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Roy

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[54] **VACUUM INTERRUPTER AND METHODS OF MAKING CONTACTS THEREFOR**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 21,919, March 23, 1970, abandoned.

[52] **U.S. Cl.** .... **200/144 B,** 200/166 C, 75/153 R, 148/11.5

[51] **Int. Cl.** **H01h 33/66**

[58] **Field of Search** .... 200/144 B, 166 C; 75/153; 148/11.5

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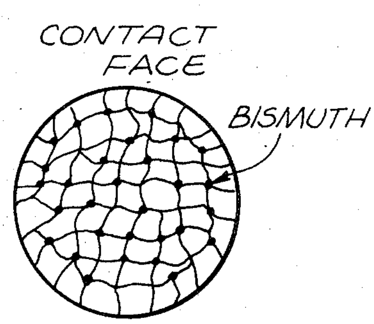
[57] **ABSTRACT**

An electrical contact for a vacuum switch comprising copper containing boron. Bismuth may also be advantageously added.

2 Claims, 5 Drawing Figures



STRUCTURE AND BISMUTH DISTRIBUTION IN COPPER CONTAINING TRACE QUANTITY OF BORON

PATENTED APR 16 1974 3,805,000

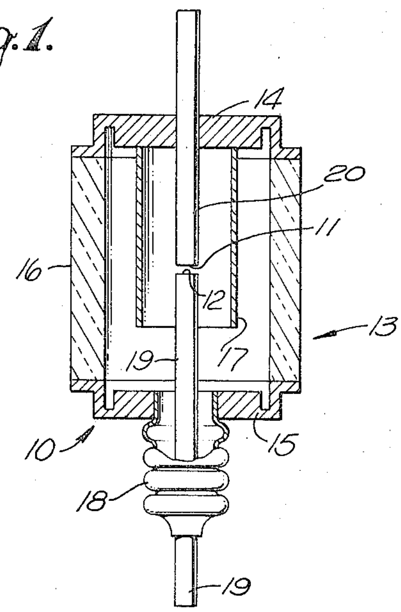


Fig. 1.

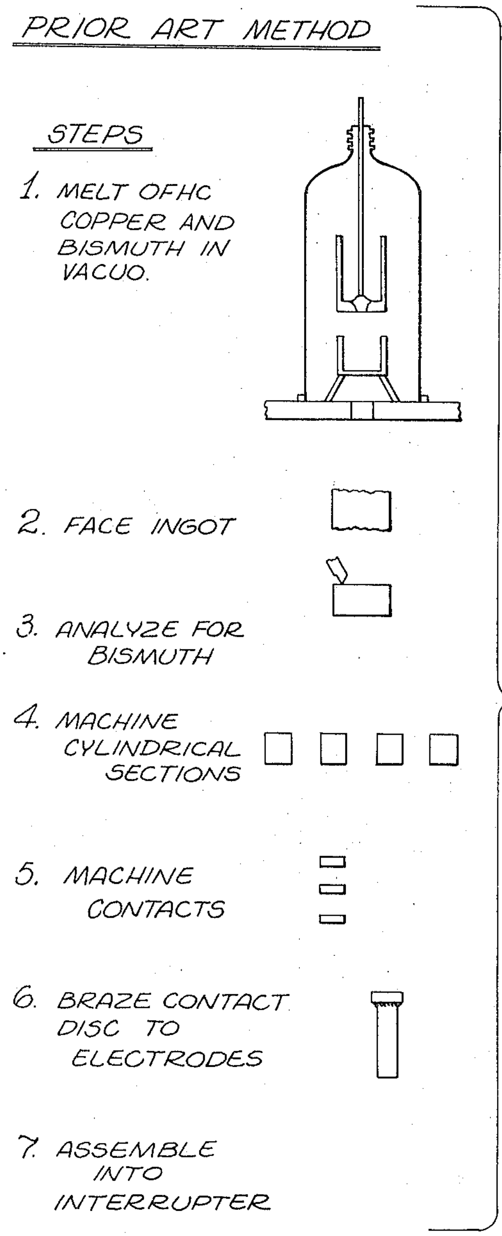
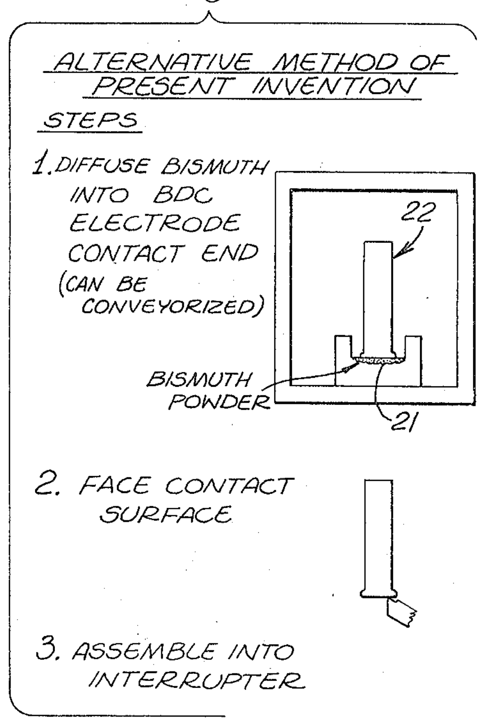


Fig. 2.

Fig. 3.


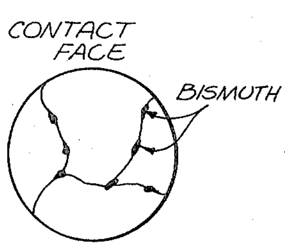
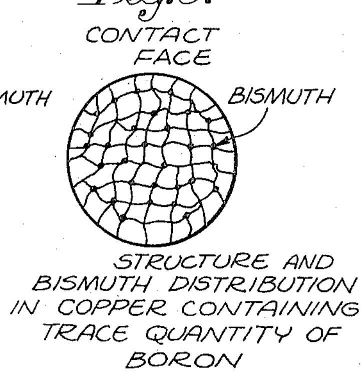


Fig. 4.

Fig. 5.


VACUUM INTERRUPTER AND METHODS OF MAKING CONTACTS THEREFOR

This is a continuation-in-part of copending application Ser. No. 21,919 filed Mar. 23, 1970 now aband. The benefit of the filing date of said copending application is, therefore, hereby claimed for this application. See also the patents cited in said copending application.

BACKGROUND OF THE INVENTION

This invention relates to vacuum switches and methods of making the same, and more particularly, to vacuum interrupters and vacuum interrupter contact fabrication methods.

Several problems are attendant upon the manufacture of vacuum interrupters and contacts therefor. One problem has been to prevent the welding of a pair of opposed contacts when they are held in engagement with one another. Another problem is to suppress any arc generated within one A.C. cycle when the pair of contacts is separated. Prior art contacts do not have a long useful loadbreak interruption life, a high fault current interruption capacity, and good current chop characteristics. These three difficiencies and the said two problems are five serious disadvantages attendant upon the use of prior art contacts.

Contacts of the prior art have failed to overcome the said two problems and the said three difficiencies.

SUMMARY OF THE INVENTION

In accordance with the device of the present invention, the said five and other disadvantages of the prior art are overcome by providing an electrical contact including boron containing copper.

It is also a feature of the invention that bismuth can be added to the boron containing copper.

The boron solubility in copper is very low, i.e., about 0.02 percent at 1,000° C. This solubility drops off rapidly so that practically none is left in solution at room temperature. For this reason, boron containing copper is highly conductive. However, the boron does an excellent job of reducing the copper oxides.

The addition of bismuth has two advantages when added to oxygen-free, high conductivity copper (OFHC copper). OFHC copper does not contain boron. However, bismuth in OFHC copper prevents contacts from welding. A further improvement is made by using boron containing copper with bismuth. This composition resists welding better than presently known contacts. It is believed that copper crystals in boron containing copper are as little as one-eighth the size of conventional OFHC copper. The smaller crystals allow a more uniform distribution of the bismuth or other similar additives and the smaller crystals are more easily pulled apart in case of welding.

The uniform distribution of bismuth between the smaller crystals of boron containing copper also provides a smooth contact surface which is less likely to induce or support an arc.

The present invention is essentially concerned with the improved performance obtained in vacuum interrupters when copper contact electrodes contain lower percentages of boron.

The advantages of low percentages of bismuth are well known. The present invention does not require bismuth in its broad practice. However, boron containing copper electrodes provide a superior host for bismuth addition over OFHC copper. The basis for this superiority is the small uniformly distributed copper grains which are characteristic of boron containing copper. Grain growth is inhibited by the presence of boron. Instead of vacuum melting a copper-bismuth mixture which on solidifying provides an ingot of copper in which a fraction of a percent of bismuth remains in the grain boundaries, bismuth may be diffused into the grain boundaries merely by heating the boron containing copper electrodes in contact with bismuth in a non-oxidizing atmosphere.

The advantages are three-fold:

1. Low cost — separate contact plinths or discs, do not have to be machined and then brazed to the copper electrode.
2. Reliability — the contact discs will not fail at the braze interface and fall off.
3. Quality — the small, regular copper grains characteristic with boron containing copper allow uniform distribution of bismuth over the entire contact face.

Although boron containing copper contact electrodes may be functionally enhanced by the addition of bismuth by diffusion, a superior contact system is obtained with the copper boron system without the introduction of bismuth. The main function of bismuth is to provide sufficient metal vapor between opening electrodes to allow a plasma to be maintained to sustain an arc to current zero, thereby preventing high voltage "spikes" to occur as a result of premature arc quenching. A second contribution of bismuth is to reduce welding of contacts.

The presence of boron also provides an arc sustaining plasma to prevent premature arc quenching as well as an anti-welding function. Additionally, however, the presence of boron in the arc plasma contributes a most important "gettering" function. There is always a minor amount of gas occluded or dissolved in practical electrode materials. These gases may be evolved during the melting of the electrode surfaces due to arc action. Boron vapor has a strong tendency to react with these evolving gases to form oxides, nitrides, carbides, etc., removing not only the evolved gases but improving the quality of the vacuum ambient by a "gettering" action.

There is a boron containing copper sold in common commercial grades as boron deoxidized copper (BD copper).

It may be noted that BD copper costs less than OFHC copper. The copper electrodes of a vacuum interrupter, when fabricated from BD copper, do not require separate contacts to be brazed on. This provides a major cost saving. Should it be desired to include bismuth in the contact system, the bismuth may be diffused into the contacting ends of such electrodes.

The use of boron to deoxidize copper is old in the art. The use of boron in copper electrodes to improve vacuum interrupters is not.

The above-described and other advantages of the invention will be better understood from the following description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a longitudinal sectional view of a vacuum interrupter;

FIG. 2 is a diagrammatic view of a prior art method of making a vacuum interrupter;

FIG. 3 is a diagrammatic view of an alternate method of the invention which may be employed in making a vacuum interrupter; and

FIGS. 4 and 5 are plan views of the faces of vacuum interrupter contacts made in accordance with the methods of FIGS. 2 and 3, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A vacuum interrupter **10** is indicated in FIG. **1.** Vacuum interrupter **10** may be entirely conventional except for switching contact surfaces **11** and **12.**

Vacuum interrupter **10** includes an evacuated envelope **13** having rigid metal plates **14** and **15** brazed to a ceramic cylinder **16.** A cylindrical shield **17** is brazed to the end of plate **14** to keep metal vapor from short circuiting plates **14** and **15** by coating cylinder **16** internally. A bellows **18** is fixed at one end to plate **15** and at its other end to a cylindrical copper rod **19.** Rod **19** may, thus, be moved toward a cylindrical copper rod **20** fixed to plate **14.** Rods **19** and **20** may be copper containing boron. For example, rods **19** and **20** may be boron deoxidized copper.

In still another embodiment of the invention, surfaces **19** and **20** may be boron deoxidized copper with bismuth added by furnace diffusion, as illustrated in FIG. **3.**

One example of how the invention may be practiced is as follows. A relatively pure copper is reduced to the molten state and boron is added to the copper at a proportion of 0.01 percent by weight. The copper may be a common commercial grade of relatively pure copper. It preferably is a highly refined electrolytic grade. The boron goes into solution in the melted copper, but approximately 0.003 percent is required to deoxidize the copper to produce oxygen free copper. When allowed to cool, the excess boron becomes approximately 0.007 percent. The excess boron is essentially precipitated out of the copper solution when the copper is allowed to cool to room temperature. This leaves what is conventionally called boron deoxidized copper (BD copper). If additives such as bismuth are desired, the boron containing copper can be reheated to a molten state in a vacuum and bismuth added. The boron-copper-bismuth mixture is then cooled to room temperature. The vacuum interrupter is then processed in a conventional manner.

Although none of the percentages of boron, copper and bismuth given hereinbefore and hereinafter are critical, a typical range for the boron is 0.003 to 0.50 percent. A typical range for the bismuth is 0.1 to 1.0 percent, although 0.2 percent is preferred. All percentages herein are given by weight.

The copper to be used to make contacts preferably should have an electrical conductivity of 100 percent IACS (International Annealed Copper Standard) and would have a typical analysis as follows:

Ingredient	Weight Percent
Copper	99.95 minimum
Oxygen	0.03–0.05
Sulfur	0.001–0.002
Arsenic	0.0001–0.001
Antimony	0.00001–0.0002
Nickel	0.0001–0.002
Selenium	0.0003–0.001

The phrase "boron deoxidized copper" is hereby defined for use herein and in the claims to be strictly limited to copper containing boron in which elemental boron is mixed with the copper while the copper is in a molten state.

The present invention eliminates:

1. Vacuum melting of copper and preparation of copper-bismuth alloy.
2. Machining of cast alloy ingot to make contact discs.
3. Brazing of contact discs to copper electrodes in hydrogen furnace.

By:

1. Diffusing bismuth from powder into contact end of copper electrode in standard hydrogen brazing furnace, and
2. Facing diffused contact surface.

Trace quantities of boron in copper electrode results in:

1. Improved homogeneity of plasma sustaining elements diffused into copper.
2. "Clean-up" of occluded gases (O_2 and N_2) by boron during arc life.

Although the present invention may be practiced by using contacts separately brazed to electrodes **19** and **20,** it is an advantage of the invention that they need not be made separately. That is, the contacts of electrodes **19** and **20** may be made integral therewith.

Two distinct methods disclosed herein are: (1) Melting BD copper and bismuth together, and (2) Diffusing bismuth powder into the surface of an end portion of a BD copper rod to provide an electrical contact surface thereat.

Note will be taken that the copper grain size in the contact surface shown in FIG. **5** is much smaller than that in the contact surface shown in FIG. **4.** The aforementioned advantages are believed to be attributable to this difference in grain structure. In actual practice, the gain of OFHC copper size is believed to be about eight times that of BD copper.

In FIG. **3,** bismuth powder is diffused into the end **21** of a BD copper rod **22** in a hydrogen (or other inert gas—argon, nitrogen, etc.) furnace.

The method illustrated in FIG. **3** may be performed by standing rod **22** on end in a vertical position, as shown, on a layer of bismuth powder. The rod **22** and the bismuth powder are then heated in an inert gas while the rod **22** is resting on the bismuth powder. The temperature may then be raised to a predetermined diffusion temperature above ambient but below the melting point of copper or to a lower temperature including, but not limited to, for example, between about 500° to 1,082° C. However, this temperature range is not critical.

The contact pressure between rod **22** and the bismuth powder due to the weight of the rod is sufficient to assure an even penetration of bismuth at the said predetermined diffusion temperature.

What is claimed is:

1. The method of making vacuum interrupter contact material, said method comprising the steps of: heating a quantity of elemental boron and a quantity of elemental copper together until the copper melts and dissolves a portion of the boron, the boron quantity being between about 0.003 percent and about 0.5 percent by weight of the sum of both quantities; allowing the boron and copper to cool to room temperature; and reheating the boron and copper with between about 0.1 percent to about 1.0 percent, by weight, of bismuth in a vacuum until the copper melts.

2. The method of making a vacuum interrupter contact said method comprising the steps of: heating a contact, of elemental boron and a quantity of elemental copper together until the copper melts and dissolves a portion of the boron, the boron quantity being between about 0.003 percent and about 0.5 percent, by weight, of the sum of both quantities; allowing the boron and copper to cool to form an ingot; placing a quantity of bismuth powder on top of an approximately horizontal surface of fixture means in a furnace; standing said ingot upright on top of said powder; filling the furnace with an inert gas; and raising the temperature inside the furnace in a manner to cause said powder to adhere to said ingot.

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