United States Patent

[11] 3,551,635

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[21] Appl. No. **757,208**
[22] Filed **Aug. 19, 1968**
Continuation of Ser. No. 551,885, May 23, 1966, abandoned.
[45] Patented **Dec. 29, 1970**
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[32] Priority **May 24, 1965**
[33] **Sweden**
[31] **No. 6771/65**

[54] **ELECTRIC RESISTOR ELEMENTS AND PROCEDURE FOR THEIR MANUFACTURE**
4 Claims, No Drawing

[52] **U.S. Cl.** **219/104,** 29/619; 338/329
[51] **Int. Cl.** **B22f 3/00,** B23k 11/02
[50] **Field of Search** 219/104, 86; 338/330, 339, 338; 29/619; 338/329

[56] **References Cited**

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976,468	11/1964	Great Britain	338/338
848,985	9/1960	Great Britain	338/330

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ABSTRACT: The specification discloses a method of providing an electric resistor element having (1) a heating zone comprising a stiffening framework of recrystallized silicon carbide the pores of which may be filled with a difficult to fuse silicide such as molybdenum silicide, and (2) thermoplastic terminal leads comprising molybdenum silicide, and an amount of grain growth inhibiting additive consistent with the terminal leads being ductile at temperatures in the range of 1,300° C. to 1,800° C., and up to 30 or 40 volume percent nonrecrystallized silicon carbide, said method comprising the steps of placing the terminal leads in contact with the ends of the heating zone part and heating the resulting composite to soften the terminal leads sufficiently for them to assume the shape of the ends of the heating zone part and sinter thereto.

ELECTRIC RESISTOR ELEMENTS AND PROCEDURE FOR THEIR MANUFACTURE

This application is a continuation of application Ser. No. 551,885, filed May 23, 1966, now abandoned.

The invention submitted herewith concerns an electric resistor element produced by powder metallurgical means with a heating zone section intended for use within a temperature range of 1,300—1,800°C. (2,370——3,270° F.) and containing a stiffening framework of recrystallized silicon carbide to which the terminal leads are connected. Heating zone parts of this type are described in detail in, for example, British Pat. No. 848,985. The advantage of the stiffening framework is that the element can be arranged horizontally without having to be supported throughout the greater part of its length. The terminal leads, which should have a lower temperature than the heating zone part, must possess better conductivity and, therefore, usually comprise molybdenum silicide with additives of silicon dioxide and possibly other oxides. In addition, small amounts of silicon carbide may occur. However, the nonconductive additives must not occur in too large a quantity as otherwise the electrical conductivity would be adversely affected. The material in the terminal leads can, for example, be produced as described in British Pat. No. 976,468.

It has previously been the practice to clamp the heating zone part between the terminal leads with a pressure of about 2—3 kg per mm^2 (2,845—4,256 lbs. per sq. in.). Such a construction with the resistor elements in three sections has been found to be economically advantageous since the same terminal leads can be successively used for up to 4 or 5 heating zones, as and when these are used up. The electrical connection between the terminal leads and heating zone can be ground concave and convex or with correspondingly rounded-off ends, and it has been proposed that a metal layer be placed between the parts, which layer must, however, be renewed about once a month.

The purpose of the invention submitted herewith is, among other things, to obviate the use of such a metal layer and is principally characterized by the fact that the terminal leads comprise molybdenum silicide with grain growth inhibiting additives in amounts chosen and distributed in such a way that the material, or at any rate the surface layers of the terminal leads which are in contact with the hot part of the heating zone, is ductile at the operating temperature. Assuming a heating zone part with a stiffening framework of silicon carbide, the pores of which are possibly filled up with a silicide which is difficult to fuse, for example, molybdenum silicide, a manufacturing procedure in accordance with the invention is characterized by the fact that the ends of the heating zone part are ground off, that the terminal leads, or at any rate the ends of them intended for connection to the heating zone part, are made of a material consisting of molybdenum silicide with grain growth inhibiting additives in limited amounts consistent with the material being ductile within a temperature range of 1,300 —1,800° C. (2,370 —3,270° F.), and that the terminal leads are sintered and their ends intended for connection to the heating zone part are ground, whereupon the heating zone part and terminal leads are pressed together and heated, for example, by means of electric current, until the ends of the terminal leads in contact with the heating zone have softened and assumed the shape of the ends of the heating zone part and have become sintered on to the latter.

In order for the terminal leads to possess suitable properties, they, or at any rate, the parts of them nearest the heating zone part, should consist of molybdenum silicide with the possible addition of one or more other silicides, but with the possible addition of one or more other silicides, but with a content of non-recrystallized silicon carbide not exceeding 30 or possibly 40 percent by volume, if any. If the terminal leads contain too large an amount of carbide, there is a risk that they will not be sufficiently ductile when heated to form a good connection to the heating zone part.

With previously used three-section resistor elements of this type, silicon carbide has been used in all three parts, whereby the terminal leads have had too large a quantity of this material, which has meant that they have not been thermoplastic.

It has been found that when an element manufactured in accordance with this invention is in continuous operation, only a thin layer of the thermoplastic material is heated to such an extent that it is deformed, this deformation insuring good contact at the joints. Due to the electrical conductivity, the other parts of the lead terminals are so cool that no deformation takes place.

The boundary layer between the heating zone part and terminal leads should preferably be concave and convex relative to the heating zone part. When manufacturing, therefore, the heating zone part is made with rounded-off, convex ends, whereas the ends of the terminal leads intended for connection to the heating zone part are formed with concave surfaces before being sintered on to the heating zone part.

I claim:

1. A process for forming an electric resistor element for use at a temperature in the range of 1,300° C. to 1,800° C. having a heating zone part, said heating zone part having a stiffening framework of recrystallized silicon carbide, and two terminal leads, wherein said terminal leads and said heating zone part are breakably joined so that said terminal leads and said heating zone part are reusable, said process comprising the steps of:
   a. manufacturing terminal leads comprising molybdenum silicide, not more than 40 percent by volume of non-recrystallized silicon carbide, and a grain growth inhibiting amount of a grain growth inhibiting additive consisting essentially of silicon dioxide, said amount being consistent with the terminal leads being ductile in the range of 1,300° C. to 1,800° C;
   b. placing said terminal leads in contact with said heating zone part having a stiffening framework of recrystallized silicon carbide; and
   c. heating the composite, including the heating zone part and the surfaces thereof abutting with the terminal leads, to a temperature in the range of 1,300° C. to 1,800° C., whereby the terminal leads soften, assume the shape of the heating zone part at the abutting surfaces, and sinter thereto.

2. The process of claim 1, wherein said stiffening framework of recrystallized silicon carbide is filled up with molybdenum silicide.

3. The process of claim 1, wherein heating is achieved by passing an electric current through said composite.

4. The process of claim 1, wherein the ends of said heating zone part are convex and the ends of the terminal leads contacting said heating zone part are concave.