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ELECTRIC CONTACT

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This invention relates to electrical contacts, particularly electrical contacts of the make and break type wherein, in addition to good electrical conduction properties, the properties of wear resistance and arc-resistance or resistance to sticking, fusing or welding of the electrical contacts as a result of arcing between the electrical contacts during operation, are highly desired properties.

The object of the present invention is to provide an improved electrical contact.

Another object is to provide a wear resistant and arc resistant metallic material for electrical contacts of the make and break type.

A further object is to provide a method of producing the improved contact material of the present invention.

Other objects will be apparent as the invention is more fully hereinafter disclosed.

In accordance with these objects, I have discovered that by selectively oxidizing, inwardly from the surface, the readily oxidizable constituent of a piece or section of metal consisting of an alloy of silver and a readily oxidized metal, as examples, a metal selected from the group of metals consisting of cadmium, copper, manganese and zinc, a structure containing the oxide of the readily oxidizable constituent dispersed throughout a silver matrix may be obtained which is characterized by having said oxide dispersed throughout the grains as well as along the grain boundaries, which structure exhibits, in addition to good electrical conductivity, the properties of wear and arc resistance or resistance to sticking, fusing or welding between contacting metal surfaces as a result of arcing therebetween, said properties being variable over a relatively wide range, with respect to the amount of said dispersed oxide contained therein, to adapt the structure to wide utility in electrical contacts of the make and break type, all as will be more fully described in the specific embodiment hereinafter disclosed.

In the practice of the present invention, I have discovered that when one or more of readily oxidizable metals, such as those of the group enumerated above, are present in a silver alloy, and the alloy is heated in an oxidizing atmosphere to temperatures above the thermal dissociation temperature of silver oxide and to a temperature not above the solidus temperature of the alloy at which the said oxidizable metal has an appreciable solid solubility in the silver base metal of the alloy, the dissolved metal selectively oxidizes, upon the penetration inwardly

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of the oxidizing constituent of the atmosphere, at a rate varying with the oxygen pressure, the amount of the oxidizable constituent in solution in the heated silver alloy, the diffusion rate of oxygen through the silver alloy, and other factors recognizable by those skilled in the art.

I have found that upon oxidation of the oxidizable constituent of the silver alloy, the metal oxide formed deposits within the grain, as well as along each grain boundary, in relatively small sized particles or aggregates, generally separated one from the other, by the unoxidized silver matrix, except where the oxide concentration is relatively high in which case the adjacent oxide particles are relatively close together with the separating silver matrix difficult to perceive or detect.

I have found also that, generally, selective oxidation of the oxidizable constituent in the silver alloy proceeds inwardly from the surface of oxygen absorption at a determined rate varying, with any given oxygen pressure, with variation in the amount of the oxidizable constituent present in the alloy; and that, in general, oxidation proceeds from one grain to the next inward grain only after the oxidizable constituent in the first grain has been substantially completely oxidized.

I have further found that, in general, as the amount of the metal oxide increases the wear and arc resistance properties of the oxidized area increases, although not in direct proportion or relation to each other.

As one specific embodiment of the present invention, but not as a limitation thereof, I will describe the invention as I have adapted the same to the forming of contacts of the make and break type comprised of silver-cadmium alloys, in which contacts the cadmium content of the alloy, for a desired depth inwardly from the contact face of the alloy, has been selectively oxidized to produce a structure consisting essentially of a silver matrix containing cadmium oxide dispersed therethrough within the grains and along the grain boundaries, having the requisite wear and arc resistant properties for the contemplated field of use.

Heretofore in the art, as evidenced by Hensel Patent No. 2,145,690 dated January 31, 1939, it has been recognized that the presence of cadmium oxide in a silver matrix improves the wear and arc resistance properties of an electrical contact formed thereof.

Heretofore, also, as evidenced by Matthias Patent No. 1,940,962 dated December 26, 1933, it

has been proposed to employ a silver-cadmium alloy in the forming of electrical contacts to minimize arcing deterioration of the contact.

I have observed, however, that while certain advantages are obtained by the use of cadmium as an alloy constituent in a silver contact, the expected property of minimizing arcing deterioration is extremely variable and not always effective, particularly at high electrical loads.

On the other hand, I have observed that contacts consisting of a sintered mixture of silver and cadmium oxide, while effective in suppressing surface welding or sticking between paired contacts have certain disadvantages and in addition are difficult to shape and to mount on contact supports.

I have found that by selectively oxidizing the cadmium in a silver-cadmium alloy for at least an appreciable distance inwardly from the contact surface, the type and character of oxidized structure thereby obtained has all the advantages and none of the disadvantages of the Matthias and Hensel type contacts, and that by a proper control over the cadmium content of the alloy and over the depth of oxidation penetration inwardly from the contact surface of the contact, the physical properties of the contact may be widely varied to meet, consistently, a wide plurality of wear and arc resistance requirements of electrical contacts in service use.

The type and character of oxidized structure obtained by the practice of the present invention is essentially different from, and superior to, the type and character of the sintered structure obtained by the practice of the Hensel invention in that the cadmium oxide is dispersed throughout each metallic grain as well as along the grain boundaries in the present invention, whereas the sintered structure of the Hensel invention consists of non-uniformly dispersed irregularly sized masses of silver and cadmium oxide aggregates.

The dispersion of the cadmium oxide in the present invention throughout each grain of the metallic matrix as well as along each grain boundary produces a uniformity of wear and arc resistance effects throughout the contact area not obtainable by the practice of the Hensel invention and not inherently obtainable in the practice of the Matthias invention, as one skilled in the art will recognize.

The dispersion of the cadmium oxide, by the practice of the present invention, throughout the grain as well as along the grain boundaries, and the limitation of the same to a desired depth inwardly from the contact surface, enables me to control or regulate the wear and arc resistance properties of the contact of the present invention to relatively close tolerances to meet the service conditions contemplated for any given service use.

In general, I have found that upon heating a silver-cadmium alloy to elevated temperatures in an oxidizing atmosphere at a temperature above the dissociation temperature of silver oxide which approximates 300° C. but not above the solidus temperature of the alloy, the oxygen contacting the surface of the alloy will penetrate inwardly from the surface at a determined rate depending upon the oxygen concentration, the pressure of the oxidizing atmosphere, the temperature, and the cadmium concentration in the alloy.

Various oxidizing atmospheres may be employed in the practice of the present invention,

such as various mixtures of oxygen and inert gases. Air at atmospheric pressures, however, has been found by me to give the most satisfactory and economically practical results.

In general, I have found that the penetration of the oxygen content of air at atmospheric pressures in the heated alloy proceeds from grain to grain as the cadmium content in each successive grain inwardly from the surface becomes substantially completely oxidized. Hence, by varying the cadmium concentration in the alloy, other conditions remaining constant, the physical properties of the oxidized structure may be varied widely from one of relatively low cadmium oxide content to one of relatively high cadmium oxide content.

The major advantage thereby gained is the precise relative proportioning of the cadmium oxide to silver in the oxidized area to provide the desired wear resistance and arc resistance properties.

In general, an improvement in the arc resistance properties develops with a cadmium oxide content approximating 1% to 3% relative to the amount of the silver due, it is believed, to the dispersion of the cadmium oxide throughout each oxidized grain as well as along each grain boundary, instead of as aggregates dispersed non-uniformly throughout the silver matrix.

In general, a substantial improvement in the wear resistant properties develops when the cadmium oxide content in the oxidized area approximates 4% to 7% that of the silver. Alloys within this range retain sufficient ductility after selective oxidation of the cadmium content to permit normal riveting or other such mechanical deformation. As the cadmium oxide percentage increases above about 8% to 10% the wear and arc resistance of the oxidized area increases relatively rapidly and with about 15% cadmium oxide the oxidized material exhibits only meager ductility.

The improvement in the arc resistance properties of the oxidized area increases with increase in cadmium oxide content in a fairly orderly manner but for maximum arc resistance properties consistent with other properties, a maximum cadmium oxide percentage of 15% to 20% appears desirable.

With these general observations in mind, it is believed apparent that for any given service requirement of wear and arc resistance, some specific percentage of cadmium oxide content will produce the best results. This specific percentage of cadmium oxide content can best be controlled or regulated by the control or regulation of the cadmium content of the alloy, bearing in mind that upon oxidation of the alloy oxygen penetration proceeds inwardly from grain to grain with substantially complete oxidation of the cadmium content of one grain before passing into the next inward grain, and bearing in mind, also, that the depth of the oxidized area controls or regulates the life expectancy of the contact under normal service use conditions.

In general, it is preferable to employ the highest possible temperature for selective oxidation of the cadmium, the limiting temperature being the solidus temperature of the alloy involved. The higher temperatures are preferred for selective oxidation since the rate of selective oxidation increases with increase in temperature. For example, 24 hours oxidation of a 15% cadmium-silver alloy at 1200° F. produced a selectively oxi-

dized depth of 0.008" while at 1400° F. the depth was 0.017" and at 1600° F. it was 0.036".

In general, the depth of oxidation is preferably controlled by the time of selective oxidation treatment, the depth increasing with time of treatment. By way of example, the effect of oxidation time on the depth of oxidation produced in a few alloys is given in table.

Table 1

Alloy Composition.....	5% Cadmium-Silver	15% Cadmium-Silver	7.5% Copper-Silver
Oxidation Temperature °F.....	1,600	1,600	1,380
Time, Hours	Depth of Selective Oxidation, Inches		
1.....	.010	.006	.003
2.....	.014	.008	.005
4.....	.020	.013	.007
8.....	.026	.021	.011
24.....	.040	.036	

If desired the selective oxidation may be limited to the active surface of the contact by any convenient means as, for example, by protecting the base or shank of the contact with refractory materials impervious to oxygen or by the use of duplex material having a contacting surface of cadmium silver alloy and a base of substantially pure silver.

In general, contacts made in accordance with the present invention may be a plurality of sizes, shapes and configurations, without essential departure from the present invention, to adapt the same for utilization in a plurality of different type switch mechanisms and to adapt the same for attachment in a plurality of different ways to the switch arms of said mechanisms.

One of the major advantages gained by the practice of the present invention, in addition to those advantages set forth above, is that by the practice of the present invention and by limiting oxide penetration to a determined depth inwardly from the contact face, the life expectancy of the contact thereby may be reasonably controlled or regulated. The main body of the contact so limitedly oxidized then is retained in its essentially metallic form, thereby facilitating its subsequent attachment to the switch arm by mechanical means, by mechanical deformation means or by welding, brazing, etc., as may be required.

Another major advantage gained by the practice of the present invention is that the silver-cadmium alloy of which the contact is to be comprised is highly ductile and is capable of being mechanically deformed to precise desired contact form or shape, prior to surface oxidation, which facilitates the production of the improved contact of the present invention.

Another major advantage gained by the practice of the present invention is that the selectively oxidized silver-cadmium alloy contacts containing less than about 6% cadmium are sufficiently ductile after oxidation to permit normal riveting.

Still another major advantage of the present invention is that the wear resistance and arc resistance properties of the contact are obtained without imparting porosity to the metal matrix.

Other advantages are believed obvious to those skilled in the art.

As one specific embodiment of the practice of

the present invention, I will describe the same as it has been adapted to the production of a contact suitable for use under the most extreme service use conditions requiring high wear and arc resistance properties, such as in a make and break switch means in an electric circuit carrying relatively heavy electric current which is subject to frequent interruption. Under these general service use conditions the contact must have maximum wear and arc resistant properties.

This is provided in accordance with the present invention by forming an alloy of cadmium and silver containing 15% cadmium and mechanically reducing and forming the alloy in any convenient manner to the desired size, shape and configuration of contact form desired, which, for example, most conveniently is a disc having a diameter approximating $\frac{5}{8}$ inches and a thickness approximating 0.050 inch.

This disc is then heated in an oxidizing atmosphere, such as air at atmospheric pressures, to a temperature approximating 1600° F. for a time interval approximating 10 hours. If desired, the base of the disc (one face thereof) may be protected against oxygen absorption in any convenient manner. The disc may be comprised of duplex material, one comprising the silver-cadmium alloy to be oxidized, welded or brazed to the other of substantially pure silver. Alternatively, the back of the silver-cadmium disc may be coated or plated with silver without departure from the present invention. At the conclusion of the said time interval, the disc is removed from the heat zone and is cooled to atmospheric temperatures.

Microscopic examination of a contact piece, so treated, discloses that the extent of oxygen penetration inwardly from the exposed face of the contact approximates .025 inch. The hardness of the oxidized structure approximate 70 Rockwell 15-T Scale and the arc resistance properties of the oxidized structure have been found adequate, on test, to meet the requirements of the heaviest electric currents normally carried through such diameter contacts over an extended service life. The unoxidized face of the contact may be readily secured by brazing, welding, etc., methods to a support contact arm without detriment to the oxidized area.

Where the cadmium content of the contact, above described, is reduced to 5% and the oxidation process disclosed repeated, the hardness of the oxidized structure is lowered to about 50 Rockwell 15-T Scale and the current carrying capacity of the contact lowered accordingly.

When a very low hardness with good arc resistance properties is desired in the contact of the above specific embodiment, the cadmium content may be lowered to about 2%.

For most universal application as a contact I have found that the cadmium content of the alloy approximating 5% is the most satisfactory. In this alloy, by varying the time interval of heating in the oxidizing atmosphere, thereby varying the depth or thickness of the oxidized structure, the normal life expectancy of the contact under standard test conditions may be varied relatively widely.

In general, however, and for most purposes and service use conditions I prefer to extend the oxidized structure to a depth at least approximating 0.010 inches, thereby to obtain substantially consistent life expectancy under standardized life test conditions for each type of contact which may be correlated between themselves in a more or less orderly manner.

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In the practice of the oxidizing method various types of oxidizing atmospheres may be employed and various pressures of such atmospheres may be employed, without essential departure from the invention but with certain attendant advantages. In commercial practice, however, I have found that air at atmospheric pressures gives excellent results.

In soldering and welding, the selectively oxidized contacts of the present invention, care should be used to avoid reducing conditions during this operation.

In place of cadmium as the readily oxidizable element in the silver alloy, copper, manganese or zinc may be used as well as various mixtures of these metals. In general the content of copper, manganese or zinc may approximate that of cadmium for equivalent results. However, where best uniformity of the oxide dispersion is desired, it is preferable to limit the maximum concentration of copper to that content soluble in the solid state at the oxidizing temperature, said maximum concentration approximating 8% to 9% at oxidizing temperatures approximating 1400° F. Since alloys must be selectively oxidized at temperatures below the solidus temperature and since at low temperatures the rate of oxide penetration is low, it is preferable to avoid alloy compositions with solidus temperatures below about 1300° F.

It is believed apparent from the above disclosure that the present invention may be widely modified without essential departure therefrom and all such modifications and departures are contemplated as may fall within the scope of the following claims.

What I claim is:

1. The method of treating an electrical contact comprised of an alloy of silver and cadmium, and containing from 5% to 15% cadmium, balance silver, to improve the wear and arc resistance properties of the contact making face of the contact which comprises heating the contact in an oxidizing atmosphere at a temperature within the range 1200°-1600° F. for from 1 to 24 hours to substantially completely oxidize the cadmium content of the alloy inwardly from the

contact making face of the contact for a depth of from .006 to .040 inch.

2. The method of claim 1, wherein the cadmium content of the alloy is 15%, the temperature of heating is 1600° F., the time interval of heating is from 1 to 24 hours and the depth of oxidation of the cadmium is from .006 to .036 inch.

3. The method of claim 1, wherein the cadmium content of the alloy is 5%, the temperature of heating is 1600° F., the time of heating is from 1 to 24 hours and the depth of oxidation of the cadmium is from .010 to .040 inch.

4. An electrical contact comprised of a silver-cadmium alloy containing 5% to 15% cadmium, balance silver, said contact having a wear and arc resistant area underlying the contact making face thereof, said area consisting of substantially pure silver containing precipitated cadmium oxide particles dispersed therethrough within the grains and along the grain boundaries and having a depth within the range .006 to .040 inch.

5. The contact of claim 4, wherein the cadmium content of the alloy is 15% and the depth of said area is .006 to .036 inch.

6. The contact of claim 4, wherein the cadmium content of said alloy is 5% and the depth of said area is .010 to .040 inch.

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