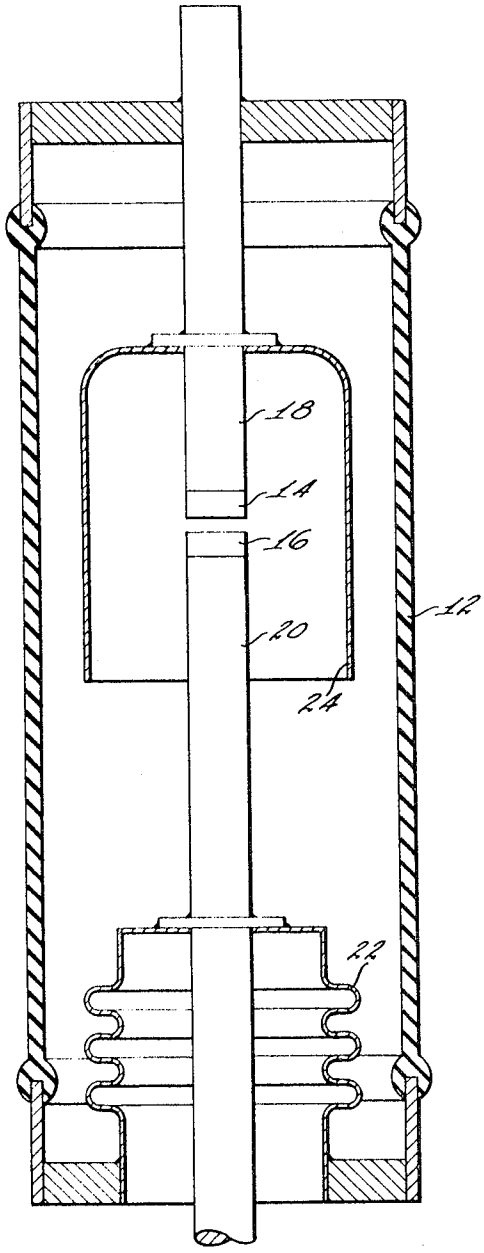
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CONTACT SUPPORTING STUD AND METHOD FOR MAKING THE SAME

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CONTACT SUPPORTING STUD AND METHOD FOR MAKING THE SAME

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ABSTRACT OF THE DISCLOSURE

In a vacuum type electric circuit interrupter having a pair of relatively movable contact studs therein, at least one of the studs is made of an alloy comprising 99.7+% copper, .2% zirconium and .03 to .08% vanadium, which alloy has first been heated to at least 980° C. for 3 to 5 minutes and subsequently reheated to about 400° C. for 10 to 16 hours.

This invention relates generally to electrical circuit interrupters. More particularly, it relates to improved current carrying members for use in vacuum switches, vacuum circuit interrupters and similar devices (all hereinafter called vacuum interrupters) and to improved methods for making such members.

Vacuum interrupters are used in the electrical power industry, for example, to switch capacitor banks and to interrupt power circuits in the event of fault conditions. Though compact in size, vacuum interrupters are adapted to handle relatively high voltages and currents. Vacuum interrupters comprise a sealed envelope in which a high vacuum is maintained and wherein one or more pairs of relatively movable contacts are disposed. In some types of vacuum interrupters each contact is mounted on the end of a current carrying member such as an electrically conductive elongated rod or stud. The studs are in axial alignment with each other and at least one stud is axially movable to effect contact opening and closing. Usually, a cylindrical glass or metal (thin molybdenum, copper, or nickel) shield is disposed within the envelope and surrounds the contacts to prevent metal vapor and particles from being deposited on the inside of the envelope during arcing between the contacts and shorting out the tube.

Heretofore, the studs were usually made of high purity copper designated as O.F.H.C. (oxygen free high conductivity) copper which is 99.95% pure. However, during manufacture of a typical vacuum interrupter it was subjected to hydrogen brazing (for example, at about 1020° C. for 3 to 5 minutes) and bake-out (for example, at about 400° C. for 10 to 16 hours) and the O.F.H.C. copper studs became fully annealed and dead soft. Consequently, great care was needed in handling the vacuum interrupters during manufacture, shipping and field use to prevent sudden jolts from bending the studs to a position where they pierced the shield, broke the envelope, or became misaligned.

It is an object of the present invention to provide improved vacuum interrupters having current carrying members such as contact supporting studs made of a material which is mechanically stronger than O.F.H.C. copper and has substantially the same electrical conductivity and resistivity under similar operating temperature conditions.

Another object is to provide studs of the aforesaid character which are made of copper-vanadium-zirconium alloy.

Another object is to provide an improved vacuum interrupter having contact supporting studs which achieve desired mechanical and electrical properties as a result of the heat treatment to which the interrupter is subjected during manufacture.

Another object is to provide an improved method for making studs for vacuum interrupters.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawing illustrates a preferred embodiment of the invention but it is to be understood that the embodiment illustrated and the process disclosed in the specification are susceptible of modification with respect to details thereof without departing from the scope of the appended claims.

The drawing shows a cross-sectional view of a type of vacuum interrupter in which the invention is advantageously employed.

Referring to the drawing, there is shown a vacuum interrupter comprising an envelope **12** made of electrical insulating material such as glass or ceramic. The interior of envelope **12** is understood to be maintained at a relatively high vacuum. The vacuum interrupter further comprises a pair of relatively movable contacts **14** and **16** (shown in open position) which are made, for example, of tungsten and are mounted on a pair of studs **18** and **20**, respectively. In the embodiment shown, stud **18** supports the stationary contact and is therefore, rigidly mounted in sealed relationship in envelope **12**. Stud **20** supports the movable contact and is movably mounted in sealed relationship in envelope **12** by means of a bellows **22**. A cylindrical shield **24** is mounted on stud **18** and extends around the contacts **14** and **16**. In practice, shield **24** is made of molybdenum on the order of .004 of an inch thick which tends to become brittle and fragile after being subjected to the heat treatment hereinafter described. In practice, the contacts are brazed to the studs, and the bellows and shield are brazed to their respective studs as hereinafter described.

In accordance with the present invention the studs **18** and **20** are made of copper-vanadium-zirconium alloy instead of O.F.H.C. copper as is the case in prior art devices of this type. In a preferred embodiment the ternary alloy comprised about 99.7+% pure copper, about .03 to .08% vanadium, and about .2% zirconium. However, an alloy comprising other percentages of the stated materials could be employed.

The following steps are followed in the manufacture of a vacuum interrupter of the type disclosed herein. First, the component parts of the vacuum interrupter are assembled using suitable jigs to hold the components in proper relationship. Brazing material of high purity and in the form of thin sheets, rings and pellets is disposed on the assembled components at places where components are to be jointed together, i.e., at the joints between the contacts **14** and **16** and the studs **18** and **20**, respectively, at the point between shield **24** and stud **18**, at the joint between bellows **22** and stud **20**, and at other places where brazing is required. The entire assembly is then disposed in an atmosphere of pure hydrogen and raised to a temperature of about 1020° C. for about 3 to 5 minutes until the brazing material melts. The assembly is then cooled so that the brazing material solidifies. Afterward, the entire assembly is pumped out to establish a high vacuum in envelope **12** and is baked-out at a temperature of about 400 to 450° C. for about 10 to 16 hours. The bake-out procedure is necessary to age the components and drive off any residual impurities. After the bake-out cycle, the envelope **12** is cooled to room temperature (which will aid in getting the vacuum to approximately 2×10^{-10} torr) and is sealed. As will be understood, all of the steps described above are carried out in a "clean room" environment.

The foregoing steps are required whether or not the studs are made of O.F.H.C. copper or of copper-vanadium-zirconium alloy. However, when the cold worked al-

loy is used the hydrogen brazing step causes the zirconium and vanadium in the alloy to be taken into solid solution with the copper when a temperature of about 980° C. or above is reached. Thus, the zirconium and vanadium are disposed throughout the copper while the basic crystalline structure of the copper remains unchanged. As a consequence, there is imparted to the alloy an excellent resistance to softening at temperatures as high as 615° C. When the alloy is subsequently subjected to vacuum bake-out the electrical conductivity of the alloy rises from 50% I.A.C.S. (International Annealed Copper Standard) to about 92%. Thus, the steps which are required when using O.F.H.C. copper and result in full annealing and softening thereof have the effect on the alloy of increasing its mechanical strength and raising its electrical conductivity to desirable levels.

It should be noted that O.F.H.C. copper has a yield strength of 40,000 p.s.i. (pounds per square inch) and a softening point of 250 to 300° C. The addition of .2% zirconium alone raises its yield strength to 55,000 p.s.i. and its softening point to about 580° C. The addition of .03 to .08% vanadium to the copper-zirconium alloy raises the yield strength to 62,000 p.s.i. and the softening point to about 615° C. The ultimate tensile strength of O.F.H.C. copper is below 32,000 p.s.i. after annealing, whereas the worst condition of the ternary alloy is 58,000 p.s.i.

While the invention disclosed herein is depicted as applied to one of several types of vacuum interrupters, it will be apparent to those skilled in the art that it is applicable to other types of vacuum interrupters and other types of devices. Furthermore, while the alloy is disclosed herein as the material of which the studs are made, it is apparent that the alloy could be used for other electrical current carrying components within vacuum interrupters or other devices which are subjected to the aforedescribed heat treatment during manufacture.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a vacuum interrupter, an envelope wherein a high vacuum is maintained, and a pair of relatively movable contact carrying studs within said envelope, at least one of said studs being made of a copper-vanadium-zirconium alloy, said alloy comprising at least 99.7+% copper, .2% zirconium, and .03 to .08% vanadium.

2. A vacuum interrupter according to claim 1 wherein said alloy has been heat treated so that it is mechanically stronger than O.F.H.C. copper and has an electrical conductivity which is about 92% of O.F.H.C. copper.

3. A vacuum interrupter according to claim 2 wherein said alloy has been first heated to at least 980° C. for 3 to 5 minutes and subsequently reheated to about 400° C. for 10 to 16 hours.

4. As an electrical contact, a high strength, high conductivity current carrying component comprised of an alloy containing copper, vanadium and zirconium, said alloy comprising at least 99.7+% copper, .03 to .08% vanadium and .2% zirconium.

5. An electrical contact according to claim 4 wherein said alloy has been raised to a temperature of at least 980° C. for a length of time sufficient to raise its yield strength to about 62,000 p.s.i. and to raise its electrical conductivity to about 92% I.A.C.S.

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