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(54) **Manufacture of vacuum interrupter contacts.**

(57) A method of manufacturing vacuum interrupter contacts by mixing powdered copper with powdered chromium and less than 0.25% powdered bismuth, cold pressing the mixture up to more than 90% of theoretical maximum density, sintering under vacuum, and then cold coining the contact up to more than 97% of theoretical maximum density. The bismuth may in some cases be replaced by lead, tellurium, thallium, antimony, tungsten or a mixture thereof.

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Manufacture of Vacuum Interrupter Contacts

The present invention relates to vacuum type circuit interrupters and more particularly to a method for forming the contact structure which is a part of such vacuum interrupters.

Vacuum type circuit interrupters generally comprise an evacuated insulating envelope having separable contacts disposed within the insulating envelope. The contacts are movable between a closed position in which the contacts are engaged and an open position in which the contacts are separated and an arcing gap is established therebetween. An arc is initiated between the contact surfaces when the contacts move into or out of engagement while the circuit in which the interrupter is used is energized.

Under various conditions of fault current or contact movement an arc may be formed that results in the melting and vaporising of some contact material. Then after the contacts are brought together under high pressure engagement welds may be formed between the contact surfaces due to the melted contact material formed during arcing. Current surges also occur in the first few milliseconds of contact closing and these can also cause contact welding. The magnitude of the force required to break the weld so that the contacts can be opened depends upon many factors including the previous fault current, for example, the contact area, and the contact material.

These welds are objectionable since they interfere with the easy movement of the separable contacts and may result in the failure of the vacuum interrupter to open.

One proposed solution to this problem, is to adjust the welding characteristics of the contacts so that the welding which may take place is of sufficiently low strength that the weld may be readily broken without unduly distorting or changing the surface of the contact material at which the weld occurs. In addition, the fundamental characteristics of the contact materials, namely, good current interruption ability, high voltage withstand capability and low electrical resistance including low chopping and low erosion characteristics must not be altered during operation.

One approach has been to utilize a major proportion of a very strong element and form a sintered network of powdered particles of this material and thereafter infiltrate the same with a lesser amount of another component which will produce a compromise in the various characteristics of the individual components. Typical of such materials has been the employment of a major constituent comprising a refractory metal such as chromium which is characterised by an high melting point and thereby minimise the welding tendency of the electrode. A pure sintered refractory metal contact formed for example, of chromium will not provide the required electrical conductivity nor the chopping characteristics and high voltage withstand capability. These characteristics are supplied by infiltrating the sintered matrix with a material of good electrical conductivity and low chopping characteristics but which may suffer from high erosion and lower voltage withstand capability, such as copper or silver.

Chromium-copper contacts are well known from for example U.K. Patent No. 1,194,674 and U.S. Patent Nos. 3,960,554 and 4,048,117. In each of these cases, the chromium is first pressed into a matrix and then infiltrated with copper. In US 4,048,117 a further component of the contact material is an "anti-welding" element which displays "anti-welding" characteristics in a vacuum enviroment. In this case between 0.3% and 2% of bismuth was dissolved in the copper before being infiltrated into the chromium matrix, which had been cold pressed and sintered beforehand. Bismuth is one example of elements such as lead, tellurium, antimony, tungsten and similar metals which form a brittle intermetallic phase thereby decreasing the ductility of the welds and so enabling the weld to be broken more easily.

It has, however, been found that the amount of such an embrittling agent that is required to provide the "anti-welding" characteristics in a vacuum environment can be considerably reduced if the constituents of the contact, that is, the refractory metal, the metal with good electrical conductivity and the embrittling agent are all mixed together as powders and are then cold pressed.

Accordingly, the invention provides a method of manufacturing vacuum interrupter contacts comprising the steps of mixing a metal of high electrical conductivity in powder form with an embrittling agent in powder form and a refractory metal in powder form, the mass of the embrittling agent being less than 0.25% of the total mass of the mixture, cold pressing the mixture to a density of greater than 90% relative to theoretical maximum, sintering under vacuum, and then cold coining the sintered contact up to a density of greater than 97% relative to the theoretical maximum.

In one preferred embodiment of the invention the metal with high electrical conductivity is copper and the refractory metal is chromium. The embrittling agent is preferably bismuth but may be any one of lead,tellurium, thallium, antimony or tungsten or, in some cases, a mixture thereof.

The copper powder which preferably has a particle size range of up to approximately 100μm is conveniently first mixed with the bismuth which preferably has a particle size range of up to approximately 40μm. This base mixture is then mixed with the chromium powder which preferably has a particle size range of up to 22μm. The proportion of base mixture to chromium is preferably in the range 40-90% by mass of base mixture to 60-10% of chromium and is most preferably approximately 75% base mixture to 25% of chromium.

Preferably also, the mixture is first cold pressed to a density of approximately 93% relative to theoretical maximum, vacuum sintered at a temperature of between about 950-1050°C and then cold coined to a density of approximately 98% relative to theoretical maximum.

One example of a method of manufacturing a vacuum interrupter contact in accordance with the invention will now be described with reference to the accompanying drawing.

In this example copper powder 1 with a particle size of less than 100μm is first thoroughly mixed with bismuth powder 3 with a particle size range of less than 40μm. This base mixture 4 is then thoroughly mixed with chromium powder 2 with a particle size range of up to 200μm in the proportions of 75% by mass of base mixture 4 to the remainder chromium 2. The amount of bismuth 3 in this mixture being 0.15% by mass.

The mixture 5 is then cold pressed 6 at approximately 45 ton/sq.inch (70 x 10^6kg/m^2) to a density of approximately 93% relative to theoretical maximum. It is then sintered 7 under vacuum at a temperature of about 1025°C for four hours to achieve partial bonding of the copper/copper and copper/chromium and annealing of the compact material.

The sintered compact is then cold coined 8 at approximately 72 ton/sq.inch (113 x 10^6kg/m^2) to a density of approximately 98% relative to theoretical maximum. It is then finally machined to prepare for inclusion as a contact in a vacuum interrupter.

CLAIMS

1. A method of manufacturing vacuum interrupter contacts comprising the steps of mixing a metal of high electrical conductivity in powder form with an embrittling agent in powder form and a refractory metal in powder form characterised in that the mass of the embrittling agent is less than 0.25% of the total mass of the mixture, the mixture is cold pressed to a density of greater than 90% relative to theoretical maximum, then sintered under vacuum, and the sintered mass is then cold coined up to a density of greater than 97% relative to the theoretical maximum.

2. A method of manufacturing vacuum interrupter contacts according to Claim 1, characterised in that the metal of high electrical conductivity is copper.

3. A method of manufacturing vacuum interrupter contacts according to Claim 2, characterised in that the refractory metal is chromium. and the embrittling agent is bismuth.

4. A method of manufacturing vacuum interrupter contacts according to Claim 2, characterised in that the embrittling agent is either lead or tellurium or thallium or antimony or tungsten.

5. A method of manufacturing vacuum interrupter contacts according to Claim 2, characterised in that the embrittling agent is a mixture of any of lead,tellurium, thallium, antimony, tungsten or bismuth.

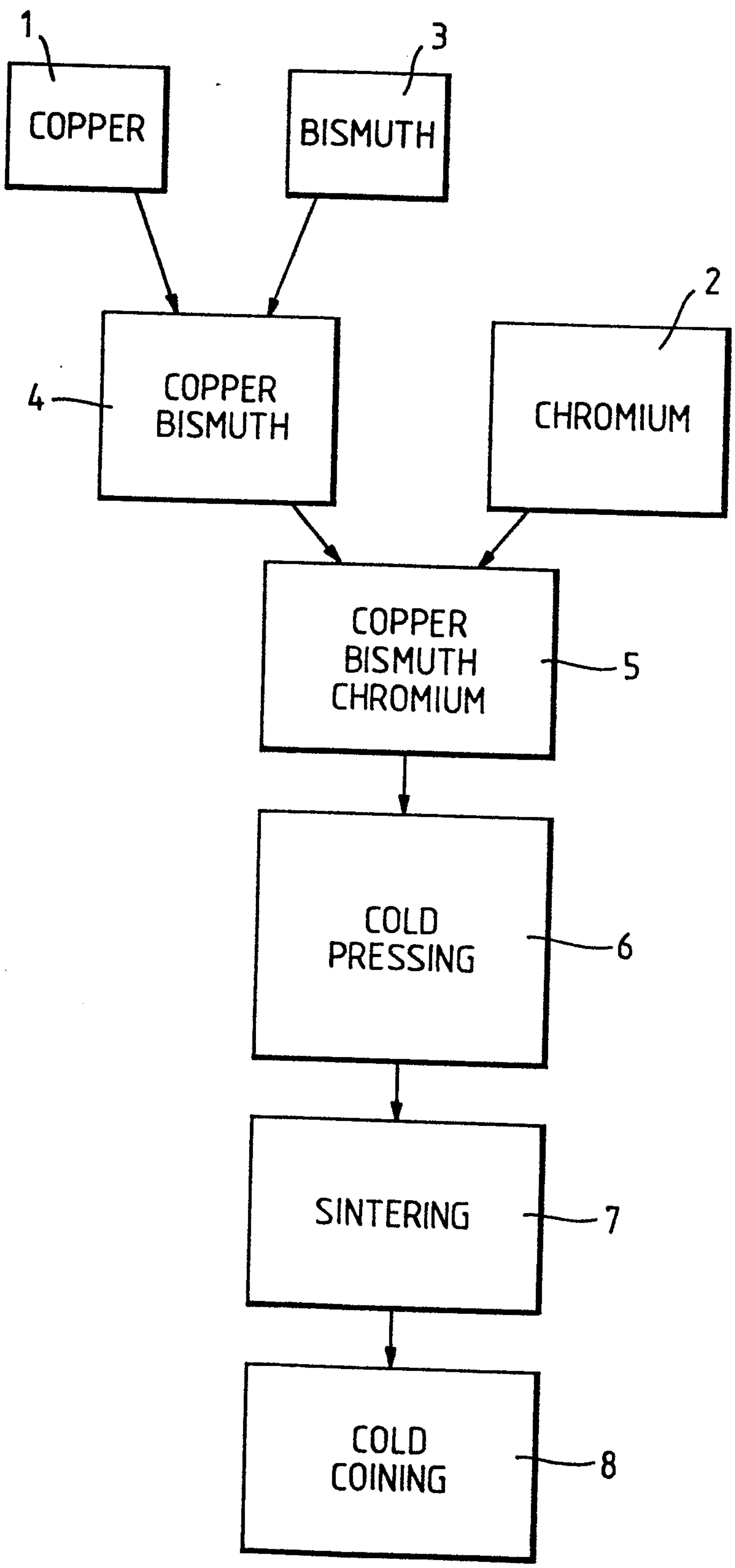
6. A method of manufacturing vacuum interrupter contacts according to Claim 3, characterised in that the copper powder 1 has a particle size range up to approximately 100μm, and the bismuth 3 has a particle size of up to approximately 40μm, and the copper powder 1 is first mixed with the bismuth 3, to form a base mixture 4 which is then mixed with the chromium 2.

7. A method of manufacturing vacuum interrupter contacts according to Claim 6, characterised in that the base mixture 4 of copper powder and bismuth is mixed with chromium powder 2 having a particle size range of up to approximately 200 μm.

8. A method of manufacturing vacuum interrupter contacts according to Claim 7, characterised in that the proportion of base mixture 4 to chromium 2 is in the range 40-90% by mass of base mixture to 60-10% by mass of chromium, this mixture including approximately 0.15% by mass of bismuth 3.

9. A method of manufacturing vacuum interrupter contacts according to Claim 8, characterised in that the mixture 5 is first cold pressed 6 to a density of approximately 93% relative to theoretical maximum, vacuum sintered 7 at a temperature of between about 950-1050°C and then cold coined 8 to a density of approxiamtely 98% relative to theoretical maximum.

Fig. 1.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