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SILVER ALLOYS

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This invention relates to metal alloys, and, in particular, to novel silver alloys and to new and improved methods for their production.

By reason of its color and excellent electrical and thermal properties, silver is a very desirable metal for many industrial applications. Its use is often restricted, however, because of its inherently poor mechanical properties, and, in particular, its low tensile strength, hardness and elasticity. For example, pure silver is widely used as a contact material because of its high electrical and thermal conductivity, and its relatively low contact resistance. At high rated currents or heavy overloads, however, silver contacts tend to fail due to sticking or welding, or from excessive metal loss due to arc erosion. Much work has been done by industry in an attempt to develop silver alloys which, while retaining the desirable properties and characteristics of pure or relatively pure silver, would also present improved physical properties and at least equivalent electrical properties. Such alloys have not, however, proved entirely satisfactory. Often, when satisfactory physical characteristics such as tensile strength and elasticity have been obtained, the resulting alloy proves to be inferior with respect to color, thermal and electrical properties, or tarnish resistance. For example, while silver has been alloyed with many other metals in an attempt to solve the foregoing problems, with the result that some of its mechanical properties have been improved in the resulting alloys, the alloying usually results in a substantially lower electrical conductivity, i.e., a decreased current-carrying capacity, and these alloys tend to fail for the same reasons as fine silver provided service conditions are too severe.

Apart from direct alloying applications, other attempts at solving the inherent disadvantages of pure silver as a contact material have been made through use of powder metallurgical techniques. Thus, refractory metals such as tungsten, or certain oxides such as cadmium oxides, have been sintered with silver. While these sintered contact materials provide a very high resistance to sticking or welding and arc erosion, their electrical and thermal conductivity is considerably lower than that of pure silver. In addition these products have a tendency to work-harden and their industrial applications are extremely limited for this reason.

It is an object of the present invention to provide new silver alloys having substantially the color of pure silver and other desirable inherent properties of silver, but which are characterized by superior corrosion and tarnish resistance as well as improved mechanical properties and extreme resistance to arc erosion, welding and sticking.

A further object of the invention is the provision of novel methods for the production of homogeneous silver alloys possessing the aforementioned improved physical, thermal and electrical properties.

In general, the alloys of the present invention comprise a major proportion of silver with smaller proportions

of copper and vanadium. I have found that the respective proportions in which these ingredients are employed within the alloys of my invention are relatively critical, it being necessary to employ formulations within the following specified ranges in order to insure the production of alloys possessing the improved properties hereinafter demonstrated:

Component	Percentage by Weight
Silver	Not less than 80%.
Copper	9–19%.
Vanadium	0.01–1.0%.

Specifically, I have found that an alloy having optimum properties for electrical contact applications is obtained in accordance with my invention when the final composition consists essentially of 90 parts by weight silver, 10 parts by weight copper, and 0.5 part by weight vanadium.

The resulting alloys are ductile, and may be cast, drawn, rolled or formed by any method commonly used in metalworking. The alloys do not work-harden, and have a superior corrosion and tarnish resistance as well as generally improved merchanical properties. The alloys of the invention are useful for virtually all electrical applications, such as for slip rings, commutators, etc. In addition, there are numerous other non-electrical industrial applications for which the alloys are ideally suited.

The silver alloys of the invention are prepared in accordance with the following general procedure. It is necessary to alloy the copper and vanadium components first since the melting point of vanadium (1710° C.) is close to the boiling point of silver (1950° C.). In order to effect good solution of the vanadium in the silver, the melting point of vanadium must be exceeded considerably. This increases the danger of loss of silver due to volatilization, however, and, accordingly, I have found that pre-alloying is essential to proper practice of the invention.

The copper and vanadium are melted together in the ratio required for the final alloy, or in the ratio forming a eutectic mixture in order to take advantage of a lowered melting temperature. In this case, additional copper, as required, is added to the silver in the final alloying step to obtain the required ratio.

The copper-vanadium pre-alloy, as well as the final silver alloy are melted under a reducing atmosphere and then re-cast in order to eliminate all gas inclusions. For applications requiring extremely high electrical and thermal conductivity, the silver alloy preferably is produced within a vacuum furnace.

The foregoing as well as other features and objects of the invention may be best understood by reference to the following specific examples of typical alloys prepared in accordance with my invention:

Example 1

A master alloy was prepared by melting 1000 grams of copper and 50 grams of vanadium in an induction furnance with a boric acid flux. In order to insure good solution of the vanadium in the copper, the melting point of vanadium was exceeded by heating the melt to just below 2000° C.

The copper-vanadium pre-alloy, in amount 105 grams, was melted with 895 grams of silver in the presence of a cover of burning natural gas.

The resulting alloy (prepared under reducing atmosphere) had a conductivity of 75% IACS and a hardness of M92 (Rockwell). An alloy of the same proportions

was prepared within a vacuum furnace and it was found that the conductivity was increased substantially.

Example II

A master alloy prepared in accordance with the procedure of Example I, but comprised of 1000 grams of copper and 100 grams of vanadium, was melted with 890 grams of silver; the vanadium-copper alloy being employed in amount of 108 grams.

Upon subsequent testing of this alloy, it was found that its conductivity was higher than the alloy of Example I. Vacuum melting improved the conductivity of this type alloy even more. The hardness, however, was lower than that demonstrated by the alloy of Example I.

Example III

A pre-alloy of copper and vanadium was prepared from 900 grams of copper and 100 grams of vanadium. The pre-alloy, in amount 100 grams, was melted with 900 grams of silver.

Upon subsequent testing, it was found that this alloy demonstrated superior hardness, but lower conductivity, than the alloys of Examples I and II.

The following tabulated examples illustrate additional alloy compositions produced in accordance with the invention which possess the same desirable properties set forth hereinbefore:

Example No.	IV	V	VI	VII
Silver (parts)	89.00	89.50	89.75	89.99
Copper (parts)	10.00	10.00	10.00	10.00
Vanadium (parts)	1.0	0.50	0.25	0.01

This application constitutes a continuation-in-part replacement of my former copending application Serial No. 656,193, filed May 1, 1957, now abandoned, and also entitled "Silver Alloys."

I claim:

1. An homogeneous silver alloy consisting of the following ingredients within the respective ranges indicated based on percentages by weight:

Silver	Not less than 80%.
Copper	9–19%.
Vanadium	0.01–1.0%.

2. An homogeneous silver alloy having substantially the color of pure silver, said alloy being characterized, as compared with pure silver, by improved mechanical properties, and being more resistant to staining, corrosion, and tarnishing, and demonstrating superior resistance to arc erosion, welding and sticking when empolyed as a contact material within electrical circuitry consisting of the following ingredients within the respective ranges indicated based on percentages by weight:

Silver	Not less than 80%.
Copper	9–19%.
Vanadium	0.01–1.0%.

3. An homogeneous silver alloy having substantially the color of pure silver, said alloy being characterized, as compared with pure silver, by improved mechanical properties, and being more resistant to staining, corrosion, and tarnishing, and demonstrating superior resistance to arc erosion, welding and sticking when employed as a contact material within electrical circuitry, consisting of the following ingredients indicated based on parts by weight:

Silver	90
Copper	10
Vanadium	0.5

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