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# ELECTRICAL CONTACT

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This invention relates to electrical contacts, and more particularly to contacts for make-and-break service.

It is among the objects of this invention to provide electrical contacts which possess adequate electrical conductivity and desirably low contact resistance characteristics and current carrying capacity; which under make-and-break service resist damage such, for example, as welding of the contact members or transfer of metal from one contact member to the other; in the use of which arcing is minimized; which possess good dielectric strength, which meet the Underwriters' Laboratories requirements of short circuit tests, and which may be made readily by well understood powder metallurgy practices.

Other objects will be understood from the following specification.

The contacts provided by the invention comprise as essential elements a hard phase of titanium carbide and a matrix of silver.

Electrical contacts of titanium and silver have been proposed heretofore but they have never functioned satisfactorily in, for example, circuit breakers. TiC stoichiometrically contains 20.05 percent of combined carbon. The accent in the industry has been on the supplying of this carbide of high combined carbon content and of low free carbon, approaching stoichiometric values. As far as I am aware the titanium carbide commercially available consistently contains at least about 19 percent of combined carbon, and a total carbon content of about 19.5 percent. According to my experiences and belief such commercial products are not capable of providing with silver a satisfactory electrical contact. A major obstacle to the production of acceptable contacts of silver and titanium carbide arises from the fact that the commercially available titanium carbides exhibit poor wetability by silver, as is indicated by the fact that the contact angle between them is about 108°. Such materials do not lend themselves to liquid phase sintering or to infiltration techniques.

The present invention is predicated upon my discovery that the difficulty of wetting the titanium carbides heretofore commercially available is satisfactorily overcome by titanium carbide containing combined carbon in a relatively narrow and critical range that is below the amount theoretically present in TiC. More particularly, I have found that the objects of the invention are attained by titanium carbide containing from about 15.5 to 18.5 percent, preferably about 16.8 to 18.5 percent, of combined carbon, with from about 0.3 or less to 2.0, and preferably from about 0.3 to 1.8 percent, of free carbon. Titanium carbide of this compositional range is, as I have found, readily wet by silver and copper, in marked contrast to the commercially available titanium carbides.

Although the free carbon content of the titanium carbide of this invention may range above that normally encountered in commercially available titanium carbide, I have found that it can be tolerated without preventing silver infiltration or making the electrical performance of the contacts unsatisfactory. However, appreciably more free carbon than about 3 percent makes the titanium carbide unsatisfactory.

The contact provided by this invention consists essentially of, by weight, about 45 to 78 percent of a metal of the group consisting of silver and copper, and about 55 to 22 percent of a hard phase consisting of, by weight,



titanium carbide of about 15.5 to 18.5 percent of combined carbon and up to about 3 percent of free carbon, and preferably about 16.8 to 18.5 percent of combined carbon with about 0.3 to 1.8 percent of free carbon. In the preferred embodiment of the invention the contacts consist essentially of about 70 percent of silver and the remainder titanium carbide of the composition just stated.

The non-stoichiometric titanium carbide in accordance with the invention can be prepared by various procedures as by reacting titanium dioxide ($TiO_2$) with carbon black, by reacting higher carbon content titanium carbide with titanium dioxide, or by reacting titanium (Ti), carbon (C) and titanium dioxide in non-oxidizing atmospheres, the reactants being proportioned in the proper ratio to yield a product of the desired and critical composition. Preferably, commercially available titanium carbide (of about 19-plus percent of carbon) is reacted with titanium dioxide in a reducing atmosphere at a temperature of 1600° C. or higher. Carbide to oxide ratios from 10:0.3 to 10:6 have found to be satisfactory for this purpose.

As evidencing the benefit to be derived from the invention, reference may be made to one series of tests in which a titanium carbide in accordance with this invention (as just described) was compared with a commercially available titanium carbide produced by the high temperature oven process by one manufacturer, and another titanium carbide prepared by the menstruum process used by another manufacturer, both of the typical commercial composition referred to above. Each type was mixed with a fugitive binder and compacts were pilled from the mixes. Slugs of silver were placed on top of the compacts and all of them were fired in a hydrogen atmosphere at 1550° C. for one minute. The compact made with the carbide of this invention was readily and fully infiltrated with silver but the compacts made from the two commercial carbides were poorly wet, if at all, and the infiltration was not sufficient to render the compacts adapted for electrical contact purposes.

These contacts are made by powder metallurgy procedures that are so well known and established that those familiar with that art will know how to practice this invention from the following illustrative procedure, operating details, such as pressures, temperatures, etc. being readily ascertainable under knowledge in the art.

In the practice of the invention, then, the materials are provided in finely divided form, they are intimately mixed with one another and with a temporary binder. The mixture is then pilled to form compacts that are sintered and finally infiltrated with silver at a high temperature above its melting point in a non-oxidizing, preferably reducing, atmosphere.

The ingredients should be fine enough to pass at least a 100-mesh sieve (Tyler) although preferably all of them will pass a 325-mesh sieve (Tyler). When thoroughly mixed a fugitive organic binder is supplied. A variety of such fugitive binders are known and used in generally related operations. The organic binders are such, of course, as to be decomposed during the sintering operation. The binders are first dissolved in a volatile solvent and the solution is then mixed intimately with the powder mixture. Polyethylene is an example of a satisfactory binder, and others are known to those working in the powder metallurgy fields.

Prior to pilling, the binder solvent is preferably evaporated from the mixture, which is then compacted, or pilled, under high pressure, which may be accomplished at room temperature. The compacts are then sintered in a neutral or a reducing atmosphere. Suitably they are given a pre-sinter in hydrogen at a temperature substantially below the final sintering temperature. Silver is then placed on top of the sintered compact and infiltration is

effected at a temperature at which silver melts, in a non-oxidizing atmosphere.

The pressure used for pilling will depend upon factors familiar in the powder metallurgy art such for example, as particle size, desired pore volume of the compacts, the exact composition and the like. For many purposes there may be used a pilling pressure of, say, 10 to 40 tons per sq. in. However, pressures as low as 2.5 tons per sq. in. may be used for pilling because then the compacts have a greater pore volume (without objectionable shrinkage in sintering) than when pressed at higher pressures, which means that larger amounts of silver may be infiltrated.

The sintering and infiltrating temperatures will likewise vary depending upon the exact composition. In general the compacts are sintered to form a carbide network for, say, 10 minutes, at a temperature above that which is later used for infiltration. A brief pre-sinter is desirable (at, say, 1000° C.) prior to this sintering step. After sintering silver is placed on top of the compact which is then heated to 1500° to 1600° C. for a few minutes in hydrogen.

As further evidencing the importance of the invention, reference will now be made to tests in which a commercial circuit breaker of 20 amp. and 120/240 volts A.C. capacity provided as standard equipment with silver-tungsten contacts was compared with a similar circuit breaker of the same maker of 30 amp. and 120/240 volts A.C. capacity provided with contacts in accordance with this invention consisting of 70 percent of silver and 30 percent of titanium carbide containing carbon in the critical range of this invention together with trace amounts of other elements.

The contact resistance after short circuit testing was noticeably lower for the contacts of this invention than in the case of silver-tungsten standard equipment contacts, and as is known, a low contact resistance is desirable in these materials. The tests further showed that the contacts of this invention exhibited highly satisfactory dielectric performance. In this test the breaker is required, as established by the Underwriters' Laboratories, Inc., to withstand 1,480 volts with the breaker in the open position without current being conducted through some path which may have been created during short circuit testing. The original equipment silver-tungsten contacts in one test underwent a dielectric breakdown below the allowable minimum of 1,480 volts, while in another test breakdown occurred at 1,600 volts; thus those W–$A_8$ contacts do not meet the U.L. requirement. In sharp contrast, in two tests the contacts of this invention withstood 2,300 and 2,500-plus volts for one minute without breakdown. This is a characteristic of the present invention that is of major importance. Furthermore, these tests showed that after short circuit testing the contacts of this invention had lost substantially less material than was the case with the original silver-tungsten contacts.

A further significant and major property of the new contacts of this invention was exhibited in the short circuiting of a single breaker at 240 volts. The original equipment silver-tungsten contacts failed this test whereas those of this invention withstood three shots single-pole at 240 volts. This silver-titanium carbide material of this invention is the only contact material known to me which withstands this test without destruction of the circuit breaker.



Electrodes in accordance with the invention not only pass the Underwriters' tests but also a particular advantage of them is that sparking is so reduced as to significantly reduce the danger of fire in the event of a short circuit.

Although the invention has been exemplified with particular reference to silver as the infiltrant, it will be understood from what has been said above that copper may be used instead of silver.

This application is a continuation-in-part of my co-pending application Serial Number 114,325, filed June 2, 1961, now abandoned.

According to the provisions of the patent statutes, I have explained the principle of my invention and have described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. An electrical contact member consisting essentially of, by weight, about 45 to 78 percent of a metal of the group consisting of silver and copper, and about 55 to 22 percent of a hard phase, said hard phase consisting essentially of titanium carbide of about 15.5 to 18.5 percent of combined carbon and up to 3 percent of free carbon.

2. An electrical contact member consisting essentially of, by weight, about 45 to 78 percent of silver and the remainder titanium carbide of about 15.5 to 18.5 percent of combined carbon with 0.3 to 2.0 percent of free carbon.

3. An electrical contact member according to claim 2, consisting essentially of, by weight, about 70 percent of silver and the remainder titanium carbide as defined in claim 2.

4. An electrical contact member according to claim 3, said titanium carbide being of about 16.8 to 18.5 percent by weight of combined carbon, and, by weight, about 0.3 to 1.8 percent of free carbon.

5. An electrical contact member consisting essentially of, by weight, about 45 to 78 percent of a metal of the group consisting of copper and silver, and the remainder consisting of titanium carbide of, by weight, about 16.8 to 18.5 percent of combined carbon and about 0.3 to 1.8 percent of free carbon.


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