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FLEXIBLE ELECTRICAL HEATING DEVICES

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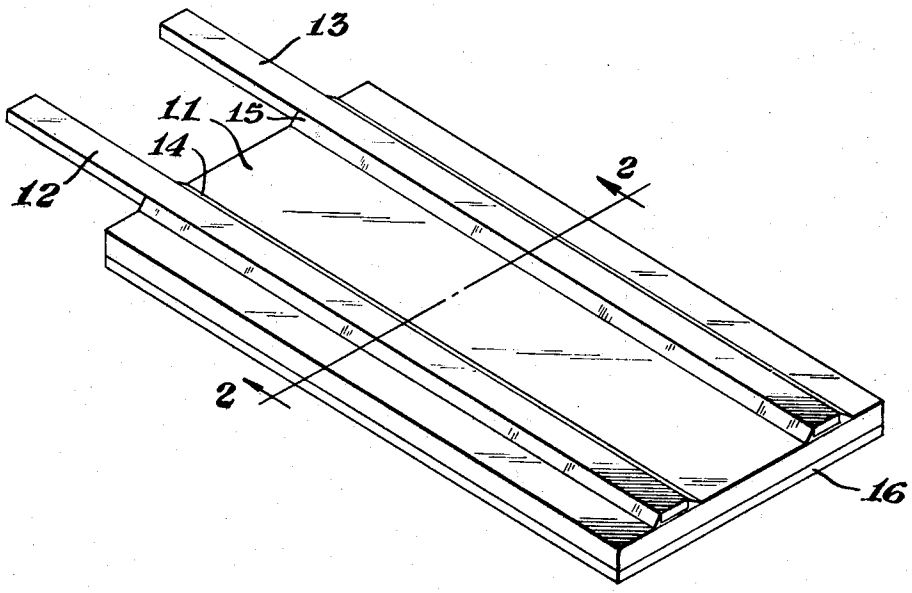


Fig. 1

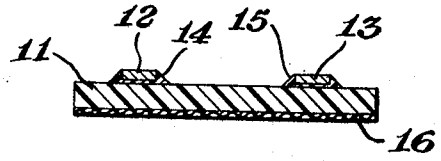


Fig. 2

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FLEXIBLE ELECTRICAL HEATING DEVICES

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ABSTRACT OF THE DISCLOSURE

A flexible electrical heating device wherein the electrodes are bonded to a thin, flexible layer of electrically conducting silicone rubber employing an electrically conducting, room-temperature vulcanizing silicone rubber to effect electrical and physical connection and adhesion between the electrically conducting siilcone rubber and the electrodes.

This invention relates to electrical heating elements, and more particularly to electrical heating elements of the type comprising a sheet or tape material having conducting properties and having attached thereto metallic or conducting silicone rubber electrodes.

Organopolysiloxanes and compositions based thereon are, in general, good electrical insulators and this property has led to the wide use of these materials as such in the electrical industry. It is also known to render organopolysiloxane compositions electrically conducting by incorporating therein a conducting filler such as a powdered metal or a carbon black. This proposal has made possible the development of electrically conducting rubbers which are capable of operating at relatively high temperatures and one example of an application where such a property may be exploited is in the manufacture of flexible heating elements. When the heating element comprises a substantial thickness of conducting silicone rubber little difficulty is experienced in attaching thereto the connections necessary for applying the activating source of electrical energy. However, when the flexible heating element comprises a woven sheet of glass or other non-conducting fabric coated with a thin layer of conducting rubber, or comprises a thin sheet of the conducting rubber, it is not easy to attach electrodes thereto in order that the required voltage may be applied. For example, difficulty is experienced in making a good electrical contact with the conducting layer that will withstand a reasonable amount of physical stress, vibration and temperature variation and yet not detract from the compact and lightweight nature of the device.

An object of the present invention is to provide a flexible heating device having improved electrode attachment means.

A further and more specific object is the provision for flexible heating elements of improved electrode attachment means capable of maintaining good electrical contact while withstanding physical stresses, vibration and temperature variation while remaining lightweight and compact.

In accordance with these and other objects there is provided by the present invention an electrode attachment means comprising an electrically-conducting organopolysiloxane-based, cold setting adhesive as a means whereby the electrode can be caused to adhere to the sheet or layer of rubber and whereby electrical and physical connection is made between the flexible conducting member and the leads thereof.

Other objects and many of the attendant advantages of the present invention will become obvious to those skilled in the art by a consideration of the following detailed description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a view in perspective of an electrical heating element made in accordance with the present invention; and

FIG. 2 is a cross-sectional view of the element shown in FIG. 1 and taken along the line 2—2 of that figure.

Referring now to the drawings, wherein like reference characters designate like parts throughout the views, there is shown in the figures a flexible, electrically conducting device comprising a flexible layer or sheet **11** of an electrically conducting silicone elastomeric material said layer or sheet having metal electrodes **12** and **13** attached thereto by means of an electrically conducting cold-setting, organopolysiloxane-based, adhesive composition **14, 15.**

The conducting layer or sheet **11** of elastomeric material forming part of the device of this invention may be supported or unsupported, that is, it may comprise a layer or a coating of an electrically-conducting silicone elastomer on a fibrous or woven, insulating support material **16** or it may comprise only an unsupported sheet or tape of the said elastomeric material. Preferably the conducting or resistive layer comprises a relatively thin coating of the elastomer on a fibrous support which is, for example, woven glass or polyethylene terephthalate cloth. The completed element may be insulated as required with a coating of insulation.

The conducting silicone elastomeric material of which the layer or sheet is comprised is based upon a vulcanizable organosilicon polymer. Preferably the organosilicon polymer is a high-molecular-weight diorganopolysiloxane in which the organic substituents are selected from lower alkyl, alkenyl and phenyl radicals. The general preparation of electrically conducting silicone elastomers and their use in the fabrication of heating elements and in other electrical applications is well-known.

The layer or sheet **11** of conducting or resistive material has attached thereto metal electrodes or leads **12, 13** by means of which electrical contact between the layer or sheet and an external source of electrical energy is achieved. In one method of carrying out this invention the electrodes are attached to the layer or sheet of conducting material by adhesion thereto employing a cold setting silicone rubber which has been rendered electrically conducting by the incorporation therein of a quantity of a conducting or semiconducting filler. The electrode, or that part of it which is in contact with the conducting layer, may comprise a metal for example aluminium, foil or it may consist of a multi strand electrical conductor. Attachment of the electrode may take place by simple adhesion, the cold setting silicone rubber being employed as the adhesive. Alternatively the electrode may be embedded in a mass of the cold setting rubber which has been deposited on the resistive layer. Electrical contact between the electrode and the layer will be ensured in view of the conducting nature of the cold setting rubber.

In order to improve the fixation of the electrode it may also be anchored mechanically to the sheet or layer, for example by interlacing it with the weave of the fibrous support, where one is employed, or alternatively crimping the electrode to the layer or sheet prior to embedding in the cold setting rubber.

The cold setting silicone adhesives employed in the practice of this invention may be any of those known in the art which are capable of producing a flexible bond when vulcanized and which may be loaded with a sufficient proportion of a conducting filler, for example carbon black or a finely divided metal such as silver, to endow the adhesive with the required electrical properties. Such cold setting adhesives include for example compositions based on acetoxy or oxime substituted organopolysilox-

anes and which vulcanize merely on exposure to moisture, and the so-called two component cold-curing systems comprising a reactive siloxane polymer, a cross linking agent and a condensation catalyst. Room temperature vulcanizing silicone rubbers are suitable when sufficiently loaded with conducting filler.

In order to improve the strength of the vulcanized adhesive the cold setting siloxane compositions may contain fillers, such as silicas and metallic oxides, in addition to the filler or fillers required to give the composition its conductive properties.

The following example illustrates the invention.

Example

A tape one inch wide and having a thickness of 0.030 inch was prepared by extruding and thereafter curing a composition comprising by weight 80 parts of a methylvinyl polysiloxane gum, 20 parts of a silica filler and 25 parts of a conducting carbon black. A cold curing organopolysiloxane adhesive composition was prepared comprising a mixture of a dimethylpolysiloxane, an alkyl polysilicate and an organotin compound as condensation catalyst, there being added 25 parts by weight of carbon black for every 100 parts of the adhesive composition to render it electrically conducting. This composition was then applied to the ends of a 12-inch length of the conducting tape and aluminium foil electrodes of dimensions ½ x 1 inch held in contact with the adhesive. After several hours the electrodes had become firmly attached to the tape and the electrical resistance between the electrodes was 30,000 ohms measured at 10 v. DC.

The device thus formed has a sustained high temperature capability and good electrical contact is maintained even under physical stress, vibration and extremes in temperature variation. The device is compact and light in weight. The manufacturing process is simple and economical.

Obviously variations and modifications of the present invention, other than those described, will become obvious to those skilled in the art. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

That which is claimed is:

1. A flexible electrically conducting heating device comprising:

a thin flexible layer of an electrically conducting silicone-elastomeric material, a pair of flexible metal electrodes in contact with and adhered to the surface of said silicone elastomeric material by a cured, electrically conducting, room-temperature vulcanized silicone rubber, said electrodes being arranged in approximate parallel relationship with each other.

2. A flexible heating device as defined in claim 1 wherein the flexible layer consists of a fibrous support of an insulating material with a coating of a vulcanized electrically conductive silicone rubber.

3. A flexible heating device as defined in claim 1 wherein the flexible metal electrodes are metal foil.

References Cited

UNITED STATES PATENTS

2,876,392	3/1959	Sanders	338—309 X
2,982,934	5/1961	Browne	338—323
3,050,490	8/1962	Nitzsche et al.	260—37
3,060,303	10/1962	Skoglund et al.	219—549
3,070,566	12/1962	Nitzsche et al.	260—37
3,127,363	3/1964	Nitzsche et al.	260—18
3,287,684	11/1966	Armbruster	338—211
3,296,195	1/1967	Goossens	260—46.5
2,559,077	7/1951	Johnson et al.	219—528 X
2,683,673	7/1954	Silversher	338—211 X
2,745,931	5/1956	Heibel	338—203
2,781,277	2/1957	Dwyer	338—203 X
2,789,155	4/1957	Marshall et al.	174—120
2,952,761	9/1960	Smith-Johannsen	117—226 X
2,961,522	11/1960	Hammer	219—549 X
3,099,578	7/1963	Hunter	338—308 X
3,179,544	4/1965	Smith-Johannsen	117—226 X
3,221,145	11/1965	Hager	219—549

FOREIGN PATENTS

674,309	11/1963	Canada.

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