

ELECTRIC CONTACT MATERIAL AND METHOD OF MAKING THE SAME

BACKGROUND OF THE INVENTION

Compared with Ag which is widely in use, Ag-CdO contact material has an excellent antifusing property and an excellent wear-resisting property. Furthermore, it has the additional feature of the contact resistance being stabilized. Because of these merits, it is widely used as electric contact material for small and medium currents.

Generally, there are two methods for the manufacture of this electric contact material. One of the methods is a powder metallurgical method in which Ag powder and CdO powder are mixed, molded and sintered. The other is a method called the internal oxidation method in which Ag-Cd alloy is first produced by a general melting process and, after fabricating the alloy to the desired shape, the Cd which is the base metal in the alloy is selectively oxidized by heating in an oxidizing atmosphere.

Generally speaking, Ag-CdO contact material has been found to have the disadvantage of excessive arc wear when used for the contact of an electromagnetic switch for medium currents. When used for a contact in a medium-large current appliance to break current of several thousand amperes, it gets fused. Because of these disadvantages, the scope of its application has been limited.

It is the object of the present invention to eliminate the aforementioned disadvantage by adding the elements, Fe and Sn, to the Ag-CdO contact material manufactured by the internal oxidation heretofore employed.

It has been proven, as a result of experiments, that the contact material of this invention retains the advantage of low contact resistance of Ag-CdO contacts in general and yet enjoys the feature of far superior performance compared with Ag-CdO contact material with respect to arc wear and resistance to fusion in the regions of medium and large currents.

The results of tests on the contact properties of the material of this invention will be explained, with reference to the following examples.

EXAMPLE I

A Cd containing alloy comprising Ag—10 wt.-% CdO was made by melting, with an addition of 2 percent Fe at the time of melting.

The analytical values of this alloy were 8.75 percent Cd and 0.11 percent Fe. After casting it into a rod shape, the surface was removed and the rod was swaged at a high temperature (700–750° C) into a wire having a diameter of 6 mm. This was fabricated into a rivet having a neck diameter of 6 mm., a thickness of 3 mm., and a leg diameter of 3 mm.

Then the specimen was held for 30 hours in an electric furnace in which pure oxygen gas was caused to flow and which was kept at 800° C., whereby Cd and Fe in the alloy were selectively oxidized to obtain the final alloy.

Tests to compare the arc wear of this material with the material without the addition of Fe were carried out three times on each material under the following test conditions:

A.S.T.M. type contact property testing apparatus

Voltage AC 100 v, Current 30 a, Resistance load

Closing pressure 75 gr. Opening force 100 gr.

Results of measurement of the wear (mean values):

	Material without addition	Material with addition of Fe
Opening & Closing 100,000 times	3.0 mg.	2.4 mg.
200,000 times	7.0 mg.	5.3 mg.

In addition, a second Cd containing alloy of Ag—9 wt.-% CdO was made by melting in the same way and 1% Fe was added at the time of melting. The analytical values of this alloy

were 7.92% Cd and 0.03% Fe. After casting it into a rectangular shape, it was subjected to surface cutting and then press-bonded to an Ag base metal to obtain a specimen of 10×8×1.5 mm.

Then the final alloy was obtained by effecting internal oxidation in the same way as already described, and subjected to wear comparing tests under the following conditions:

Voltage AC 440 v., Current 300 a., power factor zero,

Rated 50 a. electromagnetic contractor

Results of measurement of arc wear:

	Material without addition	Material with addition of Fe
Opening & Closing 3000 times	88 mg.	60 mg.
Opening & Closing 5000 times	150 mg.	100 mg.
Opening & Closing 8000 times	8000 230 mg.	175 mg.
Opening & Closing 10000 times	280 mg.	10000 208 mg.

From the above, the improving effect of the addition of Fe with respect to wear is evidently recognized.

As is widely known, Fe has no solid solubility in both Ag and Cd. Consequently, Fe is present in the alloy only in a very small quantity with respect to the quantity charged. Moreover, it is considered to exist with the crystalline grains of Ag-Cd alloy in the form of a sort of mechanical mixture. It has been found that even such small quantities influence the constitution after oxidation, so that the crystalline grain size of Ag which is the base of the oxidized alloy becomes a fraction of that of the material without the addition of Fe and that the particles of separated-out CdO are distributed more spherically uniform.

It should be noted that the above tendency appears when the quantity of Fe is 0.01 percent or more. The quantity of Fe which can be melted in stably at the time of melting is 0.80 percent.

Therefore, it is necessary that the quantity of Fe in the alloy made by melting is 0.01 to 0.80 percent.

With regard to the quantity of CdO contained, it has been confirmed by other experiments that the effect of the addition of Fe is recognized irrespective of the content of CdO. Consequently, the material according to the present invention is not limited by the range of CdO content.

EXAMPLE II

Ag—10% Cd alloy with additions of 2% Sn and 1% Fe at the time of melting was prepared. The analytical values of Cd, Sn and Fe of this alloy were 10.3 percent, 1.95 percent and 0.02 percent, respectively. After casting it into a board shape, the surface cutting was made and an Ag base metal comprising 10 percent of the total thickness was press-bonded to only one side. The alloy was then rolled to 1.5 mm. and then punched to a diameter of 7 mm. The alloy was next held for 50 hours at 700° C. in an oxygen circulating atmosphere to selectively oxidize Cd, Sn and Fe in the alloy to obtain the final alloy.

The properties of this alloy are shown below in comparison with an alloy Ag—13% CdO formed by internal oxidation.

	Ag—13% CdO	Alloy of present invention	Pure silver
Specific gravity	10.1	10.1	10.5
Electric conductivity %TACS	72	70	107
Hardness (H v 5 kg.)	65	100	

ELECTRICAL RESISTANCE ALLOY**SUMMARY OF THE INVENTION**

Conventional electrical resistance alloys utilizes nickel and chromium as major constituents, as for example 80 % nickel, 20 % chromium. We have invented a new type of electrical resistance alloy which can be substituted for the conventional nickel-chromium alloys. Our alloy is far more resistant than conventional alloys to "green rot" and corrosion in sulfur containing atmospheres. Moreover, our alloy is substantially less expensive because of its reduced nickel content. These advantages are obtained by replacing a portion of the nickel by iron and small amounts of silicon. Aluminum, calcium, zirconium and one or more rare earth metals, as for example misch metal, are to be added for longer operating life.

Our alloy, which is single phase and stable over the entire range of operating temperatures, can have the following composition as expressed in percent by weight:

Chromium: 28%-40%

Nickel: 30%-40%

Silicon: 1%-2percent

Iron:Balance

This composition is augmented, to increase operating life, by the following:

Aluminum: 0.02%-0.3%

Calcium: 0.01%-0.15%

Zirconium: 0.01%-0.3%

Rare Earth Metals: 0.10%-1%

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Our alloy can be produced by conventional techniques as used in producing nickel-chromium electrical resistance alloys.

Our alloy utilizes 30 to 40% by weight of nickel and 28 to 40% by weight of chrome. As the nickel content is decreased below 30%, while the chromium content is held at the high end of its range, our alloy tends to develop two or more phases. One of these phases is a complex phase, SIGMA, which is exceedingly brittle and makes the alloy difficult to forge. In addition the phases oxidize differently. Moreover, the various phases have different coefficients of thermal expansion. As a result, oxides that are formed on the surface of the alloy spall and crack which cause the alloy to exhibit sharply reduced and commercially inadequate operating life. As the nickel content is increased beyond 40%, and the chromium is held toward the low end of its range, the resulting alloys are subject to "green rot" and corrosion in sulfur bearing atmospheres.

Our alloys utilizes 1%-2% of silicon. The silicon is required both to enhance the "green rot" resistance and, for reasons of which we are not fully aware, to prevent rapid burn out during operation as a resistance element.

In attempting to define a lower limit for the chromium addition, we experimented with percentages as low as 19% and found that the operating life dropped so sharply with contents

below 28% and 28% represents the minimum value. Attempts to increase the chromium content above 40% created severe forgeability problems that we have not been able to overcome.

While the operating life of our nickel-chromium-iron-silicon alloy is acceptable at relatively low operating temperatures, in order to obtain an acceptable operating life, as measured from initiation to burn out, at a temperature of 2,150° F., it is necessary to add minor constituents i.e. aluminum (0.02%-0.3%), calcium (0.01%-0.15%), zirconium (0.01%-0.3%) and one or more rare earths such as misch metal (0.10%-BY%).

One typical alloy, which exhibited an operating life in excess of the conventional 80% nickel 20% chrome allot at 2,150° F., has the following composition:

15 Nickel:36.64%

Chromium:29.86%

Silicon:1.67%

Aluminum:0.09%

Calcium:0.02%

20 Zirconium:0.05%

Misch Metal:0.20%

Iron:Balance

Another such alloy, which exhibited an excellent operating life at 2,150° F., has the following composition:

25 Nickel:36.41%

Chromium:28.93%

Silicon:1.62%

Aluminum:0.06%

Calcium:0.04%

30 Zirconium:0.05%

Misch Metal:0.19%

Iron:Balance

While we have described our invention with particular reference to performed embodiments, our protection is to be limited only by the terms of the claims which follow.

35 What is claimed is:

1. An electrical resistance alloy adapted to resist "green rot" and corrosion in sulfur containing atmospheres and adapted to be operable at a temperature of 2,150° F., said alloy, as expressed in weight percent, consisting essentially of:

chromium:28%-40%;

nickel:30%-up to about but less than 40%;

silicon:1%-2%; and

iron:balance with said chromium, nickel, silicon, and iron forming a stable single phase. phase.

2. An alloy as set forth in claim 1 further including aluminum %-0.3%; calcium 0.01%-0.15%; zirconium 0.01%-0.3%; and misch metal 0.10%-1%.

3. An alloy as set forth in claim 2 wherein the percentages of the various metals are as follows: nickel 36.64%; chromium 29.86%; silicon 1.67%; aluminum 0.09%; calcium 0.02%; zirconium 0.05%; and misch metal 0.20%.

4. An alloy as set forth in claim 1 wherein the percentages of the various metals are as follows: nickel 36.41%; chromium 28.93%; silicon 1.62%; aluminum 0.06%; calcium 0.04%; zirconium 0.05%; and misch metal 0.19%.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,607,245 Dated September 21, 1971

Inventor(s) Arnold J. Gottlieb & C. Dean Starr

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

Col. 2, line 9 - in the specification "(0.02%-)C%)" should read "0.02%-0.3%) - - .

Col. 2, line 11 - in the specification "(0.10%-BY%)" should read "(0.10%-1%)"

Col. 2, line 13 in the specification "allot" should read - - "alloy" - - .

Col. 2, Claim 1 - last line "phase." second instance should be deleted

Col. 2, Claim 2, line 2 - "%-0.3%" should read "0.02%-0.3% - .

Signed and sealed this 21st day of March 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
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ROBERT GOTTSCHALK
Commissioner of Patents