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ELECTRICAL RESISTANCE HEATER

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Fig. 1.

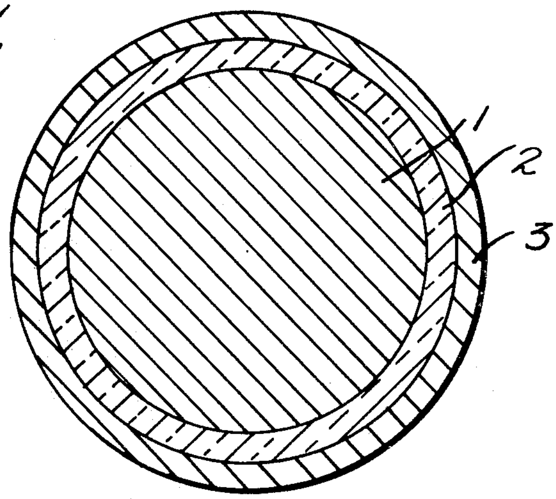
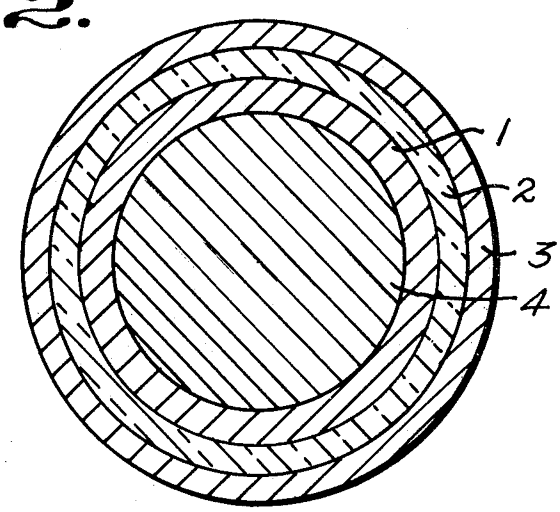


Fig. 2.



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ELECTRICAL RESISTANCE HEATER

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U.S. Cl. 219—553 3 Claims

ABSTRACT OF THE DISCLOSURE

An electrical resistance heater having high heat emission is constructed by shrinking a tubular metal jacket about a rod of electrically insulating material such as boron nitride or beryllium oxide, drilling out the central part of the insulation and shrinking the composite tube about a rod-shaped or tube-shaped resistance conductor. The conductor and jacket are preferably constructed of molybdenum, tantalum, columbium or alloys thereof.

DISCLOSURE

This invention relates to resistance heating elements and in particular to heating elements having high heat emission characteristics due to tight engagement between the insulating layer and an inner conductor and between the insulating layer and an outer jacket.

In practice, heating elements of the conductor-insulation-jacket type often suffer from the disadvantage that the thermal loading capacity as expressed in watts/cm.^{2} is not sufficiently high for a variety of applications. According to the present invention it is possible to obtain a high thermal load, actually a thermal load of the order of about 500 watts/cm.^{2}, at a temperature of about 600° C., because the heating element is constructed in such a way that even at the working temperature of the element there is maintained a contraction joint or shrink fit, and hence a surface pressure, between the outer jacket and the insulating layer. This surface pressure at the working temperature is of great importance, as it constitutes the only way in which the emission of the heat produced is ensured. This pressure furthermore ensures, in conjunction with the close fit of the contraction joint, that the basic geometry of the heating body is maintained. This is an important improvement as compared with electrical heating elements of prior art, which often showed local cavities due to deficient surface contact, or asymmetrical geometry, as a result of the swaging process to which the element had been subjected. Such asymmetrical configurations and local cavities invariably gave rise in practice to local overheating (hot spots), which adversely affected the loading level.

It is, moreover, desirable that measures be taken to provide a further contraction joint between the resistance conductor and the insulating layer surrounding it, which contraction joint should already exist at room temperature. It is pointed out by way of information that the first-mentioned, or outer contraction joint is particularly important. As the contact surface on which the outer contraction joint acts is situated more toward the outer side of the heating element, the temperature gradient there has already lost some of its importance. In order to allow for possible inequalities in the coefficients of thermal expansion of the materials exerting pressure upon each other thereabouts, it is advisable to ensure a continual surface pressure at this particular location by providing a firm contraction joint.

This provision is necessary to a somewhat lesser extent at the contact between the resistance conductor and

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the insulating material, situated more toward the center of the heating element. Owing to the high temperature of the resistance conductor itself it will as a rule expand so much more than the insulating layer around it that it generally creates a surface pressure due to difference in thermal expansion even without the aid of a contraction joint.

The condition for this, however, is that even when cold there shall be close contact between the resistance conductor and the insulating layer. On this account it is advisable, according to the second preferred embodiment, to make a slight contraction joint between the resistance conductor and the insulating material.

According to a preferred embodiment, the insulating layer is made of boron nitride, while both the resistance conductor and the metal outer jacket are made of molybdenum, tantalum or columbium, or of alloys of these metals. The advantageous effect that is obtained in this way, especially with the preferred materials boron nitride and molybdenum, is enhanced by the fact that the coefficients of thermal expansion of boron nitride and molybdenum are of approximately the same magnitude. The result is that, when the heating element has heated up, its temperature gradient gives rise to such an expansion of the component materials that a mutual surface pressure is maintained.

Although the coefficients of expansion of boron nitride and tantalum differ somewhat from each other it is quite possible to make serviceable use of this combination of materials if the contraction measures are matched with this inequality in coefficient of expansion.

Instead of boron nitride, beryllium oxide may be used to advantage as an electrical insulating material.

The most efficacious way of obtaining the said contraction joint in a heating element is by first selecting a tube of molybdenum, tantalum or columbium or of alloys of these metals, after which this tube is firmly shrunk around a solid cylinder of the electrical insulating material consisting essentially of boron nitride or beryllium oxide. Owing to the fact that this cylinder is solid, the required contraction joint or shrink fit may be effected so as to have a firm contraction fit at about 700° to 800° C., without there being any need to fear that the boron nitride or the beryllium oxide might show dislocations. After the structure described has cooled down, the central part of the cylinder made of the electrical insulating material is drilled out, with consequent formation of a cylindrical jacket of the electrical insulating material which is surrounded, via a contraction joint, by a cylindrical jacket of molybdenum, tantalum, columbium or alloys of these metals.

Then, after the inner side of the cylindrical jacket of the electrical insulating material has been subjected to precise after-machining, this structure of coaxial cylinder and jacket is shrunk at a temperature of 100° C. with a light contraction fit around a resistance conductor which is likewise composed of molybdenum, tantalum, columbium or an alloy of these metals.

Attention is drawn here to the fact that the highly loaded electrical heating elements of prior art have sometimes failed. This was generally caused either by the formation of local cavities due to differences in thermal expansion, or by chemical reactions, either because in many cases the thickness of the insulating layer was not uniform or because the insulating material was not homogeneous in its qualities. By applying the method described above for making a heating body according to the invention, the drawbacks attaching to heating elements of prior art are surmounted, because the structure taken as basis is a cylindrical tube of the insulating material made out of full-bodied material. To this is added the advantage arising from the possibility of obtaining the desired and necessary surface pressures, as a result of correct selection of the contraction measurements which have to be obtained with a high degree of precision.

The heating element made in this way proves capable of emitting a very high heating current, resulting in a thermal load up to about 500 watts/cm.^{2} at temperatures in the neighborhood of 600° C.

This heating element is very well adapted for heating liquid metals such as sodium, potassium, lithium or alloys thereof.

It is particularly suitable for heat transfer tests with cooling by liquid sodium, to be carried out in a nuclear reactor or in a plant other than a nuclear reactor but designed to simulate the latter. This is because the metal outer jacket of molybdenum, tantalum or columbium or alloys of these metals is in no way attacked by the said liquid metals.

In many cases the heating elements according to the invention will have an external diameter of about 5 mm. or slightly higher. With this diameter it is possible to obtain a length of such a heating body of about 50 cm.

The invention will be further understood from a consideration of the drawings in which:

FIGURE 1 is a transverse cross-sectional view of one form of a heating element embodying the principles of the present invention; and

FIGURE 2 is a similar view of a modified form of heating element.

In FIGURE 1 there is shown a heating element constructed of a central rod-shaped resistance conductor **1**, a surrounding layer of insulating material **2**, such as boron nitride or beryllium oxide and an outer metal jacket **3** of molybdenum, tantalum, columbium or alloys thereof. The heating element is fabricated by the steps previously described.

The embodiment of FIGURE 2 differs from the embodiment represented in FIGURE 1 only insofar as the central resistance conductor **1** possesses the form of a cylindrical jacket having inside it a cylinder **4** in which other possible components (not shown in the drawing) may be incorporated. In this cylinder **4** may be fitted, for instance, channels for electrical conductors or for a fluid. Cylinder **4** may be made of a material having qualities suitable for this purpose.

While preferred embodiments of the present invention have been described, further modifications may be made without departing from the scope of the invention. Therefore, it is to be understood that the details set forth or shown in the drawings are to be interpreted in an illustrative, and not in a limiting sense, except as they appear in the appended claims.

What is claimed is:

1. An electrical resistance heating element comprising: an elongated resistance conductor having a closed cylindrical outer layer and constructed of a metal selected from the group consisting of molybdenum, tantalum and columbium and alloys thereof, a solid tube of solid insulating material concentrically surrounding said resistance conductor and being shrink-fitted in tight engagement therewith so as to establish a contraction joint at room temperature, said insulating material being selected from the group consisting of boron nitride and beryllium oxide, and an outer tubular jacket concentrically surrounding said layer of insulating material and shrink-fitted in tight engagement therewith so as to establish a contraction joint at the working temperature of said heating element in the range of 700° to 800° C., said jacket being constructed of a metal selected from the group consisting of molybdenum, tantalum and columbium and alloys thereof.

2. An electrical resistance heating element as in claim **1** wherein said conductor is a solid cylindrical body.

3. An electrical resistance heating element as in claim **1** wherein said conductor is a tubular cylindrical body.

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