United States Patent

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[72] Inventors Horst Schreiner Nuremberg; Helmut Ohmann, Erlangen, both of Germany
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[73] Assignee Siemens Aktiengesellschaft Berlin and Munich, Germany
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[54] COMPOSITE CONTACT STRUCTURE FOR VACUUM-TYPE CIRCUIT INTERRUPTERS

5 Claims, 4 Drawing Figs.

[52] U.S. Cl. .... 200/166 C
[51] Int. Cl. H01h 1/02
[50] Field of Search .... 200/166 C, 144.2

[56] References Cited

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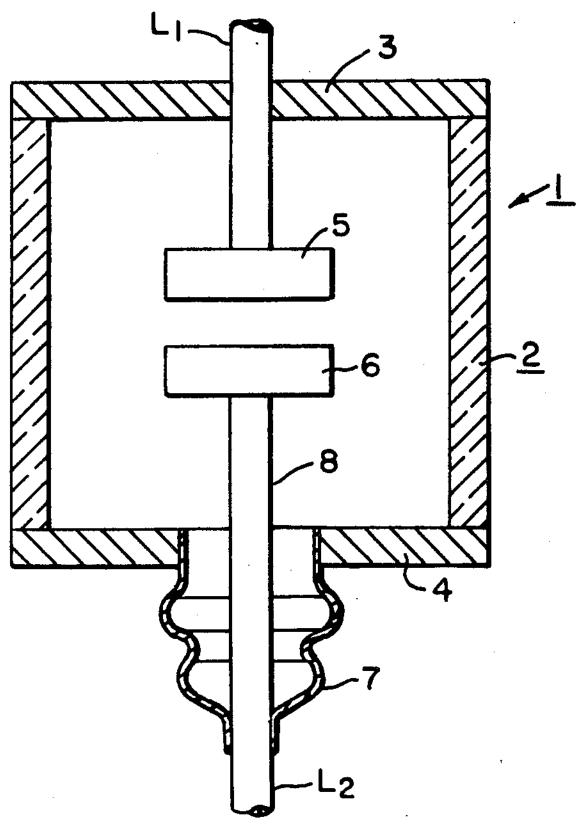
Primary Examiner—H. O. Jones
Attorneys—A. T. Stratton, C. L. McHale and W. R. Crout

ABSTRACT: A composite contact for a vacuum-type circuit interrupter is formed from a porous sintered refractory structure, such as tungsten or molybdenum, infiltrated with an impregnating metal having a liquid phase below 400° C. To assure a wetting action between the porous refractory sintered structure and the infiltrant stock, preferably an auxiliary agent, or an additive, of small quantity is utilized, such as silver, cobalt, copper, iron, nickel, titanium and zirconium in small quantities, for example, a few tenths of one percent.

In use in a vacuum-type circuit interrupter such a composite contact results in a vaporization of the low-melting-point infiltrant. For certain constructions, a reservoir may be provided interiorly of the composite contact to provide an additional quantity of the low-melting-point infiltrant.



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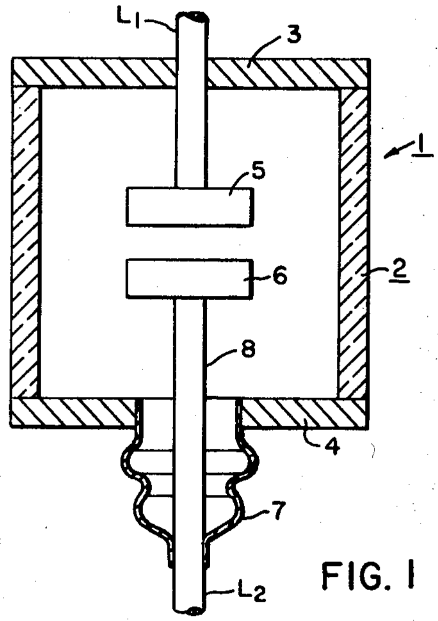

FIG. 1

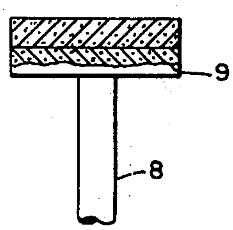

FIG. 2

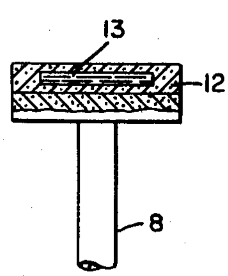

FIG. 3

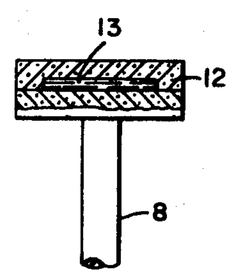

FIG. 4

COMPOSITE CONTACT STRUCTURE FOR VACUUM-TYPE CIRCUIT INTERRUPTERS

CROSS-REFERENCES TO RELATED APPLICATIONS

U.S. Pats. Nos. 3,360,348 and 3,340,022 are concerned with the provision of composite contact structures for switching devices.

BACKGROUND OF THE INVENTION

Contact materials, which are used in vacuum-type circuit interrupters, ought to have, besides extremely low content of gases and of impurities, which give off gases, particularly the characteristics of small welding forces and low erosion due to vaporization in the arc during operating conditions. Generally, the known contact materials consist of copper alloys, which demonstrate, particularly in applications to vacuum-type circuit interrupters, high welding forces and considerable erosion. There has been proposed heretofore contact materials of arc-resisting characteristics, for example, high-melting-point metals, such as tungsten and molybdenum, which contain within the porous structure relatively low-melting-point metals with relatively high-vapor pressure and low-arc voltage. The distribution of such constituents leads to a larger vaporization of the low-melting-point constituent, and to a reduction of the surface portion of the arc-erosion-resisting material.

The object of the present invention is the provision of a composite contact material, which is particularly suitable for contacts utilized in vacuum-type circuit interrupters. Such a composite contact material will preferably have considerable life.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, a composite contact is provided particularly suitable for vacuum-type circuit interrupters, in which a high-melting-point refractory metal, such as tungsten or molybdenum, has a porous structure, when in the sintered condition, which is infiltrated with an infiltration stock, or an impregnating metal, having a liquid phase below 400° C. In addition, to assure an adequate wetting condition between the refractory porous sintered structure and the infiltrant filler material, there is provided an auxiliary agent, or an additive, which provides the desired wetting action.

Accordingly, a general object of the present invention is the provision of an improved composite contact for a vacuum-type circuit interrupter, which will render improved performance and long life.

Still a further object of the present invention is the provision of an improved composite contact for a vacuum-type circuit interrupter comprising a porous refractory high-melting-point skeleton structure, which is impregnated, or penetrated, with an infiltration stock, comprising a relatively low-melting-point nonrefractory material, which has a liquid phase below 400° C.

Further objects and advantages will readily become apparent upon reading the following specification taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat diagrammatic vertical sectional view taken through a vacuum-type circuit interrupter, the contact structure being illustrated in the open-circuit position;

FIG. 2 is an enlarged view, partially in section, of one of the contacts utilized in the vacuum-type circuit interrupter of FIG. 1;

FIG. 3 is a modification of the contact structure of FIG. 2 illustrating the use of a reservoir; and,

FIG. 4 is a variant structure showing a different location of the reservoir.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As well known by those skilled in the art, the contact materials which are used in vacuum-type circuit interrupters ought to have, besides an extremely low content of gases and impurities giving off gases, particularly low welding forces and low arc erosion, due to vaporization in the arc during operating conditions. Generally, in the past, the known contact materials have consisted of copper alloys, which show particularly in the applications to vacuum-type circuit interrupters, high-welding forces and considerable arc erosion. It has, therefore, been proposed to utilize contact materials which are particularly resistant to arc erosion for example high-melting-point materials, such as tungsten and molybdenum, which contain in the pore structure relatively low-melting-point metals having relatively high vapor pressure and a low-arc voltage. The thus-obtained distribution of the constituents leads to a larger vaporization of the low-melting-point constituent, and to a reduction of the surface portion of the high-melting-point arc-errosion-resisting material.

Accordingly it would be desirable to provide a composite contact material, which is particularly suitable for use in vacuum-type circuit interrupters, which consists of a porous sintered structure of an erosion-resisting metal, or a metallic alloy, the pores of which are filled with a low-melting-point metal, or a low-melting-point alloy.

According to the present invention, the pores of the sintered structure are filled with a low-melting-point constituent, which forms a liquid phase below 400° C, and which has, in comparison with the high-melting-point, arc-erosion-resisting constituent, a lower arc voltage. Further, in accordance with the principles of the present invention, the refractory porous structure and/or the filler component, or infiltrant metal, contain auxiliary agents, or additives, which assure of a desired wetting action between the porous sintered structure and the filler material.

An important difference which exists from known composite contact material consists in that in the case of the composite materials according to the present invention, there is obtained a finer and in narrower limits controllable distribution of both constituents with mutual respect. In the composite material according to the present invention, namely the arc-erosion-resisting constituent, which consists preferably of tungsten, molybdenum or rhenium, there exists in the form of the sintered body a definite porosity, the pores of which are filled with the low-melting-point constituent, or infiltrant. The pore part of the sintered body, and therefore the volume part of the low-melting-point constituent can be suited to the switching conditions. At the relatively low switching currents, the pore part is assumed at being 20 percent; at the higher currents, and at the highest switching currents, the pore part is assumed as being up to 60 percent. The porosity of the porous refractory sintered structure is thus fitted to the switching conditions. The part of the low-melting-point effective constituent obtained at the 20 percent volume porosity is sufficient to eliminate the chopping effect at the low currents.

TABLE A

Refractory Skeleton Structure

		Melting Pt. °C.
Mo	Molybdenum	2,625° C.
W	Tungsten	3,410° C.
Re	Rhenium	3,170° C.

TABLE B

Nonrefractory Infiltrant Stock

		Melting Pt. C.
Bi	Bismuth	271.3° C.
Cd	Cadmium	320.9° C.
Ga	Gallium	29.8° C.

Table – Continued

In	Indium	156.4° C.
Pb	Lead	327.4° C.
Sn	Tin	231.9° C.
Tl	Thallium	300° C.

According to the present invention, the low-melting-point constituent consists of metals, or metal alloys, which exist in liquid form below 400° C. Due to this, there is assured a sufficiently fast subsequent delivery of the constituent removed, or lost from the pores at the contact surface by vaporization. Suitable low-melting-point metals, utilized for the infiltrant stock are, for example, bismuth, cadmium, gallium, indium, lead, tin, and thallium, as shown in table B below. Their melting points are listed below to show that all of them have a liquid phase below 400° C.

In addition to the above low-melting-point infiltrants, in addition, their alloys with the metals silver, copper, mercury, antimony, and zinc may be utilized.

Further, the composite contact material, according to the present invention, contains in its structure, or the infiltrant stock, or filler material, an additive, or an auxiliary agent, which provides a desired wetting condition. It has appeared that a sintered body with a metallically clean surface, and the necessarily low gas content, which can be obtained by sintering in hydrogen, subsequent heat treatment in high vacuum, and impregnation with the filler metal in high vacuum is not sufficient; but that a satisfactory wetting, and thus adequate impregnation, can be obtained only through suitable additives to the sintered body and/or to the filler material.

As effective additives to the sintered body there have proven themselves effectives the following metals; silver cobalt, copper, iron, nickel, titanium, and zirconium. As additives for the filler infiltrant stock, there have proved effective aluminum, cobalt, iron, nickel, titanium, zirconium, as well as alkaline or alkaline-earth metals. These additives, or auxiliary agents, are effective in small quantities of, for example, a few tenths of 1 percent.

FIG. 1 illustrates schematically a vertical sectional view taken through a vacuum-type circuit interrupter embodying the composite contact materials of the present invention. It will be noted that the vacuum-type circuit interrupter 1 comprises an evacuated envelope, or housing 2 with end plates or covers 3 and 4 made of metal. The stationary contact 5 is brought into the evacuated envelope 2 through the upper cover 3, and the movable contact 6 is brought, in a vacuum-type manner, through the lower cover 4 by means of a flexible metallic bellows 7.

FIG. 2 shows, in a specially simple and advantageous design, a form of a composite vacuum circuit breaker contact. The reference numeral 8 is a rodlike current lead made of pure copper, or of low-alloyed copper. The reference numeral 9 designates a plate made of the sintered body provided with the filler material. It may be threaded, cemented, soldered (brazed), or welded into position.

An especially desirable form of contact construction for the sintered plate of the vacuum interrupter contacts is shown in FIGS. 3 and 4. The refractory sintered body 12 is provided with an impregnating metal reservoir 13, similar to that provided in an oil reservoir of a self-lubricating sintered bearing. If the supply of the low-melting-point constituent contained in the pores of the refractory sintered body 12 does not suffice, the vaporization loss over the operational life of the composite contact can be replaced from this reservoir 13. The reservoir 13 is located, as it is shown in FIG. 3, preferably inside of the sintered body and beneath the requisite thickness of the contact layer 12. It is filled during the infiltration, or impregnation process. However, the reservoir 13 of the infiltrant stock may be located also on the underside of the contact piece 12, as it is shown in FIG. 4.

EXAMPLE

Tungsten powder graded to pass 100 mesh and be retained on a 200-mesh screen is placed in a compaction die of suitable strength and compacted at approximately 50,000 p.s.i. The compact is then sintered 1 hour in dry hyrodgen at 1,250° C. The hydrogen is pumped off and sintering continued one-half hour in vacuum. The sintered compact is then lowered into a pool of molten In or Pb located in a cooler portion of the furnace. Wetting elements such as Ti may be added to the In or Pb to improve impregnation of the tungsten by indium or lead.

The impregnated sintered structure may assume various geometrical shapes or forms. For example, it may constitute the center portion of a generally platelike contact piece. Moreover it may assume a ring part, or the outer portion of a contact piece. In addition, it may assume a spiral path formed, or it may be a ring part with spirally shaped outwardly running strips, not shown.

From the foregoing it will be apparent that there has been provided an improved composite contact for a vacuum-type circuit interrupter generally comprising a refractory porous sintered body, which is impregnated or infiltrated with a relatively low-melting-point metal having a liquid phase below 400° C., and having a relatively low arc voltage compared with that of the aforesaid refractory sintered body. To promote a desired wetting action therebetween, preferably an auxiliary agent, or an additive is provided to provide a tight bonding of the materials.

Although there has been illustrated and described specific structures and formulations, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. A composite contact material having a low volume of gas content for use as an electrical contact material in vacuum-type switching devices consisting of a porous sintered refractory structure of an arc-resisting metal, the pores of which are infiltrated with a lower melting point metal, characterized in that the pores of the skeleton refractory structure are filled with the low-melting-point constituent which forms a liquid phase under 400° C. and which also has in comparison with the first-mentioned refractory structure a lower arc voltage, a reservoir being provided in the metallic skeleton structure to accommodate a greater supply of the low-melting-point impregnating metal.

2. A composite contact material having a low volume of gas content for use as an electrical contact material in vacuum-type switching devices consisting of a porous sintered refractory structure of an arc-resisting metal, the pores of which are infiltrated with a lower melting point metal, characterized in that the pores of the skeleton refractory structure are filled with the low-melting-point constituent which forms a liquid phase under 400° C. and which also has in comparison with the first-mentioned refractory structure a lower arc voltage, the skeleton structure being a metal selected from the group consisting of tungsten, molybdenum, and rhenium and their alloys, whereas the low-melting-point impregnating metal being selected from the group consisting of bismuth, cadmium, gallium, indium, lead, tin, and thallium and their alloys, and a reservoir being provided within the contact body for accommodating an extra supply of the impregnating metal.

3. A composite contact material having a low volume of gas content for use as an electrical contact material in vacuum-type switching devices consisting of a porous sintered refractory structure of an arc-resisting metal, the pores of which are infiltrated with a lower melting point metal, characterized in that the pores of the skeleton refractory structure are filled with the low-melting-point constituent which forms a liquid phase under 400° C. and which also has in comparison with the first-mentioned refractory structure a lower arc voltage, an additive in a few tenths of 1 percent being added to increase the wettability between the metallic skeleton structure and the impregnating metal, and the additive being a metal selected from the group consisting of silver, cobalt, copper, iron, nickel, titanium and zirconium.

4. A composite contact material having a low volume of gas content for use as an electrical contact material in vacuum-type switching devices consisting of a porous sintered refractory structure of an arc-resisting metal, the pores of which are infiltrated with a lower melting point metal, characterized in that the pores of the skeleton refractory structure are filled with the low-melting-point constituent which forms a liquid phase under 400° C. and which also has in comparison with the first-mentioned refractory structure a lower arc voltage, an additive in a few tenths of 1 percent being added to increase the wettability between the metallic skeleton structure and the impregnating metal, and the additive being a metal selected from the group consisting of aluminum, cobalt, iron, nickel, titanium, zirconium, as well as the alkaline and alkaline earth metals.

5. A composite contact for a vacuum-type circuit interrupter consisting of a metallic refractory matrix filled with a low-melting-point metallic infiltrant stock, said metallic refractory matrix formed of a refractory metal selected from the group consisting of tungsten, molybdenum, and rhenium and their alloys, and said low melting point metallic infiltrant stock having a liquid phase below 400° C., and the low-melting-point metallic infiltrant stock being a metal selected from the group consisting of bismuth, cadmium, gallium, indium, lead, tin, and thallium and their alloys with an additive metal selected from the group consisting of silver, copper, mercury, antimony and zinc in a few tenths of 1 percent for increasing wettability.