May 16, 1961 L. F. NEELY ET AL 2,983,996

COPPER-TUNGSTEN-MOLYBDENUM CONTACT MATERIALS

Filed July 30, 1958

FIG. 1.

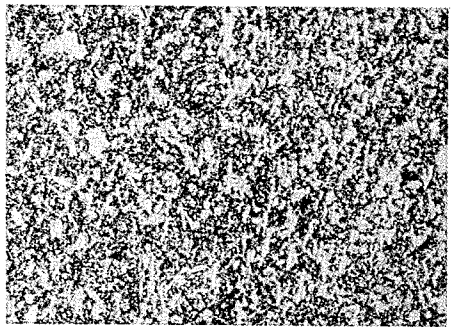
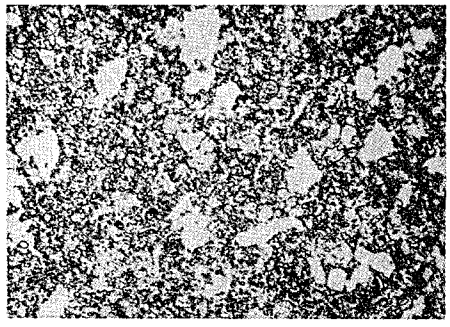


FIG. 2.



INVENTORS
LLOYD F. NEELY
CHOH-YI ANG

BY

ATTORNEY

United States Patent Office 2,983,996
Patented May 16, 1961

2,983,996

COPPER-TUNGSTEN-MOLYBDENUM CONTACT MATERIALS

Lloyd F. Neely and Choh-Yi Ang, Indianapolis, Ind., assignors to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

Filed July 30, 1958, Ser. No. 751,984

8 Claims. (Cl. 29—182)

This invention generally relates to contact materials, and, more particularly, to electric make-and-break contacts formed of a copper-tungsten-molybdenum composition.

Electric contacts comprising a refractory constituent, such as tungsten, and a high conductivity constituent, such as copper, have been used in the electrical arts for many years and on a very substantial scale. The principal advantage of contacts of this type is that they combine the substantial hardness and other desirable characteristics of the refractory metal with the high thermal and electrical conductivity of the high conductivity metal. However, these contacts would erode very badly when used for certain applications, for example in circuit breakers for interrupting currents of high intensity, causing operating difficulties and requiring frequent replacement of the contacts at considerable expense.

It is an object of the present invention to improve contacts of the described general type.

It is another object of the present invention to provide novel and improved electric contact materials having excellent electrical and mechanical properties, especially greatly improved resistance to arc erosion.

The invention also contemplates electric make-and-break contacts having greatly improved characteristics, including superior resistance to arc erosion, which can be readily manufactured and sold at a cost below that of conventional contacts.

Other and further objects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a photomicrograph showing the microstructure of a preferred contact composition of the invention at a magnification of 100 diameters; and

Fig. 2 is a similar photomicrograph showing the microstructure of the said composition at a magnification of 500 diameters.

Broadly stated, in accordance with the principles of the present invention, there is provided a novel contact material which has excellent electrical and mechanical properties and is particularly characterized by a high resistance to arc erosion. The novel contact material can be used as high current make-and-break contacts in circuit breakers, as pressure exerting welding electrode, or as medium to heavy duty contacts or electrodes in any application where the prime requisite is a low erosion rate. These new results and advantages are obtained by a metal composition containing copper, tungsten and molybdenum within a well-defined and narrow range. Thus, it has been found that materials essentially composed of 28% to 36% by weight of copper, 32% to 36% by weight of tungsten, and 32% to 36% by weight of molybdenum consistently provide the advantages of the invention, the preferred composition range being about 30% to about 34% by weight of copper, about 33% to about 35% by weight of tungsten, and about 33% to about 35% by weight of molybdenum.

Various methods may be used for making the contact compositions of the invention, of which the press-sinter-infiltration method has been found to provide highly satisfactory results. In carrying this method into practice, the preferred raw materials are tungsten powder and molybdenum powder not over 5 microns in Fisher average particle size and copper powder minus 100 mesh. A mixture of these powders in suitable proportions, such as 41% by weight of tungsten powder, 41% by weight of molybdenum powder, and 18% by weight of copper powder, is blended thoroughly by ball milling for 6–12 hours, using a ceramic mill and balls. The powder mix is then screened through a 40 mesh sieve. Binders, such as Amberol (an oil-soluble phenol-formaldehyde and maleic glyceride resin), and/or lubricants may be added to the powders in amounts as high as 2% by weight to improve powder flow and apparent density and to increase the green strength of the pressed compacts.

Compacts of desired shape are pressed from the blended powder mixture by means of conventional powder metallurgical procedures. The pressed density of the compacts may be varied from 7 to 9 gm./cc. Keeping sintering conditions constant, the final copper content after infiltration is roughly inversely proportional to the pressed density. The higher the pressed density, the lower is the porosity to be replaced by copper during infiltration. The composition ranges given in the foregoing cover the practical range of pressed density here described.

Either batch or stoker type sintering operations may be employed in sintering the pressed compacts. The sintering temperature may be 1300° to 1350° C. and the time at heat 6 to 20 minutes. The compacts can be placed in either graphite or metal (such as molybdenum) boats, with or without Alundum sand. The furnace atmosphere must be either reducing or inert. Together with the variation in pressed density, sintering conditions may be varied slightly to obtain the desired linear shrinkages, which will affect tooling and also final composition analysis. The nominal range of linear shrinkages expected from the processing conditions specified in the foregoing is 1 to 6%.

The furnacing conditions of sintering also apply to the infiltration step, except that the temperature is lowered to 1200° to 1275° C. The calculated amount of copper with some excess is placed on top of the compact, or, if desired, at the ends in the case of a bar, or applied in any other manner practiced by a powder metallurgical shop. The sintered compacts may have some of their sides, or faces, covered by an impervious refractory paste, such as kaolin, to control the direction or amount of bleeding of the copper. The infiltrated parts usually have some excess of copper, which is machined off.

Another satisfactory method of preparing the contact materials of the invention is the straight press and sinter procedure without subsequent infiltration. In this case, the correct amounts of tungsten, molybdenum and copper powders to make up the final composition, for example 30% by weight of copper, 35% by weight of tungsten, and 35% by weight of molybdenum are thoroughly blended and then fritted at about 1100° to 1200° C. in a reducing atmosphere into slightly sintered cakes. These cakes are broken up by pulverization and then screened. Binders, lubricants, or both, may be added to the powder. The compacts pressed from said powder are then sintered to a density over 95% of the theoretical density at some temperature between 1350° and 1425° C. for not less than 30 minutes.

Other methods of preparing the contact materials of the invention are simultaneous sintering and infiltration of compacts pressed from the constituent powders, or hot pressing.

A comparison of properties between the novel contact material A (composed of 31.85% by weight of copper,

34.07% by weight of tungsten, and 34.08% by weight of molybdenum), and conventional contact material B (composed of 32.10% by weight of copper, balance tungsten), can be shown by the following tabulation:

	A	B
Copper analyses, percent by weight	31.85	32.10
Hardness, Rockwell B	90–95	86–90
Conductivity, percent IACS	39–41	30–40
Average weight loss, mg./operation	2.62	6.89
Average volume, loss, cc.×10−4/operation	2.33	4.90

The average weight and volume losses per operation have been optained from results of short circuit arc erosion tests carried out under oil. The short circuit test consisted of 30 interruptions of 1,400 amperes, 240 volts, A.C. The current flow was limited to one-half cycle by an electronic timer which controlled the energizing of the circuit.

From the foregoing tabulation, the superiority of the contact material of the invention over the conventional material, which is extensively used as heavy duty electrical contacts, is clearly apparent. Particularly striking is the improvement of the resistance to arc erosion which is probably the most important requirement in contacts of the described type. Comparative tests indicate that the contacts of the invention are about 27% more erosion resistant, on weight basis, than the conventional contacts.

In preparing the contact material of the invention referred to in the foregoing table, the ball milling time was 7–8 hours. The compacts were pressed to a density of 8.75 g./cc. and sintered at 1325° C. for 12 minutes. Thereupon the sintered compacts were infiltrated at 1250° C. for 8 minutes. Typical properties of the novel contact material prepared by the method just described will appear from the following:

Density	11.25 g./cc., nominal.
Hardness	95±5 Rockwell B.
Electrical conductivity	42±4% IACS.
Average ultimate tensile strength	80,000 p.s.i.
Average 0.2% offset yield strength	60,000 p.s.i.
Elongation in 1"	1–2%.
Average rupture modulus	156,000 p.s.i.

Figs. 1 and 2 of the drawing show the microstructure of the contact material of the invention obtained at a magnification of 100 and 500 diameters, respectively, with an etchant of $NaOH+K_3Fe(CN)_6$. The white areas are the infiltrant copper and the clearly visible grains are particles of tungsten and molybdenum. There is practically no alloying between copper and tungsten or molybdenum. Excellent physical and mechanical properties are derived from the uniformity of microstructure, clearly apparent in Fig. 1, and from the homogeneity of bonding between grains of the refractory metals, with a minimum amount of residual porosity.

It will be noted that the contact materials of the invention provide a number of important advantages. First of all, the electrical and mechanical properties of the novel contacts, particularly their resistance to arc erosion, are greatly superior to those of comparable conventional contact materials composed of copper and tungsten in the absence of molybdenum. Although both tungsten and molybdenum have about the same electrical conductivity at room temperature, molybdenum has a lower temperature coefficient of electrical resistivity and a lower electron work function than tungsten. Furthermore, molybdenum has higher thermal conductivity than tungsten. Together with tungsten, which has a high melting point, and copper, which is an excellent electrical and thermal conductor, the presence of molybdenum within a clearly defined range in the novel contact material makes it highly resistant to arc erosion. In comparison with the straight copper-tungsten materials of the prior art, the contact material of the invention is characterized by a much lower surface temperature during arcing because of its lower work function and its greater capacity to conduct away the heat. The loss of material during arcing is therefore reduced to a minimum.

It is also to be observed that, as the preferred process of making the contacts of the invention is closely similar to that of making conventional tungsten-copper materials, there is no significant difference in the cost of manufacture of the two types of materials. A substantial amount of saving is realized, however, in the cost of raw materials. Molybdenum powder is about 11% cheaper per pound than tungsten powder and its density is only about half of that of tungsten. A simple calculation will show that, as the cost of making contacts is based on volume, the cost saving on raw material per given piece of electrical contact embodying the invention is about 24%. A cost saving of such magnitude is, of course, of great commercial value in a highly competitive art as that of electrical contacts.

Although the present invention has been disclosed in connection with preferred embodiments thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the invention. All of these variations and modifications are considered to be within the true spirit and scope of the present invention as disclosed in the foregoing description and defined by the appended claims.

What is claimed is:

1. A metal composition particularly suitable for electric contacts and pressure exerting welding electrodes which comprises 28% to 36% by weight of copper, 32% to 36% by weight of tungsten, and 32% to 36% by weight of molybdenum, said tungsten and said molybdenum being substantially unalloyed with each other.

2. A metal composition particularly suitable for electric contacts and pressure exerting welding electrodes essentially composed of 30% to 34% by weight of copper, 33% to 35% by weight of tungsten, and 33% to 35% by weight of molybdenum, said tungsten and said molybdenum being substantially unalloyed with each other.

3. An electric make-and-break contact made of a metal composition essentially composed of about 30% by weight of copper, about 35% by weight of tungsten, and about 35% by weight of molybdenum, said tungsten and said molybdenum being substantially unalloyed with each other.

4. An electric make-and-break contact having high resistance to arc erosion essentially composed of 28% to 36% by weight of copper, 32% to 36% by weight of tungsten, and 32% to 36% by weight of molybdenum, said tungsten and molybdenum being substantially unalloyed with each other and being in the form of a porous matrix, the pores of which are substantially filled with said copper.

5. An electric make-and-break contact characterized by high resistance to arc erosion formed of a pressed and sintered porous compact of tungsten and molybdenum infiltrated with copper, said tungsten and said molybdenum being substantially unalloyed with each other and each constituting about 32% to about 36% by weight of the contact, the balance of said contact being substantially all copper.

6. An electric make-and-break contact characterized by high resistance to arc erosion formed of a pressed and sintered porous compact of tungsten, molybdenum and copper which is infiltrated with an additional amount of copper, said tungsten and said molybdenum being substantially unalloyed with each other and each constituting about 32% to about 36% by weight of the contact, the balance of said contact being substantially all copper.

7. An electric make-and-break contact characterized by high resistance to arc erosion formed of a pressed and sintered compact essentially composed of about 32% to about 36% by weight of tungsten, and about 32% to about 36% by weight of molybdenum, the balance being

substantially all copper, said tungsten and said molybdenum being substantially unalloyed with each other.

8. An electric make-and-break contact essentially composed of 28% to 36% by weight of copper, 32% to 36% by weight of tungsten, and 32% to 36% by weight of molybdenum, said tungsten and said molybdenum being substantially unalloyed with each other, said contact having electrical and mechanical characteristics including resistance to arc erosion which are considerably better than those of conventional contacts composed of similar amounts of copper and the balance tungsten in the absence of molybdenum.

References Cited in the file of this patent

UNITED STATES PATENTS

1,236,384	Fahrenwald	Aug. 7, 1917
2,851,381	Hoyer	Sept. 9, 1958

OTHER REFERENCES

Goetzel: "Treatise on Powder Metallurgy," vol. I, 1949, page 204; vol. 2, 1950, pages 197–201.