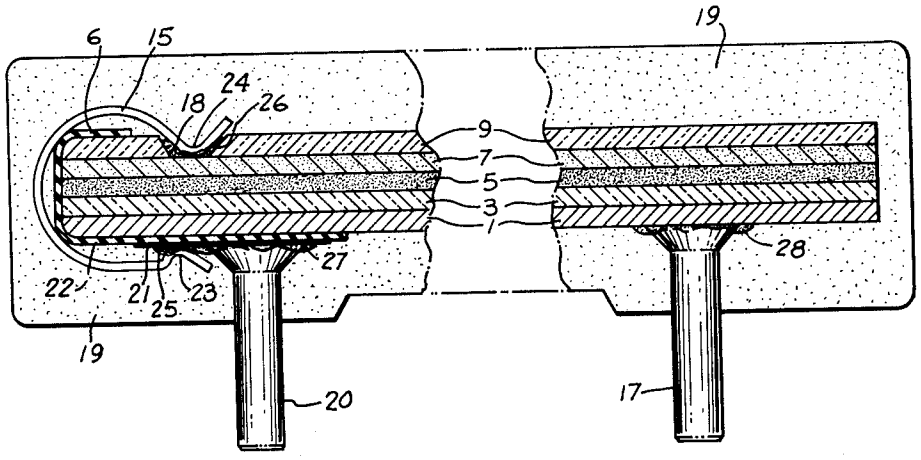
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ELECTROLUMINESCENT CELL HAVING ELECTRICAL CONTACT WITH INCREASED RELIABILITY

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ELECTROLUMINESCENT CELL HAVING ELECTRICAL CONTACT WITH INCREASED RELIABILITY

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This invention relates to pressure and spring type electrical contacts encapsulated in plastic. Particularly, this invention concerns encapsulated electroluminescent devices having spring or pressure type electrical contacts of increased reliability.

Encapsulated electrical contacts are known to the art and methods have previously been devised for their fabrication. Examples of devices using these encapsulated contacts are described in the copending applications of George H. Bouchard, Serial Number 51,554 filed August 8, 1960 entitled Electroluminescent Device and Robert S. Bowser et al. Serial Number 130,661, filed August 10, 1961, entitled Electroluminescent Device, each of which is assigned to the assignee of the instant application.

Certain problems have arisen in electroluminescent devices encapsulated in plastic when pressure or spring type electrical contacts are used for conducting current to a film of metal oxide which serves as an electrode of the device. Often such contacts tend to loosen when subjected to vibration or shock, thus breaking the circuit and rendering the device inoperative. Also, as the plastic ages it will pull the contact away from the contact surface. Because of the possibility of heat damage to the metal oxide, the above-mentioned types of electrical contacts cannot be welded or soldered thereto. Another difficulty with such contacts is produced by encapsulation media. Particularly when encapsulating with epoxies, which have a tendency to wet very close surfaces, these materials will coat and insulate the contacts from each other. Of course, after such coating and insulation, the electrical circuit will be broken, even if the contact is quite close. Often the defect cannot be detected until after the resin has hardened and thus the electroluminescent device is useless; reworking cannot be economically effected.

To eliminate these problems and difficulties, we have formulated a so-called "conductive grease" which we prepare by milling a suitable finely divided electrically conductive material such as carbon, aluminum, gold, silver, platinum, copper, iron or nickel into a compatible polymer which generally is the same polymer as the encapsulation media. We may use 10% to 50% by weight electrically conducting material in the mixture and no catalysts are added so that the grease will always remain fluid.

After milling, a small portion of the conductive grease is applied to the base contact point and the spring or pressure contact is forced upon this coated base. The device is then ready for encapsulation in plastic according to conventional techniques. The encapsulation media will harden and surround the still-fluid grease. When using an epoxy resin for the dispersing media of the grease and an epoxy containing a catalyst for the encapsulation media, the outer surface of the conductive grease hardens and prevents the encapsulation media from creeping between the contacts. Thus, insulating encapsulation media cannot effectively penetrate and break the circuit.

Accordingly, the primary object of this invention is the assurance of reliable electrical connections with pressure or spring type electrical contacts encapsulated in plastic.

Another object of our invention is the assurance of reliable electrical connections with pressure or spring type electrical contacts used in encapsulated electroluminescent devices.

A feature of this invention is the use of a finely divided, electrically conductive material dispersed in polymer to form an electrically conductive grease of heavy viscosity.

Another feature of this invention is that the conductive grease remains in a viscous but fluid state when disposed between the electrical contacts.

An advantage of this invention is that a positive and reliable electrical connection is always afforded in an encapsulated electrical device.

The many other objects, features and advantages of the instant invention will become manifest to those versed in the art upon reading the following specification, when taken in conjunction with the accompanying drawings, wherein a specific embodiment of this invention is shown and described by way of illustrative example.

Referring to the figure, a cross section of an encapsulated electroluminescent device is shown together with pressure type and spring type electrical contacts.

Describing now the structure of the electroluminescent device, base electrode 1 is preferably prepared of a metal plate, since such a material imparts stability, however it is apparent that many other materials also can be used. For example, the base electrode 1 may be prepared of a metal foil or of other material, such as glass which has been rendered electrically conductive. In these latter examples, the device has the added features that it may have two light emitting faces or may be flexible.

When desired, a ground coat layer 3 prepared of a layer of low melting, ceramic dielectric material of known and suitable composition is coated over the base electrode 1 to provide a bonding surface for light producing layer 5. It has been found that when using a metal plate for the base electrode 1, permanent adherence of the glass dielectric, light producing layer is rather difficult to establish, unless a ground coat is used. However, the ground coat may be omitted if the light producing layer readily adheres to base electrode 1, such as would be the case if the electrode is electrically conductive glass.

Superposed upon the ground coat 3 or on the base electrode 1, as desired, is a light-emitting layer 5 which is generally prepared of an electroluminescent phosphor suspended in a light-transmitting dielectric material. The electroluminescent phosphor may be for example a copper activated zinc sulfide such as described in the copending application of Goldberg et al. entitled Electroluminescent Device, Serial No. 714,484 filed February 11, 1958. The light-transmitting dielectric may be for example a glass frit such as described in the application of Richard M. Rulon, Serial No. 365,617 filed July 2, 1953.

Adhering to the light-emitting layer 5 is a coating which forms a light-transmitting electrode 7. This coating may be applied by spraying the light-emitting layer 5 with a solution of metal compounds, for example chlorides, oxides, sulfates or organic complexes of tin, antimony or indium; however other available methods of applying an electrically conductive coating are for example, dipping or vapor deposition of metals. If the light-emitting layer 5 is hot when the solution of metal compounds is applied, a metal oxide of the metal compound will be formed, however other methods may also be devised for formation of the metal oxide layer.

After the application of the light-transmitting electrode 7 on the face of the light-emitting layer 5, it is good

practice to protect the various layers of the electroluminescent device from the effects of humidity and the possibility of scratching. Such protection is conveniently afforded by forming a glass or other suitable protective layer 9 over the light-transmitting electrode 7. In a few cases however, the protective layer 9 may be eliminated and the light-transmitting electrodes 7 will then serve as the face of the electroluminescent device. Since protective layer 9 is an insulator and since electricity must be conducted to light-emitting layer 7 to illuminate the device, a cavity is provided in protective layer 9 to expose an electrical connection. Conveniently, the cavity may be produced by masking the light-transmitting electrode 7 before the protective layer 9 is applied. Thus when the masking is removed, the light-transmitting electrode 7 is exposed for electrical contact.

For many applications of electroluminescence, it is desirable to have lead-in conductors extending from the rear of the device through an encapsulating resin layer 19. Pressure type connector studs 17 and 20 are provided for this purpose. Connector stud 20 butts against a printed circuit which comprises a conductor 21 on an insulator 22, such as copper or silver on Mylar or vinyl. The insulator 22 insulates the current carried by lead-in prong 20 from the base electrode 1. A side insulator 6 which is a unitary prolongation of the insulator 22 is folded over the edge of the electroluminescent device to insulate a spring-type, electrical contact clip 15 from the various layers. Conductive clip 15 not only conducts current, but also tightly holds the printed circuit against the electroluminescent device. Since one end of clip 15 is forced against printed conductor 21 and since the other end is in electrical communication with the light-transmitting electrode 9, electricity will be conducted from connector stud 20, through conductor 21 and conductive clip 15 to light-transmitting electrode 9. Connector studs 17 and 20 are held rigidly in place by the encapsulating plastic 19 which surrounds not only the electroluminescent device but also each electrical connection. The electrical connection between the connector studs 17 and 20 results chiefly from the pressure exerted by the stud butting against the respective elements.

Each end of the spring type contact clip 15 is provided with biasing surfaces 23 and 24 which are pressured against the light-transmitting electrode 7 and the conductor 21 respectively. The conductive clip 15 is prepared of hard, spring-type brass, phosphorus bronze or beryllium copper, although tempered steel and resilient aluminum may also be used.

We assemble the electroluminescent device in the manner conventional with the art. But after each of the layers of the device has been formed and before the spring clip 15 has been placed in position, and before pressure type connector studs 17 and 20 are butted against the base electrode 1 and the conductor 21 respectively, we place a small dab of the conductive grease on the contact points. Between the biasing surfaces 23 and 24 and the conductor 21 and light-transmitting electrode 7 we have placed dabs of conductive grease 25 and 26 respectively. Because the pressure contacts made by connector stud 20 contacting the conductor 21 and connector stud 17 contacting the base electrode 1, we place dabs of 27 and 28 respectively of conductive grease.

In this manner, the wetting action of the encapsulating resin on the electrical contacts is eliminated together the prevention of the resin's tendency to seep or draw into close spaces. Upon subsequent encapsulation, a positive and reliable electrical contact will be insured.

Many resins may be used for the encapsulation media and the judicious selection of the proper plastic will depend upon the conditions under which the electroluminescent device will be operated. For example, it is possible to use thermosetting resins such as allyl casting resins, phenolic casting resins, epoxy resins, glyceryl-phthalate casting resins and polyester casting resins. Additionally, more opaque thermosetting resins such as diallylphthalate molding resins, epoxy molding resins, furan molding resins, melamine formaldehyde molding resins, polyester molding resins, polyacrylate molding resins and ureaformaldehyde resins also have applicability. Furthermore, relatively transparent thermoplastic resins may be used such as methylmethacrylate, cellulose nitrate, ethylcellulose acetate, cellulose propionate, cellulose acetate butyrate or polychlorotrifluoroethylene. Moreover, we may use vinyl-allyl, vinyl-butyral and vinyl-chloride molding resins. But these resins which we have recited are only exemplary of some which may be used for encapsulating our electroluminescent device and are not to be taken as indicative of a complete or entire list of resins which have possible applicability. As we have stated, the conductive grease which we place between electrical contacts in our device is a dispersion of a very finely divided electrical conductive material such as acetylene black, aluminum, gold, silver, platinum, copper, iron or nickel together with a polymer which is compatible with the encapsulation media, but to which no catalyst has been added. Preferably conductive carbon is used in the grease. The reason for not adding a catalyst is so that permanent fluidity is maintained in the conductive grease even after the encapsulation media has set and hardened. In this manner, an electrically conductive pocket of fluid, viscous grease is maintained so that a barrier is formed against the penetration of encapsulation media. This pocket also eliminates another problem long prevalent in encapsulated lamps, usually as the encapsulating plastic hardens, it tends to shift the contacts and unless a fluid conductive seal is maintained, the circuit would be broken. Many different resins are possible as the dispersant to form the conductive grease. For example, when using an epoxy plastic for encapsulation, the dispersant would normally be an epoxy.

While certain specific embodiments of the invention have been described in detail, the same are intended as illustrative and not in order to limit the invention thereto. The scope of the invention is to be determined by the appended claims.

As our invention we claim:

1. An encapsulated electroluminescent lamp having at least two superposed electrodes, at least one of which is light transmitting, and a layer of light-emitting material including an electroluminescent phosphor interposed between said electrodes; means to conduct current to at least one electrode in said device comprising an electrical connector disposed in electrical conducting relation with said electrode, a fluid layer of electrically conductive grease interposed between said connector and said electrode; an encapsulating layer of hardened resin surrounding said electroluminescent device, said conductive grease, and said electrical connector.

2. The encapsulated electroluminescent device according to claim 1 wherein said electrical connector is spring biased against said electrode.

3. The encapsulated electroluminescent device according to claim 1 wherein said electrical connector is pressure biased against said electrode.

4. An encapsulated electroluminescent device having at least two superposed electrodes, at least one of which is light transmitting and a layer of light emitting material including an electroluminescent phosphor interposed between said electrodes; means to conduct current to at least one electrode in said device comprising, an electrical connector disposed in electrical conducting relation with said electrodes, a fluid layer of an electrically conductive material dispersed in an uncatalyzed polymer interposed between said connector and said electrode; an encapsulating layer of hardened resin surrounding said electroluminescent device, said fluid layer and said electrical connector.

5. An encapsulated electrical device having a surface adapted to receive a contact type electrical connector; means to conduct current to said surface comprising an electrical connector disposed in electrical conducting relation with said surface, a fluid layer of conductive grease disposed between said connector and said surface; an encapsulating layer of hardened resin surrounding said electrical connector and said fluid, conductive grease.

6. An encapsulated electroluminescent device having at least two superposed electrodes at least one of which is light-transmitting and a layer of light emitting material including an electroluminescent phosphor interposed between said electrodes; means to conduct current to at least one electrode in said device comprising, a bearing surface on at least one of said electrodes, an electrical connector biasing against said bearing surface and in electrical conducting relation with said electrode, a layer of fluid conductive grease interposed at least in part between said connector and said bearing surface; an encapsulating layer of hardened resin surrounding said electroluminescent device, said conductive grease and the electrical connection.

7. The electroluminescent device according to claim 6 wherein the electrical connector is spring biased against the bearing surface.

8. The electroluminescent device according to claim 6 wherein the electrical connector is pressure biased against the bearing surface.

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