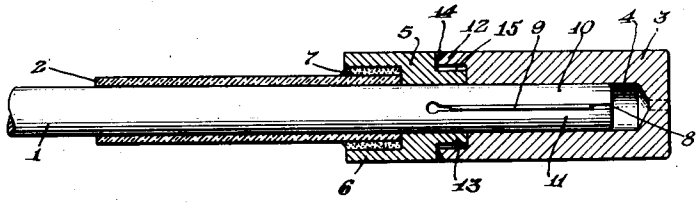
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ELECTRICAL HEATING ELEMENT

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## ELECTRICAL HEATING ELEMENT

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6 Claims. (Cl. 201—64)

This invention relates to substantially rigid electrical heating elements of the type comprising a rigid resistor of a metal or alloy of high melting point surrounded by a ceramic sheathing or cover for protecting the resistor against oxidation and other corrosion due to the surrounding atmosphere when operated at high temperatures.

This application is a division of my copending application Ser. No. 220,211, filed July 20, 1938.

It has been suggested previously to cover a resistor by a protective sheathing projecting beyond the ends of the resistor, and to insert pin-like bodies of metal into those projecting ends and to connect them with the resistor. The pin-like bodies consist of copper, nickel, silver or another proper metal, or of an alloy, such as an iron-nickel-cobalt alloy. Over the projecting ends of the pin-like bodies sleeve-like plugs are drawn tightly which are preferably of the same metal or alloy of which the pins consist, and the plug gas-tightly contacts the ends of the sheathing or is cemented thereto.

According to my parent application Ser. No. 220,211 of which the present application is a division, the ends of the resistor project over the ends of the protecting sheathing and the sleeve-like plug which preferably forms the contact by which the heating element is to be inserted in an electric circuit, are slipped over the projecting ends of the resistor. The sleeve-like plugs are preferably subdivided and consist of at least two parts each one of which is interposed between the outer part and the end of the ceramic sheathing.

In order to secure a permanent contact between the end of the resistor element and the outer part of the plug which preferably serves as a contact, resilient means are interposed between that part of the plug and the end of the resistor.

It is an object of the invention to simplify the connection between the end of the resistor and the plug.

It is a further object of the invention to render the end of the resistor contacting the plug resilient in itself in a simple and efficient way, so as to firmly maintain that contact independent of variations of temperature during operation.

It is still another object of the invention to connect the plug with the ends of the sheathing and the resistor in such a way that differences as to longitudinal expansion between the resistor and the sheathing during operation do not affect the gas-tight connection between the plug and the sheathing.

These and other objects of the invention will be more clearly understood as the specification proceeds with reference to the drawing in which by way of example a feature of the invention is shown in longitudinal cross section through one end of a heating element.

It is to be understood that the heating element may be of any desired length and its other end made in a similar way as that shown in the drawing.

It is further to be understood that the invention is not limited to this exemplification but is to be derived in its broadest aspect from the appended claims.

Referring to the drawing, a resistor element 1 of metal of high melting point such as tungsten, tantalum, molybdenum, or an alloy thereof is applied in form of a bar or wire. Since metals or alloys of this type are liable to oxidation in open air at temperatures even far below the operating temperature, the resistor element 1 is surrounded by a ceramic sheathing 2 preferably obtained by sintering powdered oxides of sufficiently high melting point or a powdery mixture of two or more refractory oxides, into a hollow body such as a tube. A shaped powdery mixture of this type consolidated by sintering into a gas-tight highly refractory body forms a ceramic sheathing in the sense of my present invention and the appended claims.

The sheathing 2 protects the resistor 1 against attacks of the surrounding atmosphere, particularly the oxygen contained therein. As outlined in my previous application referred to above great difficulties arise in connecting the resistor with an electrode in such a way that no air can penetrate into the space between the resistor and the sheathing at the end of the latter where the electrode has to be connected with the resistor. In order to prevent such penetration of air into the interior of the heating element, various types of end closures have been suggested in the prior art. According to the present invention the resistor element 1 projects beyond the end of the ceramic sheathing 2 and extends into a plug made of suitable metal such as copper or any other metal or alloy preferably of better electrical conductivity than the material of which the resistor 1 consists. This plug consists preferably of two parts 3 and 5, although a single body may be used for the same purpose. While the outside of the plug is shaped in any desired way so as to form e. g. a contact

by means of which the heating element can be inserted into an electric circuit, a hole 4 is provided inside the plug into which the projecting end of the resistor fits.

Part 5 of the plug is provided with a projecting flange 6 at its end facing the end of sheathing 2. Flange 6 is spaced from the end of the sheathing and the space is filled and gas-tightly closed by means of a refractory cement 7 which rigidly connects part 5 of the plug with the end of the sheathing.

The other part 3 of the plug is provided with a flange 12 overlapping a flange 13 on the adjacent end of part 5 of the plug. A seal 14 of solder or other suitable metal cement may be provided between flange 12 and the adjacent surface of part 5 so as to unite them into a coherent body. If no such cement is provided the overlapping flanges 12, 13 may move relative to each other.

In operation, the resistor covered by the sheathing, is heated to operating temperatures while its end covered by plug 3, 5 is heated to a temperature far below. This is due to the fact that plug 3, 5 contacts electrodes through which the heating current is applied and cooled thereby, and that the plug has a by far greater heat dissipating surface than the heating element between the plugs. Furthermore, the sheathing made of ceramic material has a lower heat expansion coefficient than the metallic resistor element and consequently the longitudinal expansion of the resistor at operating temperatures will considerably exceed that of the sheathing. Since the plug 3, 5, or at least its part 5 is rigidly attached to the end of the sheathing, the end of the resistor when rigidly connected with the plug would tend to pull the plug off that end of the sheathing resulting in cracks at the end of the sheathing or destruction of the joint 7.

In order to avoid this, the end of the resistor 2 is slidably and resiliently connected with the plug. To this effect the end of the resistor is made resilient in itself substantially radially so that a full and gas-tight contact is secured between that end and the interior surface of the plug without interfering with their relative movement when the resistor expands upon heating and contracts upon cooling to a larger extent than the sheathing to which the plug is rigidly attached.

According to the feature exemplified in the drawing, the end of the resistor is provided with a longitudinal slot 8, and a leaf-shaped spring 9 is inserted into that slot which forces the adjacent portions 10, 11 of the slotted end of the resistor against the inside surface of the hole in plug 3, 5. The spring may be of any suitable metal and of any desired other form than shown in the drawing.

A getter substance may be pressed into the space 15 between the overlapping flanges 12, 13 or any other place within the plug 3, 5 near the end of the sheathing 2. Barium-magnesium, barium-calcium or other well known getter substances may be used. They serve to completely remove harmful gas residues.

In the preferred feature of the invention shown in the drawing, resistor 1 forms a substantially cylindrical body, such as a wire or bar, and cover 2 a tubular member shrunk upon or otherwise brought into close contact with the resistor. The plug or its parts are likewise cylindrical hollow bodies though the outer surfaces of part 3 may be shaped in any desired way to form the desired contact or electrode.

It will be appreciated from the above that according to the invention the end of the resistor, or of an element rigidly connected therewith is made capable of sliding during operation within an electrically conductive plug which is gas-tightly attached to the end of the ceramic cover of the resistor element. Due to the fact that that end is made resilient in itself substantially radially, it is constantly pressed into substantially gas-tight contact with the interior surface of the hollow plug independent of prevailing temperatures, and permits sliding movement relative to the plug due to differences in expansion of the cover and the resistor element during operation.

What I claim is:

1. An electrical heating element comprising, in combination, a rigid metallic resistor at least one end of which is resilient substantially radially, a ceramic gas-tight cover for said resistor, said resilient end projecting beyond said cover, a hollow metallic plug gas-tightly and rigidly connected with the adjacent end of said cover and engaging said resilient end so that a permanent electrical contact is established between said plug and said resilient end and the latter can move relative to the former.

2. An electrical heating element adapted for operation at high temperatures, comprising, in combination, a rigid metallic resistor of high melting point and substantially cylindrical shape at least one end of which is resilient substantially radially, a refractory ceramic gas-tight cover for said resistor, said resilient end projecting beyond said cover, a cup-like electrode slipped over said resilient end and gas-tightly and rigidly connected with the adjacent end of said cover so as to seal the latter, said resilient end permanently contacting the inside surface of said electrode and movable relative to it when different longitudinal expansions occur between said cover and said resistor at operation temperatures.

3. An electrical heating element adapted for operation at high temperatures in open air and under other oxidizing conditions, comprising, in combination, a substantially cylindrical rigid resistor of metal of high melting point capable of oxidation at operation temperatures, the ends of said resistor being resilient substantially radially, a highly refractory ceramic gas-tight cover for said resistor substantially composed of a highly refractory oxide compound, the resilient ends of said resistor projecting beyond those of said cover, cup-like metallic plugs composed of coaxial parts in gas-tight connection with each other, a plug each slipped over a resilient end each of said resistor and gas-tightly and rigidly connected with the adjacent end of said cover so as to form a unit therewith, a resilient end each permanently contacting the inside of a plug each and being movable relative to the latter when different longitudinal expansions occur between said cover and resistor during operation.

4. An electrical heating element adapted for operation in open air and under other oxidizing conditions at high temperatures, comprising, in combination, a rigid resistor of metal of high melting point, a refractory gas-tight ceramic cover for said resistor, an end of the latter projecting beyond the adjacent end of said cover, a hollow metallic body engaging the projecting end of said resistor and gas-tightly connected with the adjacent end of said cover, a slot in said end of the resistor extending substantially

in its longitudinal direction, and springy means in said slot for pressing the portions of said resistor adjacent to said slot against the inner surface of said hollow body so as to permit relative movement between them due to differences in the longitudinal expansions of said cover and said resistor during operation.

5. An electrical heating element adapted for operation in open air and under other oxidizing conditions at high temperatures, comprising, in combination, a rigid resistor substantially of metal of high melting point selected from a group consisting of tungsten, molybdenum and tantalum, a refractory gas-tight ceramic cover for said resistor, an end of the latter projecting beyond the adjacent end of said cover, a hollow metallic plug comprising two gas-tightly connected co-axial portions engaging the projecting end of said resistor, the portion of said plug adjacent the end of said cover gas-tightly and rigidly connected therewith, a slot in said projecting end of the resistor, and springy means in said slot for pressing the portions of said slotted end of the resistor into electrical and gas-tight contact with the portions of said plug so as to permit movement of said end of the resistor relative to the portion of said plug connected with the end of said cover due to differences in longitudinal expansions of said cover and said resistor during operation.

6. An electrical heating element adapted for operation in open air and under other oxidizing conditions at high temperatures, comprising, in combination, a rigid substantially cylindrical resistor of metal of high melting point substantially selected from tungsten, molybdenum and tantalum, a refractory gas-tight ceramic cover for said resistor, an end of the latter projecting beyond the adjacent end of said cover, a hollow metallic plug comprising two co-axial portions engaging each other and the projecting end of said resistor, the portion of said plug adjacent said end of the cover being gas-tightly and rigidly connected therewith by means of a cement, the other portion of said plug forming a cup-like electrode engaging the cylindrical surface of said projecting end and spaced from its front end, a slot in said projecting end of the resistor, and springy means in said slot for pressing the cylindrical portions of said slotted end of the resistor into electrical and gas-tight contact with the portions of said plug so as to permit movement of said end of the resistor relative to the portion of said plug connected with the end of said cover due to differences in longitudinal expansions of said cover and said resistor during operation.

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