United States Patent

Shibata

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[54] **COMPOSITE SILVER CADMIUM OXIDE ALLOY CONTACT WITH SILVER CADIUM SURFACE**

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[52] **U.S. Cl.** .....**200/166 C,** 29/630 C

[51] **Int. Cl.**.....**H01h 1/02**

[58] **Field of Search** .75/173 R; 200/166 C; 29/630 C

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[57] **ABSTRACT**

A composite electric contact comprising a silver-cadmium oxide alloy as the contact material or element and having a silver-cadmium layer integrally formed on the face opposite to the contact face. The concentration of cadmium oxide particles increases from a minimum at the contact face to a maximum toward the face with the silver-cadmium layer.

2 Claims, 5 Drawing Figures

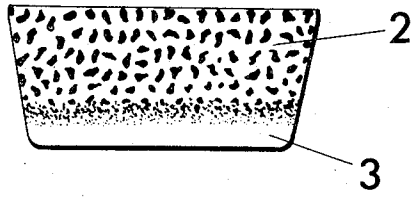


Fig. 1

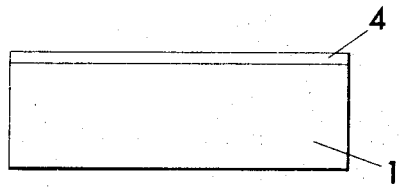


Fig. 2

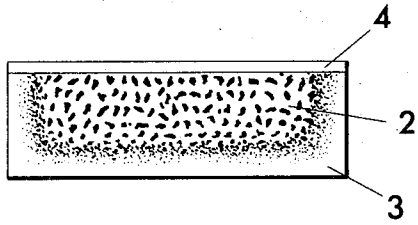


Fig. 3

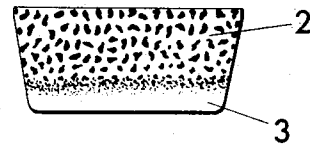


Fig. 4

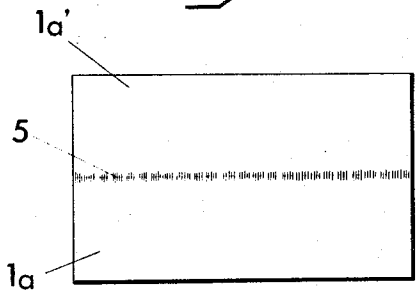
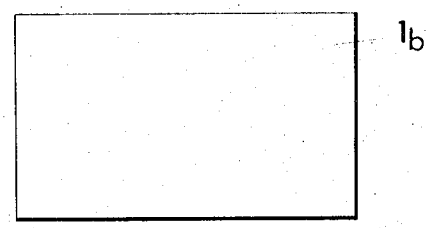


Fig. 5



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COMPOSITE SILVER CADMIUM OXIDE ALLOY CONTACT WITH SILVER CADIUM SURFACE

This invention relates to a novel electric contact and a process of producing the same, and more particularly, to a novel electric contact employing a silver-cadmium oxide alloy as a contact material and having a silver-cadmium layer integrally formed on the opposite face with respect to the contact face thereof, and a process of producing said electric contact by one-face internal oxidation and reduction.

The conventional processes of producing contact materials of silver-cadmium oxide alloy are generally classified into two methods; one is a sintering method by powder metallurgy and the other is a method of internal oxidation of an alloy. The internal oxidation method is, as well known, a method of obtaining a contact material of a silver-cadmium oxide alloy by subjecting a silver-cadmium alloy (cadmium content: 5–20 percent by weight) to an oxygen atmosphere at a high temperature to cause oxidation of cadmium and other metals contained in the alloy so that the oxidation proceeds from the circumferential area of the contact material. However, a silver-cadmium oxide alloy is difficult to braze to brass or phosphor bronze etc. used as a backing metal or a spring material. There are two methods used to solve this problem. One is a method of applying a silver layer onto the brazing face of a contact material, wherein the silver layer is generally pressure-bonded to a silver-cadmium alloy. According to this method, oxidation progresses towards the inside from the circumference, and due to the way the oxidation of a silver-cadmium type alloy progresses, a thin oxide layer is present in the central portion around the midst of its sectional area. Such contact material may often show some serious defects such as increase of wear and decrease of weldability, when practically used, as wear of the contact develops from the contact face into the area of said thin oxide layer.

Another method to solve the problem in brazing is what is generally called a one-face oxidation method, wherein one face of a contact, namely the brazing face, is left unoxidized. In order to leave some portion unoxidized, the fact that oxidation proceeds from the circumference towards the inside of the material is taken advantage of; that is, two pieces of the contact material mated with each other before oxidation may be welded at their mated faces, followed by oxidation for a given period of time so as to leave one face of the contact material unoxidized. It is, however, almost impossible practically at the present stage to weld miniature contacts one by one, so usually two sheets of a contact material of a silver-cadmium alloy are mated and welded prior to oxidation, and they are separated in two sheets again at the welded faces after oxidation. Then each sheet is cut to a given size. In this method, however, as the mated faces of the two sheets, which serve as brazing faces in finished contacts, should be left unoxidized, the period of oxidation is restricted and a desired thickness of oxidation can hardly be obtained.

For overcoming the defects of such conventional contacts, there is described in U.S. Pat. application Ser. No. 815,677, now U.S. Pat. No. 3,596,030, a composite electric contact element of silver-cadmium oxide alloy and a process of producing the same which comprises providing an element formed of an alloy of silver-cadmium one face of which is a contact-forming face; bonding a layer of silver to the face opposite to said contact-forming face of said element; applying a barrier layer to said contact-forming face to inhibit oxygen diffusion therethrough and into said contact-forming face; subjecting said element with said layers thereon to an oxygen atmosphere at an elevated oxygen diffusion temperature whereby to oxidize the cadmium in said alloy to cadmium oxide as particles distributed from said silver layer to said barrier layer; and then removing said barrier layer from said contact-forming face; whereby a composite electric contact element is produced having a contact face on one side and a silver layer on the opposite face, and in which the cadmium oxide particles increase from a minimum at the contact face to a maximum towards the face with the silver layer.

The composite electric contact obtained according to the above-described U.S. Patent application Ser. No. 815,677 has the advantage of providing a constantly equal contact resistance over the entire period of its life, since a layer containing a rather coarse distribution of cadmium oxide forms the initial contact face and a large pressure is applied to the contact face from a base material, and when the contact material is gradually worn away and the pressure applied from the base material to the contact face is gradually reduced, a layer comprising more thickly distributed cadmium oxide begins to appear on the surface forming the contact face. The composite electric contact produced by this method, however, has a disadvantage, namely, that it employs an expensive silver material on the brazing face. It also has an additional defect of insufficient strength, because said silver layer is formed by means of pressure-bonding silver to the contact material. It is, therefore, the primary object of the present invention to provide a novel electric contact of a silver-cadmium oxide alloy and a process of producing the same which maintains the advantages of the above-described composite electric contact, that is, forming a cadmium oxide layer which is the coarsest on the contact face of the contact material and becomes gradually thicker towards the brazing face opposite to said contact face, but is superior in its strength and economic properties to the above-described composite electric contact which uses a silver layer on the brazing face.

The gist of the present invention lies in a novel electric contact of silver-cadmium alloy and a process of producing the same comprising a contact material formed of a silver-cadmium oxide alloy, one face of which is a contact-forming face; applying an anti-oxidant layer to said contact-forming face to inhibit oxygen diffusion therethrough and into said contact-forming face; subjecting said contact material with said layer to an oxygen atmosphere at an elevated oxygen diffusion temperature thereby to perform one-face internal oxidation of cadmium and other metal constituents, except silver, contained in said alloy; after oxidation of the said constituents such as cadmium to a given degree, taking said contact material out of the oxidation atmosphere, and heating it in a reduction atmosphere to reduce said previously oxidized face thereby to form the original silver-cadmium alloy layer.

The novel electric contact thus obtained according to the present invention has a silver-cadmium alloy

layer serving as a brazing face and integrally formed on a contact material of a silver-cadmium oxide alloy. The brazing face is the opposite face with respect to the contact face of said electric contact. Such electric contact is remarkedly superior in strength and economic properties to the above-described composite electric contact having a brazing face formed by pressure-bonding of silver.

Various further objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a sectional view of a contact material with an anti-oxidant layer applied thereto according to one embodiment of the present invention;

FIG. 2 is a sectional view of the same showing a state of internal oxidation of a contact after being treated;

FIG. 3 is an enlarged sectional view of the contact material as shown in FIG. 2 cut into the shape of a contact and showing the state of internal oxida-tion thereof;

FIG. 4 is a sectional view of a contact material according to another embodiment of the present invention; and

FIG. 5 is a sectional view of a contact material according to still another embodiment of the present invention.

In FIGS. 1 to 3, 1 is a piece of a contact material formed of a silver-cadmium alloy. 4 is an anti-oxidant layer of a metal such as nickel, chromium, aluminum, copper, iron, or alloys thereof which can serve as an anti-oxidation layer in an oxidation atmosphere at a high temperature. The anti-oxidant layer 4 is applied in a thickness of 10μ -100μ to one face of the contact material 1. Said anti-oxidant layer 4 which is used only for preventing oxidation, is not required to be thicker, but if it is too thin, it cannot serve as anti-oxidant. The anti-oxidant layer may be applied by any method such as pressure-bonding, plating and vaporizing. The contact material to which an antioxidant layer is applied as shown in FIG. 1 is heated to be oxidized in an oxidation atmosphere such as oxygen or air at a temperature of 600° – 800°C. The heating time varies depending on the temperature and the kind of the oxidation atmosphere used. As the degree of oxidation progresses almost in proportion to the square of time, the oxidizing time can be adequately selected depending on the thickness of the contact material to be oxidized. After oxidation is attained, the material is taken out of the furnace, and is heated at 500° – 800°C. in a reducing atmosphere such as hydrogen, carbon monoxide or ammonia for reducing the previously oxidized surface, thereby to form an exterior layer of the original silver-cadmium alloy which serves as a brazing face of the contact product. The heating time for the reduction treatment is selected so as to obtain the exterior layer of a silver-cadmium alloy thick enough for brazing, usually about one-tenth of the thickness of the finished contact: for instance, when the thickness of the contact is 2mm., a heating time of 2 10 hours is preferable. After the reduction treatment is complete the layer 4 comprising oxide of a metal of nickel, chromium, aluminum, copper or iron or alloys thereof is removed with pincers, or by a severing or pickling treatment, thereby obtaining a contact of the desired shape. FIGS. 2 and 3 show the state of internal oxidation of the contact after the reduction treatment and after being into an individual contact. 2 is an oxidized layer and 3 is a silver-cadmium layer formed by the reduction. As seen in the figures, said contact has excellent contact properties, as the oxidized layer of cadmium is the coarsest on the contact face, i.e. the face that was adjacent the anti-oxidant layer, and becomes gradually thicker towards the opposite brazing face, that is, the silver-cadmium layer 3, and moreover, it is superior in strength due to its integrally formed brazing face. Referring to FIG. 4, another embodiment of this invention is illustrated. Two pieces of contact material of silver-cadmium alloy 1 and 1*a* are mated together and welded at their mated faces 5 into a single plate, then subjected to oxidation and reduction treatment as described in FIGS. 1 to 3. After said treatments are completed, said metal composite plate is separated into two pieces and the pieces are cut into a desired shape of the contact. The mated and welded portions of said two pieces are adapted to serve as an anti-oxidant for each other.

A still another embodiment is illustrated referring to FIG. 5. A piece of a contact material 1*b* of a silver-cadmium alloy twice as thick as the desired size of a contact is treated similarly as explained in FIGS. 1 to 3, and then cut in half, each of which is then cut to a desired shape of the contact.

The contacts prepared by the above-described methods have excellent characteristics, compared with those produced by the conventional methods. In the conventional contact prepared by pressure-bonding of silver and oxidizing from the circumference, the particles of the oxide become larger and their distribution becomes more coarse towards the central area from the circumferential area. Considering the phenomenon from the standpoint of hardness, such a contact is hard around the circumferential area and soft around the central area. In case of one-face, oxidation the contact is hard near the contact face and becomes softer towards the brazing face. According to the present invention on the contrary, the contact is soft near the contact face and becomes harder towards the brazing face: consequently, it shows a stable contact resistance from the beginning. Comparing these three kinds of contacts from a viewpoint of wear, an extraordinary wear occurs around the central area of the contact prepared by pressure-bonding of silver and oxidizing from the circumference. The contact formed by one-face oxidation, shows a tendency that the thinner the contact becomes by wearing, the more rapid the wear occurs. The wear resistance of the contact of the present invention, however, tends to increase as the thickness of the contact decreases by wearing.

In addition, a brazing face is formed as a silver-cadmium layer by reduction integrally with the contact material of a silver-cadmium oxide according to the present invention, the strength of the contact is greatly improved, compared with a contact prepared by applying silver by pressure-bonding for forming a brazing face.

The present invention is further concretely illustrated by the following examples.

EXAMPLE 1

After applying a nickel plate of 0.1mm. thickness, 30mm. wide and 100mm. long to a face of a silver-cadmium alloy plate (Cd = 13percent) having a thickness of 18mm., 30mm. wide and 100mm. long, the laminate was rolled into a plate of a thickness of 1.5mm. It was oxidized at 800°C. under 1 atm. in an oxygen atmosphere for 96 hours, taken out of the furnace, and reduced at 400°C. under 1 atm. in the hydrogen atmosphere for 6 hours. The thickness of the silver-cadmium layer on the surface obtained by said reduction treatment was 0.3mm. A disc of 8mm. in diameter was punched out from said plate to obtain a contact of the present invention. The thus obtained contact was mounted on an electromagnetic contactor, and the contact resistance was tested at each degree of wear (0, 25, 50, and 75 percent) on the contact face. Breaking strength was also measured by a shearing tester. These values were also determined on a conventional silver-cadmium oxide contact of 8mm. in diameter and 1.5mm. in thickness prepared by applying silver and oxidizing from the circumference under the same conditions as in this invention (hereinafter referred to as Control Sample A) and a contact of the same dimensions prepared by the method of U.S. Patent application Ser. No. 815,677 (hereinafter referred to as Control Sample B) and the results were compared. The lives of the contacts were also compared. The results are shown in Table 1.

Table 1

Wear	Contact resistance 0%	25%	50%	75%	Breaking strength Kg/mm²	Life
The invented contact	8	35	40	40	Not broken	1,200,000 times
Control sample A	68	46	35	35	Broken (10Kg/mm²)	500,000 times
Control sample B	8	30	46	40	Broken (10Kg/mm²)	1,200,000 times

EXAMPLE 2

The same plate of alloy as used in Example 1 was rolled into a plate of a thickness 1.5mm., and plated over with chromium of 0.01mm. in thickness, then the plate was oxidized at 800°C. Under 1 atm. in an oxygen atmosphere for 96hours; then it was taken out of the furnace, and reduced at 400°C. under 1 atm. in a CO atmosphere for 5 hours. The thickness of the silver-cadmium layer on the surface obtained by the said reduction treatment was 0.3mm. A disc of 8mm. in diameter was punched out from said plate to obtain a contact of the present invention. The obtained contact and Control Samples A and B were tested as described in Example 1 and the results are shown in Table 2.

Table 2

Wear	Contact resistance 0%	25%	50%	75%	Breaking strength Kg/mm²	Life
The invented contact	8	30	40	42	Not broken	1,200,000 times
Control sample A	60	30	30	32	Broken (10Kg/mm²)	500,000 times
Control sample B	12	32	38	40	Broken (10Kg/mm²)	1,200,000 times

EXAMPLE 3

Two plates of a thickness of 1.5mm., were prepared by rolling the same plate of alloy as used in Example 1. The thus obtained two plates were mated with each other and welded at the mated faces. The resultant plate was oxidized at 800°C. under 1 atm. in an oxygen atmosphere for 96 hours, taken out of the furnace, and reduced at 300°C. under 2 atm. in a hydrogen atmosphere for 4hours. The thickness of the silver-cadmium layer on the surface obtained by said reduction treatment was 0.2mm. The welded faces were cut and separated to obtain two plates, and from each plate a disc of 8mm. in diameter was punched out to obtain a contact of the present invention. The obtained contact and Control Samples A and B were tested similarly as in Example 1 and the results are shown in Table 3.

Table 3

Wear	Contact resistance 0%	25%	50%	75%	Breaking strength Kg/mm²	Life
The invented contact	8	28	39	45	Not broken	1,300,000 times
Control sample A	80	32	30	25	Broken (10Kg/mm²)	600,000 times
Control sample B	9	34	30	38	Broken (10Kg/mm²)	1,200,000 times

EXAMPLE 4

The same plate of alloy as used in Example 1 was rolled into a plate with a thickness of 3mm., double the size of those used in the previous examples. The obtained plate was oxidized at 800°C. under 1 atm. in an oxygen atmosphere for 96 hours, taken out of the furnace, and reduced at 750°C. under 1 atm. in a CO atmosphere for 2 hours. The thickness of the silver-cadmium layer on the surface obtained by the said reduction treatment was 0.2mm. The plate was cut in half to obtain two plates, and from each plate a disc of 8mm. in diameter was punched out to obtain a contact of the present invention. The obtained contact and Control Samples A and B were tested similarly as in Example 1 and the results are shown in Table 4.

Table 4

Wear	Contace resistance 0%	25%	50%	75%	Breaking strength Kg/mm	Life
The invented contact	10	30	40	50	Not broken	1,200,000 times
Control sample A	70	33	35	30	Broken (10Kg/mm²)	600,000 times
Control sample B	8	28	36	36	Broken (10Kg/mm²)	1,200,000

What is claimed is:

1. An electric contact comprising a contact material formed of a silver-cadmium oxide alloy having a cadmium oxide distribution which is the most coarse on its contact face and gradually becomes thicker towards its

opposite face; and a silver-cadmium layer integrally formed on said opposite face.

2. An electric contact as claimed in claim 1, wherein said silver-cadmium layer has a thickness of substantially one-tenth of the thickness of said contact material.

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