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H. KERSCHBAUM
RODLIKE HEATING ELEMENT

2,215,587

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Fig. 1

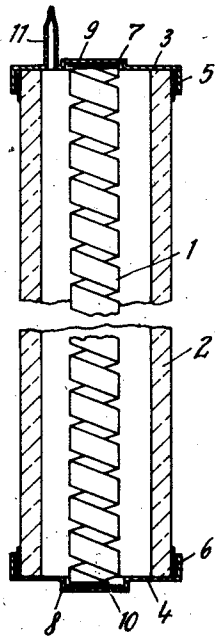
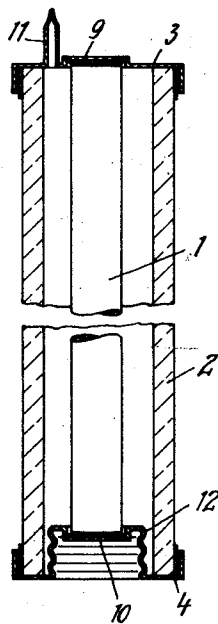


Fig. 2



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2,215,587

RODLIKE HEATING ELEMENT

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6 Claims. (Cl. 201-67)

My invention relates to rodlike heating elements for electric resistance furnaces operating at high temperatures.

To attain high temperatures in electric resistance furnaces it is well known in the art to employ therein rodlike heating elements consisting of highly refractory material. In furnaces in which temperatures higher than 1400 degrees centigrade are required such heating elements have proved unsatisfactory in continuous operation. At such high temperatures the life of the electric heating elements is considerably shortened and, therefore, the operation of the furnace is uneconomical. Thus, for instance, in firing porcelain, steatite and other ceramic materials a furnace temperature of 1400 degrees centigrade is necessary. If electric resistance furnaces operating with rodlike heating elements were to be employed for such purposes, the temperature of the heating element would have to be at least 100 degrees centigrade higher, that is 1500 degrees centigrade. In firing certain ceramic materials such as pure aluminum oxide a temperature of about 1600 degrees centigrade is necessary so that when employing resistance elements the latter must withstand a temperature of about 1700 degrees centigrade. In producing other materials, for instance, some hard alloys containing highly refractory carbides it is necessary that much higher temperatures prevail in the firing zone.

The known silundum (Silit) resistors which consist of silicon carbide are not suitable for such high temperatures, since the life thereof is considerably shortened if a temperature of 1200 to 1400 degrees centigrade is exceeded. To attain such temperatures carbon tube furnaces or induction furnaces are, therefore, generally employed. The maintenance of a constant temperature in such furnaces is, however, difficult and requires a continuous control.

Rodlike heating units have already been proposed, in which the resistance conductor is enclosed in a sheath produced by ceramic methods. However, the electric heating units of this character have not proved wholly successful, since the enclosure could not be kept sufficiently impervious to gas at high operating temperatures.

An object of my invention is, therefore, to provide a rodlike heating unit adapted for use in connection with electric resistance furnaces and of such nature as to ensure an economical continuous operation of the furnace at temperatures of the above-mentioned value.

Another object of my invention is to provide an electric heating unit in which the gas-tight en-

sure of the resistance conductor is more reliable and durable than has been the case with the known resistors having ceramic sheaths.

A further object of my invention is to provide an electric heating unit of the type in which a resistance conductor enclosed in a ceramic sheath is protected against the action of oxygen, even against oxygen which separates from the sheet material itself, when manufacturing or using the resistance conductor.

A still further object of my invention is the provision of an electric heating element of a reliable construction in which deterioration of the gas-tight joint due to a relative displacement between the resistance conductor and the sheath is prevented.

Electric heating elements according to my invention are made in the following manner:

A resistance conductor of molybdenum, tungsten, the alloys thereof or of another extremely highly refractory substance is enclosed in a sheath made of ceramic material containing aluminum or magnesium silicate in such an amount as to render the ceramic structure absolutely impervious to gas when fired. Ceramic materials of such type are known per se and are characterized by an extremely dense structure. By the use of such ceramic materials it is possible in contradistinction to the known sheaths of pure aluminum oxide to produce a gas-tight sheath in a simple manner which remains also gas-tight in continuous operation at high temperatures. By referring to the aforementioned silicates as elements of the ceramic mass I do not merely mean traces of silicate such as may constitute accidental impurities; but I refer here to silicates added to a sufficient extent to render the structure gas-tight when firing the ceramic material.

According to my invention a substance is provided between the sheath and the resistance conductor so as to prevent the resistance conductor from being affected by the oxygen, even by the oxygen developing from the sheath, or to reduce the action thereof to a negligible amount. Further, a gas-tight compound, particularly a metal, welded to the ceramic sheath is employed for providing a gas-tight joint at the ends of the electric heating unit.

By the above-mentioned means it is possible to produce rodlike heating elements for high temperatures adapted for use in electric resistance furnaces and which have a sufficiently long life also at temperatures much higher than 1400 degrees centigrade; for instance, temperatures ranging from 1600 to 2000 degrees centigrade.

However, the electric heating units according to the invention may also be advantageously employed in electric resistance furnaces operating at lower temperatures; e. g. temperatures varying from 900 to 1400 degrees centigrade.

My invention will best be understood by reference to the accompanying drawing in which Fig. 1 shows a vertical sectional view of an electric heating unit having a spirally wound resistance conductor and Fig. 2 shows a similar view of another electric heating unit provided with a rodlike resistance conductor, both units being broken away in the middle portion thereof.

In Fig. 1, 1 denotes a helically wound resistance wire or ribbon made of a highly refractory metal, such as molybdenum or tungsten or of the alloys thereof. The resistance conductor 1 is located in a tube 2 of ceramic material of the above mentioned type. The tube is provided at both ends with gas-tight metallic caps 3 and 4 respectively. These metallic caps are soldered to the ceramic tube 2 by means of a hard solder. As hard solder, for instance, silver is particularly suitable. In using the electric heating unit care should be taken to see that its ends remain cooler than the portion of the resistance conductor serving to develop an intense heat.

The electric heating unit may be, for instance, manufactured in the following manner:

The resistance conductor 1 and the sheath 2 are separately manufactured. The tubular sheath 2 is formed of the ceramic material above mentioned and is fired to a dense structure absolutely impervious to gas. The ends 5 and 6 of the tube 2 thus formed before being soldered to the caps 3 and 4 are provided as hereinafter described with a coating consisting of metal.

The powder of a base metal, such as iron powder, which is produced according to the carbonyl method is mixed with an organic binding agent to form a paste. The paste is applied to the ends of the ceramic sheath 2; whereupon the latter is heated preferably in a vacuum furnace to the sintering temperature. In this manner a metallic coating is obtained which is impervious to gas and capable of being readily soldered or welded.

The metallic caps 3 and 4 are provided in their central portions with recesses 7 and 8 in which is also placed a solder 9 and 10 respectively. The metallic caps 3 and 4 are placed over the ends of the sheath 2 so as to engage the resistance conductor 1. The whole is then heated to integrally associate the resistance conductor 1 with the caps 3 and 4.

The parts 1, 2, 3 and 4 may be united with one another in the manner that the above-mentioned paste is first applied to the ends of the sheath 2, the parts are then assembled and soldered together by heating them in a vacuum furnace.

In the embodiment shown the metallic cap 3 is provided with an outlet 11 by means of which the inner space of the electric heating unit may be evacuated. When evacuated, a reducing or neutral gas may be introduced thereinto. For this purpose, for instance, hydrogen or a rare gas, particularly argon may be employed.

In the embodiment shown in Fig. 2 the resistance conductor 1 consists of a rodlike body; for instance, a rod consisting of silicium (Silic). The latter is silver-plated at its end faces and conductively connected with the metallic caps 3 and 4 by means of the solder 9 and 10 re-

spectively. The metallic caps 3 and 4 are united with the ceramic body 2 in the same manner as described hereinabove. To enable an expansion of the rod 1 relatively to the sheath 2 due to heat the cap 4 is provided with a resilient member 12. 11 denotes an outlet by means of which the inner space of the electric heating unit may be evacuated or filled with gas.

The specific embodiments may be varied in detail and it is, therefore, to be understood that my invention is not confined to the details described. Thus, for instance, the resilient member 12 shown in Fig. 2 may be modified in various ways. In many cases resistance conductors and sheaths are employed which have substantially the same coefficients of expansion. In such cases the resilient member may be dispensed with. If small relative movements should, nevertheless, occur they may be compensated for by the resiliency inherent in the material employed for sealing the ceramic sheath.

The compound between the sheath and the resistance conductor which serves to protect the resistance conductor against the action of oxygen may also consist of other substances than the above-described. For instance, the intermediate space may be filled up with carbides or nitrides of boron, aluminum or titanium or with mixtures thereof. Furthermore, metallic hydrides, for instance, hydrides of lithium, lanthanum, nickel or titanium may be employed. These substances may also be singly employed or in a mixed state. Also other substances than the described are suitable as intermediate layer, the essential point being that they protect the resistance conductor against the action of oxygen.

In the embodiments shown the heat is transferred from the resistance conductor 1 to the ceramic sheath 2 essentially by heat radiation, whereas when employing solid intermediate layers between the resistance conductor and the sheath or in case the resistance conductor contacts with the sheath more heat is transferred by conduction. However, by the use of a ceramic sheath material consisting of the above-mentioned type containing aluminum and magnesium silicates and fired to a dense and gas-tight structure, the action of oxygen upon the resistance conductor even in continuous operation at high temperatures is diminished to such an extent that the life of the electric heating element is sufficiently long to warrant an economical operation of the electric resistance furnaces equipped with the rodlike resistance conductors.

When using electric heating units according to the invention in electric resistance furnaces it is preferable to make them so long that the ends of the heating elements lie outside the firing zone of the furnace in order that they remain sufficiently cool. Thus, in the embodiments shown the electric heating units may be so mounted in a furnace that the metallic caps thereof lie outside the furnace chamber. Such an arrangement not only permits to readily connect the leading-in wires to the ends of the electric heating units, but also the same may be effectively cooled by a fluid cooling agent, such as water or air.

I claim as my invention:

1. A rodlike heating element for producing high temperatures in electric furnaces, comprising a straight, cylindrical, solid and self-supporting rod of highly refractory resistance material capable of producing operating temperatures above 900° C., a sheath of a dense and

highly refractory ceramic material gas-tight at said temperatures, said sheath having the shape of an open cylinder and concentrically surrounding said rod with intermediate space, two metallic closures covering said ends, said closures being in good conductive connection with said rod to form terminals for supplying current to said rod, a hard-solder bond gas-tightly joining said closures and said sheath, and a substance disposed in said intermediate space for protecting said rod against oxygen within the range of the working temperature of the heating element.

2. A heating rod for electric high-temperature resistance furnaces, comprising a resistance body of elongated general shape consisting of a highly refractory resistance material capable of producing normal operating temperatures considerably above 900° C., a tubular sheath coaxially surrounding said resistance body for protecting it from oxygen when in operation, said tubular sheath consisting of highly refractory and dense ceramic material of the type densified by a silicate content selected from the group of Al and Mg silicates so as to stay gas-tight at said operating temperatures, two gas-tight metallic closure members covering the two ends of said tubular sheath respectively, said closure members being conductively connected with the ends of said resistance body, respectively, so as to form terminals for supplying current to said resistance body, a fused bond of refractory metal gas-tightly joining said sheath with each of said closure members.

3. A rodlike heating element for high-temperature furnaces, comprising a self-supporting rod-shaped resistance conductor of non-metallic and highly refractory resistance material, a highly refractory tubular sheath concentrically surrounding said conductor with intermediate space and consisting of a highly refractory and gas-tight ceramic material of the type containing silicate from the group of Al and Mg silicates, two metallic closures conductively connected with said conductor rod and disposed on the ends of said sheath respectively, a bond of refractory metal gas-tightly joining each of said closures with said sheath, and a substance in said intermediate space for protecting said conductor against oxidation.

4. An electric heating element for high-temperature furnaces, comprising a centrally arranged resistance body of elongated general shape

consisting of highly refractory resistance material capable of producing normal operating temperatures considerably above 900° C., a tubular dense sheath surrounding said conductor with intermediate space, said sheath consisting of highly refractory and gas-tight ceramic material, a coating of refractory base metal deposited on the outer ceramic surface of each end of said sheath, metallic closure members conductively connected with said resistance body and covering said coated ends of said sheath, hard-solder bonds gas-tightly joining said closure members with said sheath, and protective substance in said intermediate space for protecting said body against oxygen within the range of the working temperatures of the heating element, said sheath and said closure members forming substantially the only support for said resistance body and said substance.

5. A rodlike heating element for producing temperatures above 900° C. in electric resistance furnaces, comprising a self-supporting resistance conductor of elongated general shape, said conductor consisting of a highly refractory metal selected from the group comprising tungsten, molybdenum, and their alloys, a highly refractory dense sheath enclosing said conductor with intermediate space and consisting of ceramic material of the dense type containing densifying silicate from the group of Al and Mg silicates, a fused bond of refractory metal gas-tightly joining said sheath and said conductor, and a substance in said intermediate space for protecting said resistance conductor against oxygen.

6. A heating rod for electric high-temperature resistance furnaces, comprising a helical resistance body of elongated shape consisting of highly refractory metal solid at a normal operating temperature of over 900° C., an elongated dense sheath enclosing said helical resistance body in order to protect it from oxygen, said sheath consisting of highly refractory ceramic material of the type containing densifying silicate selected from the group of Al and Mg silicates so as to stay gas-tight at said operating temperatures, gas-tight closure means of refractory metal conductively connected with said resistance body and gas-tightly bonded with said sheath, said sheath and said closure means forming the only solid support for securing said resistance body in its position.

HANS KERSCHBAUM.

CERTIFICATE OF CORRECTION.

Patent No. 2,215,587.

September 24, 1940.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the grant, line 1, name of inventor, for "HANS KERCHBAUM" read --HANS KERSCHBAUM--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of October, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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