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ELECTRICAL CONTACT MATERIAL

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ABSTRACT OF THE DISCLOSURE

An electrical contact material consisting essentially of tungsten or its carbides, a metal of high electrical conductivity such as silver or copper, and magnesium oxide. Tungsten or its carbides are used to provide the contact material with a high melting temperature constituent. The silver or copper is used to provide the contact material with a constituent of high electrical conductivity. The magnesium oxide constituent is used to provide the contact material with improved arc erosion resistance and improved arc interruption characteristics when compared to the same characteristics of a contact material consisting essentially of tungsten or its carbides, and silver or copper. The tungsten or its carbides with silver or copper type contact material of the present invention consists essentially of 90 to 10 weight percent silver or copper, 0.25 to 7 weight percent magnesium oxide, the remainder essentially tungsten or carbides.

The presence of small amounts of impurity elements is not believed to play a critical role in the invention. It is to be understood that the invention contemplates the possibility of the addition of other elements to electrical contact material as long as such additives do not have a harmful effect on the function of the magnesium oxide in the contact material.

The present invention relates to an electrical contact material and, more particularly, to an electrical contact material of the type including tungsten or its carbides, a metal having good electrical conductivity which is substantially mutually insoluble and non-reactive with tungsten or its carbides such as silver or copper, and magnesium oxide which improves the arc erosion resistance and improves the arc interruption characteristics of the contact material when compared to a contact material of the type consisting essentially of tungsten or its carbides with silver or copper.

Usually engaged working surfaces of current carrying contacts do not disengage or "open" uniformly across such surfaces. Rather, during opening of the working surfaces, some small area of each of such working surfaces remains engaged across which is created a sufficiently high current density to melt the contact material at the small area of engagement of the working surfaces. As the small engaged area of the working surfaces of the contacts move apart, a liquid bridge appears to be created which vaporizes to supply a medium for sustaining an electric arc between the working surfaces of the contacts. The arc tends to remain in existence as long as sufficient contact material can be boiled off the contacts by the heat of the arc to make up for condensation and expulsion of vapor from the contact gap.

Electrical contacts of a high conductivity material such as silver or copper have poor arc erosion resistance and arc interruption characteristics and, therefore, among other things, tend to experience pitting of the working surface and to experience rapid arc erosion of the working surfaces of the contact material.

To reduce the arc erosion rate of the working surfaces of high conductivity materials, composite contact materials have been made from tungsten with a matrix of

either silver or copper. However, such composite contact materials tend to lose some of the matrix of silver or copper since under the action of heat normally associated with the operation of such composite contact materials, the silver or copper volatilizes creating tungsten nodules that act to increase the electrical transfer resistance of the working surface of the composite contact material and raise the temperature of the tungsten nodules.

Additions of oxides of metals such as zirconium, aluminum and silicon in the composite contact material of tungsten and silver or copper type increases the hardness of the contact material and increases the electrical contact resistance of the contact material. None of the above metals or oxides of metals when added to the tungsten with silver or copper composite contact type material appears to have a substantial effect on improving the arc erosion resistance and improving the arc interruption characteristics of such contact material.

It was found that a tungsten or its carbides with silver or copper composite contact type material which includes from about 0.25 to 7 weight percent magnesium oxide had significantly improved arc erosion resistance and decreased arc interruption characteristics. Surprisingly, it was found that the addition of substantially the same weight percent of magnesium oxide to an electrical composite material of molybdenum or its carbides with silver or copper did not significantly improve the arc erosion resistance and improve the arc interruption characteristics of such a composite contact material. The substitution of 0.25 to about 7 weight percent calcium oxide, an oxide of a metal from same group of the Periodic Table of Elements as is the oxide of magnesium, for the magnesium oxide in a composite of tungsten or its carbides with either silver or copper did not significantly improve the arc erosion resistance and improve the arc interruption characteristics of such a composite contact material. The theoretical reason or reasons why magnesium oxide does not improve the arc erosion resistance and improve the arc interruption characteristics of a molybdenum composite or why calcium oxide cannot be substituted for magnesium oxide in the composite material of the present invention is not clearly understood.

It is a feature of the invention to provide a tungsten or its carbides with silver or copper type electrical contact material with about 0.25 to about 7 weight percent magnesium oxide to provide a composite electrical contact material having improved arc erosion resistance and improved arc interruption characteristics when compared to a composite material of tungsten or its carbides with either silver or copper. A further feature of the electrical contact material is that the weight ratio of tungsten or its carbides to either silver or copper is 9:1 to 1:9 of the total weight of a composite and including from about 0.25 to 7 weight percent magnesium oxide.

Generally speaking, the present invention relates to an electrical contact composite material of the type consisting essentially of tungsten or its carbides, a highly conductive metal which is substantially mutually insoluble and non-reactive wtih tungsten or its carbides such as silver or copper, and magnesium oxide (either light or heavy) wherein such material has improved arc erosion resistance and improved arc interruption characteristics. The contact material of the present invention can be made by any of several techniques including press techniques and press-sinter-infiltrate techniques.

A powder blend of tungsten or its carbides, with silver or copper, and magnesium oxide is compacted into a desired body shape in a suitable mold under a compacting pressure of up to 22 tons per square inch. The particle size of each of the powdered constituents of the blend range up to 10 microns, average particle size. The compacting pressure and particle size of the powder blend may be varied over a fairly wide range depending on the strength of the compact required and the porosity of the compact desired. The compacted body of the powder blend, sintered or unsintered, but preferably sintered, is suitably contacted with a melt of silver if the powder in the compact is silver or with a melt of copper if the powder in the compact is copper in a reducing atmosphere at elevated temperatures. Preferably, the infiltration temperature is above the sintering temperature of the compact but below the boiling point temperature of the infiltrant. Suitable temperatures for infiltration of the compact are in the range of up to 1400° C. An infiltration temperature of less than 1000° C. can be used, but the infiltration time is lengthened considerably. A suitable reducing atmosphere for use during infiltration is hydrogen or dissociated ammonia.

Another method for preparing the electrical contact material of the present invention is to compact a blend of tungsten or its carbides, with silver or copper, and magnesium oxide, presinter the compact, sinter the compact and then infiltrate the sintered compact with a melt of either silver or copper, as the case may be.

It is pointed out that processing of the compact in a protective or reducing atmosphere is important in order to realize the current carrying material of the present invention.

The weight content of tungsten or its carbides in the electrical contact material of the present invention is about 10 to about 90 weight percent of the total weight of the contact material. A contact material including less than about 10 weight percent tungsten or its carbides tends to experience serious erosion of the working surfaces of the contact. A contact material including more than about 90 weight percent tungsten or its carbides experiences undesirable electrical characteristics such as high electrical contact resistance. The content of magnesium oxide in the electrical contact material of the present invention is about 0.25 to about 7 weight percent of the total weight of the contact material. A contact material including more than about 7 weight percent of magnesium oxide has a higher than desired electrical contact resistance. A contact material including less than about 0.25 weight percent magnesium oxide does not appear to significantly improve the arc erosion resistance and improve the arc interruption characteristics of the contact material. The preferred weight range in which the advantageous characteristics of arc erosion resistance and arc interruption are associated with the composite material are from about 0.5 to about 3.5 weight percent magnesium oxide, with about 1.5 to about 2.5 weight percent magnesium oxide being the most preferred range.

Of the materials tungsten and its carbides, tungsten is preferred. Of the materials silver and copper, silver is preferred. Therefore, the most preferred composite material of the present invention is about 10 to 90 weight percent tungsten, about 90 to 10 weight percent silver and about 1.5 to 2.5 weight percent magnesium oxide.

The following Examples and data are illustrative of the composite material of the present invention.

EXAMPLE 1

A blend of 90 weight percent silver powder, 8 weight percent tungsten powder, and 2 weight percent magnesium oxide is prepared by ball mill blending for 8 hours. The powders, prior to blending, have an average particle size of about 1 to 10 microns. The blend is compacted by any suitable means such as by pressing at a compacting pressure of about 11.5 tons per square inch. The compact is then sintered in a reducing atmosphere of hydrogen at about 825° C. for about 50 minutes. The sintered material is hot extruded into bar form. Contact material taken from the bar is brazed to a brass test stud and machined to 0.375 inch by 0.25 inch thick and fixed to a circuit breaker contact test device to be operated at 1500 amperes, 240 volts at 50% powder factor

under short circuit conditions. A number of pairs of contacts are operated in three series of tests at 10 operations per series. Weight loss measurements are taken after each set of 10 operations. The results of the operations in quiescent air at 21° C. are:

Material:	Average volume loss per operation
90% Ag-8% W-2% MgO	4.916 cc. $\times 10^{-4}$.
90% Ag-10% W	8.428 cc. $\times 10^{-4}$.

The composite of 90 weight percent silver, 10 weight percent tungsten is made employing essentially the method of Example 1. The tests conducted on such material are essentially as outlined in Example 1.

EXAMPLE 2

A mix of 81.6 weight percent tungsten carbide powder, 15 weight percent silver powder, and 3.4 weight percent magnesium oxide powder is blended by ball mill blending for 8 hours. The powders, prior to blending, have an average particle size of 1 to 10 microns. The blend is compacted at a pressure of 22 tons per square inch. The compact is sintered for about 30 minutes at about 1325° C. in a hydrogen atmosphere. The sintered compact is infiltrated with a melt of silver for about 30 minutes at about 1400° C. The final composition of the composite is 48 weight percent tungsten carbide, 50 weight percent silver and 2 weight percent magnesium oxide. Tests using the test procedure of Example 1 provide the following results:

Material:	Average volume loss per operation
48% WC-50% Ag-2% MgO	3.871 cc. $\times 10^{-4}$.
50% WC-50% Ag	4.353 cc. $\times 10^{-4}$.

The composite of 50 weight percent tungsten carbide and 50 weight percent silver is made using essentially the method of Example 2. The test procedure of Example 1 is used to test the material.

EXAMPLE 3

A blend of 88.2 weight percent tungsten, 10 weight percent silver, and 1.8 weight percent magnesium oxide is prepared by ball mill blending for 8 hours. The blend is compacted at a pressure of about 22 tons per square inch. The compact is presintered in a hydrogen atmosphere at 400° C. for 15 minutes, sintered in a hydrogen atmosphere at 1275° C. for 30 minutes and infiltrated with a melt of silver at 1400° C. for 30 minutes. The final composition of the composite is 36 weight percent silver, 1.3 weight percent magnesium oxide, the remainder essentially tungsten. Tests using the test procedure of EXAMPLE 1, except that the current applied is 1400 amperes, provides the following results:

Material	Average volume Loss per operation
36% Ag-62.7% W-1.3% MgO.	1.4306 cc. $\times 10^{-4}$.
35% Ag-65% W	2.275 cc. $\times 10^{-4}$.

The composite of 35 weight percent silver and 65 weight percent tungsten is made using essentially the method of Example 3. The test procedure of Example 1 is used to test the material.

The term "arc erosion resistance" means and includes the ability of the composite contact material to withstand the effects of an electrical arc without significant loss of the contact material. The term "arc interruption" means and includes the ability of the composite contact material not to sustain an electrical arc for periods in the order of up to 2 electrical cycles depending on the type of switch device in which the contact material is used. The term "magnesium oxide" means and includes both light and heavy magnesium oxide.

The presence of small amounts of impurity elements is not believed to play a critical role in the invention. It is to be understood, however, that the invention contemplates the possibility of the addition of other elements to the electrical composite material of the invention so long as such additions do not have a harmful effect on the function of the magnesium oxide in the composite material.

Changes and modifications may be made by those skilled in the art without departing from the spirit and the scope of the present invention. Such modifications and variations are considered to be within the purview and the scope of the present invention and the appended claims.

I claim:

1. An electrical contact material of the tungsten or tungsten carbide with silver or copper type including from about 0.25 to about 7 weight percent magnesium oxide of the total weight of the electrical contact material, the addition of magnesium oxide improving the arc erosion and arc interruption characteristics of the electrical contact material.

2. The electrical contact material of claim **1**, wherein the addition of magnesium oxide is from about 0.5 to about 3.5 weight percent of the total weight of the electrical contact material.

3. The electrical contact material of claim **2**, wherein the addition of magnesium oxide is about 1.5 to about 2.5 weight percent of the total weight of the electrical contact material.

4. The electrical contact material of claim **1**, wherein the contact material is of the tungsten-silver or copper type.

5. The electrical contact material of claim **4**, wherein the contact material is of the tungsten-silver type.

6. The electrical contact material of claim **1**, wherein the contact material is of the tungsten carbide-silver or copper type.

7. An electrical contact material having improved arc erosion and arc interruption characteristics, the contact material consisting essentially of about 90 to about 10 weight percent of a constituent selected from the group consisting of tungsten or its carbides, about 10 to about 90 weight percent of a constituent selected from the group consisting of silver or copper, and about 0.25 to about 7 weight percent of magnesium oxide with the possible inclusion of minor amounts of impurities.

8. The electrical contact material of claim **7**, wherein the magnesium oxide is about 0.5 to about 3.5 weight percent of the total weight of the contact material.

9. The electrical contact material of claim **8**, wherein the magnesium oxide is about 1.5 to about 2.5 weight percent of the total weight of the contact material.

10. The electrical contact material of claim **7**, wherein one constituent is about 90 to about 10 weight percent tungsten, one constituent is about 10 to about 90 weight percent silver, and about 0.25 to about 7 weight percent magnesium oxide with the possible inclusion of minor amounts of impurity constituents.

11. The electrical contact material of claim **10**, wherein the magnesium oxide is about 0.5 to about 3.5 weight percent of the total weight of the contact material.

12. The electrical contact material of claim **11**, wherein the magnesium oxide is about 1.5 to about 2.5 weight percent of the total weight of the contact material.

13. An electrical contact material of the tungsten or tungsten carbide with a highly conductive metal which is substantially mutually insoluble and non-reactive with tungsten or its carbides type including from about 0.25 to about 7 weight percent magnesium oxide, the addition of magnesium oxide improving the arc erosion and arc interruption characteristics of the contact material.

14. In a method of making the electrical contact material of claim **13**, the steps of blending powders of tungsten or tungsten carbide and the highly conductive metal and the magnesium oxide, compacting the blended powders, and sintering the compacted powders to provide an electrical contact material.

References Cited

UNITED STATES PATENTS

1,984,203	12/1934	Sieger	75—173 A X
2,162,380	6/1939	Doty et al.	75—173 A X
2,180,826	11/1939	Hensel et al.	75—173 A X
2,300,286	10/1942	Gwyn	75—173 A
2,396,101	3/1946	Hensel et al.	75—173 A X
2,410,717	11/1946	Cox	75—173 R X
2,669,512	2/1954	Latsen et al.	75—173 A
3,045,331	7/1962	Ang et al.	75—153 X
3,459,915	8/1969	Swazy et al.	75—173 R X

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CERTIFICATE OF CORRECTION

Patent No. 3,827,883 Dated 08/06/74

Inventor(s) Lloyd F. Neely

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col, 1 line 32, delete "additives" and substitute therefore -- additions -

Signed and sealed this 15th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

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