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HEATING CONDUCTOR AND METHOD OF MAKING THE SAME

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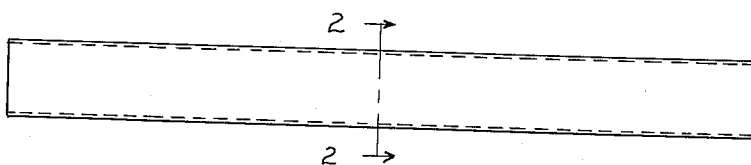


Fig 1

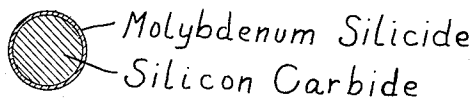


Fig 2

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## HEATING CONDUCTOR AND METHOD OF MAKING THE SAME

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This invention relates to a heating conductor and a method of making the same.

Silicon carbide and carbon incandescent bars are known. Further, heating conductors are already known that consist of a carbonaceous core with a coating containing molybdenum and resistant to oxidizing. Finally, also metallic molybdenum heating conductors are known, which have a coating containing molybdenum silicide and resistant to oxidizing.

The invention consists principally in the utilization of the coating known per se, containing molybdenum and resistant to oxidizing, on silicon carbide bars that are also known. Silicon carbide bars provided with the mentioned oxidizing-resistant coating have essentially the following advantages over the carbon incandescent bars provided with a corresponding coating.

The silicon carbide bar with coating containing molybdenum has a lower electric conductivity than the conventional carbon bars with corresponding coating. This means, that when the known carbon heating bars are used as incandescent bodies, much higher strengths of current are needed than for the bar according to the invention; that accordingly the conventional coated carbon incandescent bars require much larger transformers, that the current leads are more expensive, etc. Because of the aforementioned reasons, the bars according to the invention are particularly suitable exactly for industrial furnaces. In addition, many existing furnaces are arranged to take silicon carbide bars, so that the bars according to the invention, which correspond electrically to the pure silicon carbide bars, can be built-in directly into existing furnaces, whereas the coated carbon bars necessitate modifications in the construction of the furnaces.

Also the thermal conductivity of the bar according to the present invention is more favorable than in the case of the conventional incandescent carbon bars, since it is lower. In addition, no cooled bar holders will be needed, as are required for the incandescent carbon bars.

Moreover, in comparison with the usual silicon carbide bars, the bar according to the invention has the advantage that the heating bars are protected against oxidation, so that at high temperatures they are many times superior to the unprotected heating conductors as regards service life. Finally, there is still another important advantage:

In the case of the conventional coated carbon bar, the whole protective coating consists of brittle, hard molybdenum silicon double carbide. If this protective coating is only very slightly damaged when being built into a furnace or when in service, the whole carbon body may—when in service in the oxidizing furnace atmosphere—be very quickly burned through at the slightly damaged place. On the other hand, the bar according to the present invention has a protective coating consisting internally of still free molybdenum silicide, and externally of a molybdenum compound that is ductile at service temperatures. If the protective coating is slightly damaged, there exist three advantages in the subsequent service as compared with the conventional bar:

(a) The exposed silicon carbide does not oxidize like

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carbon with the formation of volatile CO or CO<sub>2</sub>, until the whole bar has burnt, but solid SiO<sub>2</sub> will be formed, which also locally produces a certain protection against oxidation.

(b) The still existing free molybdenum silicide of the neighboring protective coating reacts with the oxygen of the furnace atmosphere and forms fresh protective-coating material which can close the gap caused by damage.

(c) At service temperatures the protective coating in the vicinity of the damage is viscous like glass and capable of assisting the self-healing action of the fresh protective material mentioned above in (b).

For these reasons, the bar according to the invention remains thoroughly serviceable, even if the protective coating has become damaged as may happen in every service, whereas the conventional coated carbon bar will very quickly become useless if slightly damaged.

The method of making the heating conductor consists principally in that the powdered molybdenum silicide is brought onto the silicon carbide by dusting or by spraying. The powder may also be applied by painting-on pastes to which adhesive means may be added or not. Finally, it is also possible to have the powder applied by dipping the core into pastes containing adhesive means or not. Thereupon the oxidation-resisting coating will be finished by sintering and oxidizing the molybdenum silicide onto the silicon carbide bar.

In the conventional method of applying a coating containing molybdenum, this coating is fused onto a core including carbon. This type of application is not possible in the case of the method according to the invention. Should it be desired to fuse molybdenum silicide onto a silicon carbide core, reactions would occur between the molybdenum silicide coating and the silicon carbide core which would render it impossible for the coating layer to combine with or to adhere to the core.

The manner of applying the coating according to the invention is also much simpler and more economical than the fusing of the coating layer onto carbon bars according to the conventional methods. The application need not be effected in vacuum or under a protective gas, as in the conventional methods. The bars according to the invention may be finished at an appreciably lower temperature, and even in the air or without using any inert atmosphere; they may therefore be formed in large quantities together in a furnace at a temperature of about 1450° C., whereas the conventional bars must be made singly and with heating up to about 2300° C.

Further features of the invention will appear from the following description and claims, and one embodiment of the invention is illustrated in the accompanying drawings wherein FIG. 1 shows the improved heating body in side elevation, and FIG. 2 is a transverse section on line 2—2 of FIG. 1.

According to the invention it has been found that it is possible to have silicon carbide heating bodies coated with a thin layer of molybdenum silicide, and then to convert this wholly or partly into the glass-like sintered layer in oxidizing atmosphere. This thin, gastight coating is capable of protecting the silicon carbide against oxidation, so that silicon carbide heating conductors treated in this way may be used at higher temperatures and during longer service periods than unprotected heating conductors. The heating conductor according to the invention thus consists for the most part of almost pure silicon carbide with its economically favorable heat-conducting properties and of a thin protective coating, made of molybdenum silicide and being especially highly resistant to oxidation.

The metallic molybdenum heating conductors already formerly proposed, with coating of oxidation-resisting

molybdenum silicide, behave so very differently mechanically with respect to the metal when heated up and cooled down, that no protective layer is obtained of a lasting nature and free from cracks. Besides that, such protective coatings on metal are very liable to get damaged, and the exposed metal portions quickly oxidize at a high temperature so as to destroy the heating conductor. In contrast thereto, through the present invention, on the non-metallic silicon carbide heating conductor a very good adhesive and gastight protective coating of molybdenum silicide and/or its oxidation-product will be obtained, which is not extremely sensitive to damage and capable of withstanding severe thermal-shock treatment. The essence of the invention is based on the novel combination of the good heating conductor qualities of silicon carbide with the high resistance to scaling of the molybdenum silicide and/or of its oxidation-product.

For making the heating conductor according to the invention, more or less pure, powdered molybdenum silicide can be brought onto the silicon carbide heating bodies in any desired way, say, by dusting, spraying, painting in the form of a paste in pure water or in water with adhesive additives, for example, tragacanth or methyl cellulose, dipping in aqueous pastes with or without the said type of adhesive additives. The heated bodies treated in this way, i.e. provided with a coating, are at first dried and then rendered incandescent for some time in air or an oxidizing atmosphere at a high temperature between 1300 and 1500° C. It has then been found suitable for certain shapes of heating conductors that this incandescence be effected from the outside, i.e. in a furnace, whereas in other cases a heating by passing a current through, or both methods, may be adopted. In the case of this incandescence some white fumes of molybdenum trioxide may be given off at the start; the main portion of the molybdenum silicide, however, passes into the glass-like protective layer which includes molybdenum, silicon, oxygen and partly also carbon, and covers the heating chamber tight, the protective layer being firmly sintered on. When the molybdenum silicide has

once been oxidized, the heating bodies may be used at all temperatures up to over 1500° C. without any more molybdenum trioxide being given off in fumes.

Through the invention it is possible to make silicon carbide heating conductors which at high temperatures are by far superior to the unprotected heating conductors as regards service life, and also possible to carry out the method favorably as regards economy.

What we claim is:

1. Heating conductor composed of a conductor consisting essentially of silicon carbide with a coating of molybdenum silicide sintered on the conductor and resistant to oxidizing.

2. The method of making a heating conductor which comprises the steps of applying pulverulent molybdenum silicide in the form of a coating to the surface of a body consisting essentially of silicon carbide, and then sintering said coating on said body by heating to incandescence at a temperature of between 1300° C. and 1500° C.

3. The method of making a heating conductor as defined in claim 2 wherein in said sintering step the body carrying said coating of pulverulent molybdenum silicide is heated to incandescence in an oxidizing gas by passing electric current through the body of silicon carbide thereby to sinter the molybdenum silicide onto said body and to form an oxidation-resistant protective layer over the latter.

4. The method of making a heating conducting as defined in claim 2 wherein in said sintering step the body carrying said coating of pulverulent molybdenum silicide is heated to incandescence in a furnace in an oxidizing atmosphere thereby to sinter the molybdenum silicide onto said body and to form an oxidation-resistant protective layer over the latter.

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**Notice of Adverse Decision in Interference**

In Interference No. 92,360 involving Patent No. 2,993,814, W. Epprecht and F. Held, Heating conductor and method of making the same, final judgment adverse to the patentees was rendered Feb. 13, 1964, as to claims 1 and 2.  
[*Official Gazette August 25, 1964.*]

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