Dec. 19, 1944. G. J. COMSTOCK 2,365,249

ELECTRICAL CONTACT ELEMENT

Filed July 21, 1942

Fig. 1

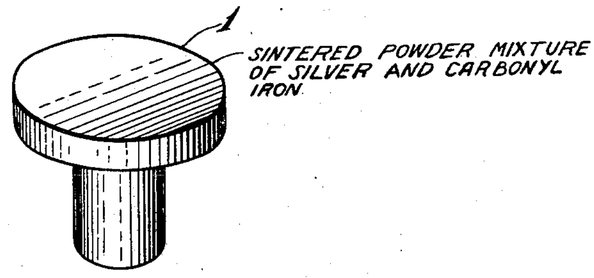
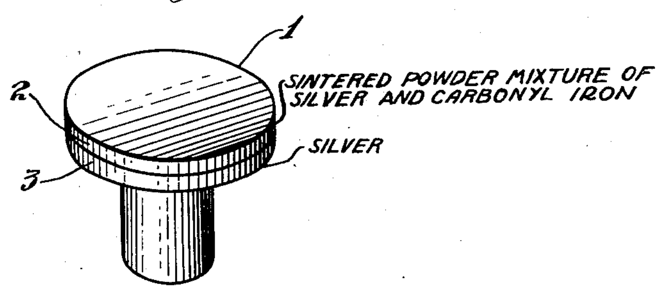


Fig. 2



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ELECTRICAL CONTACT ELEMENT

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This invention relates to electrical contact elements suitable for use in making and breaking electric current, and is concerned in particular with the improvement of electrical contacts of silver.

Electrical contacts should have high current carrying capacity and low contact resistance. They should be resistant to oxidation and have sufficient mechanical strength. In operation they should be subject to as little metal transfer as possible so as to avoid pitting and sticking. High melting point is desirable in order to decrease deleterious consequences of arcing.

Electrical contacts are usually manufactured of platinum, alloys of platinum, tungsten, silver, or alloys of silver. Fine silver has found the widest use as it is relatively cheap, has excellent current carrying capacity, and does not oxidize easily. Silver contacts, however, are subject to the disadvantage that they tend to stick, particularly when heavy electric currents are employed. Furthermore, the mechanical strength of silver contacts is low.

It is one object of this invention to provide an improved electrical contact element which shall have high current carrying capacity, minimum tendency to pitting and sticking, and good mechanical strength. It is another object of this invention to provide an electrical contact which shall possess the desirable characteristics usually associated with silver contacts but which, at the same time, shall be free from the objections of silver contacts as heretofore known.

Various proposals have been made to improve silver contacts by alloying with the silver other metals or metal compounds. The addition of precious metal is too expensive in many cases, and not always successful in other cases, and the addition of base metals has not been successful heretofore as it tends to increase the resistance and otherwise deleteriously affect the properties of the silver contacts.

I have found that the objects of my invention can be attained, and that silver contacts can be considerably improved by the incorporation therein of iron in the form and manner hereinafter described. It is the essence of the invention that the iron is in the form of carbonyl iron powder, i. e., iron powder obtained by the decomposition of iron carbonyl, and that the contact comprising silver and such carbonyl iron is manufactured by methods of powder metallurgy.

Carbonyl iron powder is prepared by condensation from iron carbonyl, $Fe(CO)_5$, a liquid formed by the reaction of iron and carbon monoxide under pressure. Upon distillation at atmospheric pressure the carbon monoxide volatilizes and the iron condenses as a very fine powder which is practically free from mineral impurities but may contain insignificant traces of carbon and nitrogen. The fine powder is almost perfectly spherical in shape and ranges from 0.5 to 10 microns in dimensions.

Electrical contacts made from a compressed and sintered mixture containing a substantial portion of silver and another portion of such carbonyl iron powder exhibit superior properties in use in that they have high current carrying capacity, develop a minimum tendency to pitting and sticking, and possess good mechanical strength, thereby possessing the favorable properties of silver contacts without suffering from the sticking and pitting shortcoming of such silver contacts.

The following examples will illustrate the method of making electrical contacts according to this invention:

Example I

A mixture of 60% fine silver powder and 40% carbonyl iron powder was pressed in a rectangular die at a pressure of 12 tons per square inch. The pressed briquette was then sintered 1 hour at 940° C. in a hydrogen atmosphere. The resultant billet was cold rolled to a reduction of 20% in thickness, then annealed ½ hour at 900° C. in a hydrogen atmosphere. Electrical contacts were stamped out of the sheet thus produced.

Example II

A mixture of 70% fine silver powder and 30% carbonyl iron powder was pressed in a ½" round pellet die at 12 tons per square inch and sintered in a hydrogen atmosphere for 1 hour at 940° C. The pellet was then cold coined in the original die at 25 tons per square inch and annealed ½ hour at 900° C. in a hydrogen atmosphere.

Example III

90 parts by weight of fine silver powder was spread in a rectangular die. On top of this was spread a layer of 10 parts by weight of a mixture of 60% fine silver powder, 40% carbonyl iron powder by weight. The powder layers were pressed at 12 tons per square inch and sintered 1 hour at 940° C. in a hydrogen atmosphere. The billet was cold rolled to a reduction of 20% in thickness and contact discs stamped from the resultant sheet. A composite contact material resulted with a backing of pure silver compris-

ing about 90% of the thickness and a face of the silver-carbonyl iron mixture comprising about 10% of the thickness.

The electrical contacts produced in accordance with the above examples, representative of the contact according to the invention, showed excellent electrical properties and good resistance to pitting and sticking in service and possessed long life. The electrical conductivity of such contacts increases with increasing silver content. Contacts in accordance with the invention are preferably manufactured from material which is rolled prior to blanking out the individual contacts therefrom as experience has shown that contacts manufactured from rolled material, as distinguished from contacts coined from unrolled material, exhibit a slower increase in the voltage drop upon frequent make and break cycles.

With a current of 15 volts D. C. and 13 amp. and upon 100,000 cycles of makes and breaks, electrical contacts in accordance with Example I had a weight loss of 0.0018 gram for the anode contact and of 0.0009 gram for the cathode contact, with the voltage drop increasing from 18 millivolts to 250 millivolts when the material was cold rolled and from 16 millivolts to 500 millivolts when the contacts were merely coined. With a like current and under like conditions contacts comprising a mixture of 80% silver and 20% carbonyl iron had a weight loss of 0.0012 gram for the anode contact and of 0.0018 gram for the cathode contact, with the voltage drop increasing from 20 millivolts to 280 millivolts when the contact material was cold rolled and from 12 millivolts to 500 millivolts when the contacts were merely coined. With a like current and under like conditions contacts comprising a mixture of 40% silver and 60% carbonyl iron stamped from rolled material showed a loss of 0.0261 gram for the anode contact and a gain of 0.0200 gram for the cathode contact, with the voltage drop increasing from 22 millivolts to 1000 millivolts. With an electric current of 18 volts A. C. and 30 amp. under otherwise similar conditions, electrical contacts in accordance with Example I had a weight loss of 0.0122 gram for the fixed contact and a weight gain of 0.0002 gram for the moving contact, with the voltage drop increasing from 10 millivolts to 120 millivolts. Under similar operating conditions coined contacts comprising a mixture of 80% silver and 20% carbonyl iron manufactured from rolled material showed a loss of 0.0058 gram for the fixed contact and a gain of 0.0023 gram for the moving contact, with the voltage drop increasing from 14 millivolts to 200 millivolts, and similar coined contacts showed a loss of 0.0027 gram for the fixed contact and a gain of 0.0009 gram for the moving contact, with the voltage drop increasing from 15 millivolts to 200 millivolts.

The contact resistance of the contacts according to the invention can be lowered by pairing in an electrical contact system one contact according to this invention with another cooperating contact of dissimilar nature such as a contact of fine silver. Sticking and pitting are substantially avoided even in such system and the lowering of the contact resistance makes the use of such system advisable in cases where heavy currents might otherwise cause excessive overheating. A contact system embodying, for instance, a fixed contact of a mixture of 60% silver and 40% carbonyl iron and a cooperating moving contact of fine silver, and employed in the making and breaking of a current of 118 volts A. C. and 30 amp. showed a voltage drop increase from 7 millivolts to only 90 millivolts even when the part according to the invention was manufactured without cold rolling.

Electrical contacts made from mixtures or alloys of silver and iron as such do not possess favorable properties but instead heat up quickly and oxidize badly. Efforts to produce such contacts have shown that contacts made of silver combined with other forms of iron stick very badly, in fact more so than fine silver contacts, and suffer considerable weight losses. Contacts made from mixtures of silver and carbonyl iron powder, however, stick less than fine silver contacts and possess, as stated above, other favorable properties.

In the contacts according to this invention the carbonyl iron powder particles are finely distributed throughout the powder mass. The mixture of silver particles and carbonyl iron particles has excellent molding characteristics, and briquettes formed from such mixture by the molding and sintering technique employed in powder metallurgy practice admirably lend themselves to further mechanical treatment such as rolling, coining, swedging, etc. The electrical contacts of my invention possess excellent physical and mechanical properties. The hardness and strength of such contacts is greater than that of fine silver contacts. Although electrical conductivity of iron is considerably less than that of silver, the contacts in accordance with this invention exhibit high electrical conductivity due to the extremely fine and even distribution of the carbonyl iron in the form of minute particles, whereby the free flow of the electric current through the silver mass is not substantially interfered with.

Composite contact structures consisting of a layer of the carbonyl iron silver mixture molded onto a layer of dissimilar material may be provided easily. Where the layer of dissimilar material comprises silver or other suitable highly conductive material, I can thus obtain a contact with a contact face of carbonyl iron silver mixture wherein the backing of such highly conductive material endows the contact with greater over all conductivity similar to that of fine silver or the like contacts but possessing freedom from pitting, sticking, etc.

In providing the mixture of silver and carbonyl iron I may employ any suitable proportion of silver and carbonyl iron. I have found small quantities, such as less than 5%, as well as large quantities, such as in excess of 50%, of carbonyl iron beneficial in attaining the objects of my invention, although I would recommend in particular mixtures embodying not less than 10% and not more than 40% of carbonyl iron. The electrical contacts may, of course, also contain other components in addition to the silver and the carbonyl iron, so long as there is present a substantial portion of silver.

For purposes of illustrating the contact of the invention I have shown two forms of contacts in the accompanying drawing in which Fig. 1 is a perspective view of one type of contact and Fig. 2 is a perspective view of another type of contact.

The contacts shown in the drawing comprise the contact element 1 which in Fig. 1 consists of a single disc of compressed sintered powder mixture in accordance with the invention and which in Fig. 2 consists of a surface layer 2 of the compressed sintered powder mixture in accordance with the invention and a backing layer

3 of silver or other highly conductive material.

The exact functioning of the carbonyl iron, as distinguished from other forms of iron, in bringing about the improvement hereinabove described has not yet been fully ascertained. I believe, however, that the favorable properties of my electrical contacts are due to a combination of factors in that the presence of the finely distributed carbonyl iron particles of spherical shape endows the contact with greater resistance to the generation of heat by the arcing which takes place during the continual making and breaking of the electric current and in that a slight oxide film is formed on the finely distributed carbonyl iron particles.

What I claim is:

1. An electrical contact for making and breaking electric current, comprising a compressed sintered powder mixture of silver and carbonyl iron.

2. An electrical contact for making and breaking electric current, comprising a compressed sintered powder mixture of silver and carbonyl iron in the proportions of from 95% to 50% silver and from 5% to 50% carbonyl iron.

3. An electrical contact for making and breaking electric current, comprising a compressed sintered powder mixture of silver and carbonyl iron in the proportions of from 90% to 60% silver and from 10% to 40% carbonyl iron.

4. An electrical contact system for making and breaking electric current, comprising a pair of cooperating electrical contacts positioned opposite each other, wherein one such electrical contact comprises a compressed sintered powder mixture of silver and carbonyl iron and the other cooperating electrical contact comprises a dissimilar electrical conductive material.

5. An electrical contact system for making and breaking electric current, comprising a pair of cooperating electrical contacts positioned opposite each other, wherein one such electrical contact has a contact surface of a compressed sintered powder mixture of silver and carbonyl iron and the other cooperating electrical contact has a contact surface of fine silver.

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