# United States Patent

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[54] **CLOSING WIRE TERMINALS**


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[21] Appl. No.: **44,777**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 873,721, Nov. 3, 1969.

[52] **U.S. Cl.** .....**29/488,** 29/492, 29/494, 29/497, 29/498, 29/502, 29/630, 339/275

[51] **Int. Cl.**.....**B23k 1/20,** B23k 31/02

[58] **Field of Search**.....29/488, 492, 494, 498, 497, 29/502, 630 A, 629; 339/275 T, 278 C



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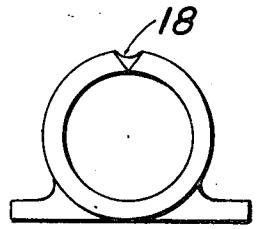
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[57] **ABSTRACT**

It is required that the open groove on the rounded portion of wire terminals, to which the wire is attached, be brazed shut or otherwise permanently filled. In accordance with this invention, a brass or copper wire terminal is plated with a very thin layer of silver, tin, or both. The surface is thereafter oxidized by heating in air. The assembly is then heated in a reducing atmosphere and, by virtue of eutectic brazing, an excellent metallurgical bond fills the groove. No solder or brazing alloys are used. This invention is a refinement of the bonding process disclosed in U.S. Pat. application Ser. No. 873,721 filed Nov. 3, 1969.


**8 Claims, 5 Drawing Figures**



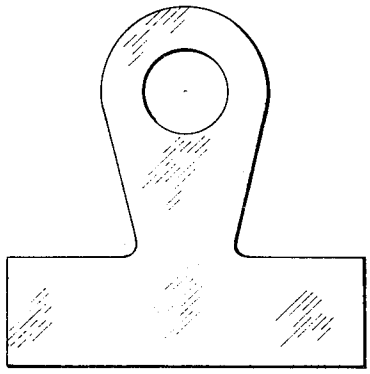


Fig. 1.

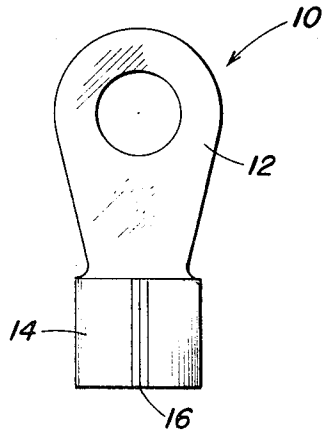



Fig. 2.

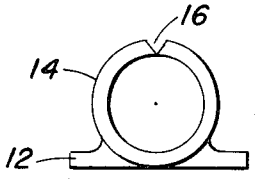



Fig. 3.

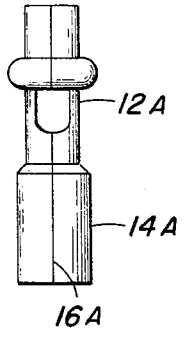



Fig. 5.

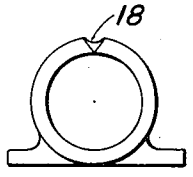



Fig. 4.

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# CLOSING WIRE TERMINALS

## BACKGROUND OF THE INVENTION

This application is a continuation-in-part of U.S. Pat. application Ser. No. 873,721 filed Nov. 3, 1969 and entitled "Bonding Metals Without Brazing Alloys."

In the above-noted application, there is described a process for bonding metals wherein one or both of the workpieces is initially, intentionally oxidized, the workpieces are placed together over the desired bond area, and the assembly is heated in a reducing atmosphere to effect metallurgical bonding. Bonding is improved in most instances if one or both pieces are plated with a dissimilar metal. The method is described with particular reference to the production of composite electrical contacts such as a copper rivet with a silver face. For example, silver discs are chemically cleaned and loaded into suitable carbon jigs. Copper rivets are oxidized in air for two hours at 700° F. and loaded into the jigs on top of the discs. The jigs then pass through a furnace maintained at 1,590° F. in an atmosphere of disassociated ammonia, time within the furnace being about 12 minutes. Excellent bonds result in about 90 percent of the parts so treated. If the copper rivets are provided with a thin (0.0001 inch) plating of silver prior to oxidation, substantially all of the parts treated have excellent bonds.

Other examples illustrate the bonding of copper to various silver alloys, copper-copper bonds, copper to steel, silver to steel, steel to tungsten, copper and silver to aluminum and clad ceramics to copper.

In some of the systems described, notably silver-copper, a eutectic structure, is observable in the bond region. Heating in the reducing atmosphere is at a temperature above the eutectic temperature of the binary system but below the melting point of either metal. The astonishing feature of the process is, of course, the intentional oxidation of one or both pieces, which is in fact responsible for creating the bond (copper rivets treated as described above but not oxidized did not bond to the silver discs).

The present invention is an application and refinement of the above-described process to the closing of wire terminals.

In the drawings:

FIG. 1 shows a wire terminal blank;

FIGS. 2 and 3 are top and end views, respectively, of the wire terminal after fabrication;

FIG. 4 is an end view of the wire terminal after the groove is filled; and

FIG. 5 is a different type of wire terminal.

A wire terminal is shown in blank form in FIG. 1, and in fabricated form in FIGS. 2 and 3. The terminal **10** can be described as having a terminal-connecting portion **12** and a conductor-connecting portion **14**. As seen most clearly in FIG. 3, the forming operation rounds the blank, bringing the distal edges of the conductor-connecting portion **14** together on a line of contact, but a groove **16** is left due to the thickness of the material While this is the way the rounded conductor-connecting portion is supposed to be fabricated, variations often occur if the distal edges are not in perfect alignment, when rounded they will meet at one point but the groove will be open elsewhere. If there is any dimensional inaccuracy, the groove will be open along its entire length. Most Underwriters' Laboratories and



military specifications require that groove **16** be brazed shut or the two distal edges be otherwise permanently united. Heretofore, furnace brazing has been the method of choice for closing these grooves. A piece of solder wire or brazing paste is hand-placed in the groove, and the terminals are passed through a furnace. This is not only a labor-intensive, expensive step. The brazed terminal may be subject to corrosion of the battery-action type due to the different electrochemical activities of the brazing material and the terminal metal.

FIG. 5 illustrates a different type of wire terminal. It has a conductor-connecting portion **14A** and a terminal-connecting portion **12A**, but the latter is also rounded for connection to a pin-type terminal. In this case groove **16A** extends along the entire length of the terminal. Specifications also require this groove to be filled.

It has now been discovered that grooves in wire terminals can be closed by an operation similar to the process described in the above-noted application. More particularly, the fabricated terminal is first plated with a very thin layer of silver, tin or both. The thickness of the plating need only be one or more ten thousandths of an inch, and can be done from a strike solution or by barrel electroplating. The plated parts are then oxidized in air at about 600° to 800° F. for 15 minutes to 2 hours. Plated parts are then passed through a belt furnace at a temperature of about 500° to about 1,600° F. for about 10 minutes in a reducing atmosphere, generally disassociated ammonia or forming gas (a nitrogen-hydrogen mixture).

The truly surprising feature of the present invention is the amount of filleting **18** that occurs with this treatment, as shown in FIG. 4. In carrying out the invention, plating is of course essential to establish a binary system. It has been found that silver and tin plating are equally effective. Of course, tin, with its very low melting point, will obviously form a liquid phase very quickly. Tin also forms a eutectic with both copper and silver with only about 1 percent of the other metal. A substantial advantage results if the parts are given both a silver and a tin plate. It has been found that terminals so treated have excellent corrosion resistance, approaching that of gold plated terminals. In applications such as battery terminals this is most important. Presuming that some sort of copper-tin-silver alloy is produced during the reducing heat treatment, the corrosion resistance is still difficult to explain. Of course, no matter what is plated, the entire terminal is covered with it, so there can be no corrosion of the electrochemical type. With both silver and tin plating, it is possible that porosity is eliminated, so that corrosive agents can not reach the underlying base metal (copper).

It is of interest to compare the present invention with the eutectic bonding process described in U.S. Pat. No. 3,051,826 issued Aug. 28, 1962 to A.J. Avila. That process bonds eutectic forming metals and semi-conductors by heating the clamped parts to a temperature between the eutectic temperature and the lowest melting point of a part, and applying ultrasonic energy laterally across the interface. In the present invention, no such energy is required; the oxidation-reduction cycle apparently provides such an active bonding sur-

face that excellent bonding and filling result. It is to be noted that terminals treated as described herein but not oxidized did not produce bonded grooves. In the absence of oxidation metal flow was observed into the interior of the rounded portion; it did not fill the groove.

In types of wire terminals where gaps between the distal edges of the conductor-connecting portion may be large, or where the above-noted corrosion resistance is desirable, both tin and silver plating are preferred. Neither the plating method, plating thickness nor order of plating are critical, but tin plating first is preferred, as it plates readily on copper and forms a good base for the silver. Generally, 0.0002 inch of tin are plated, followed by 0.0001 inch of silver. Oxidation of the plated parts is carried out at 600° to 800° F. in air for from 15 to 120 minutes, depending on the size of the part; for most parts 30 minutes is adequate. With low melting tin between copper and silver, it is possible that alloying starts during the oxidation. The parts are then heated to **800°–1,500°** F. in a reducing atmosphere in a belt furnace. Transit time (heating-at temperature-cooling) is about ten minutes. Dissociated ammonia, forming gas, hydrogen or other reducing gases form the atmosphere.

While, as noted above, tin readily forms eutectics with both silver and copper, the total time above the tin melting point is sufficient for solid-liquid diffusion to form higher melting alloys.

In some cases the two plating steps will close the gap and in some they will not; this is not critical to the operation of the invention. The gaps will be brazed shut when they emerge from the reducing furnace in any event.

When bronze terminals are to be treated, or other copper alloys having melting points lower than pure copper, plating with tin only is preferred. Plating thickness is about 0.0002 inch as above, and the oxidation cycle is the same. Reducing is at a temperature of about 500°–1,200° F. for a ten minute transit time.

Plating with silver only is preferred if the terminals are relatively pure copper. Plating is 0.0001 inch thick, and oxidation and reduction cycles are the same, except in this case the reducing temperature is in the range of about 1,350°–1,600° F. It will be noted that the lower temperature is about 100° below the copper-silver eutectic temperature, but apparently the increased activity due to the oxidation-reduction cycle, and/or solid state diffusion, causes melting or otherwise acts to flow the metal. The precise mechanism is not known.

The foregoing description relates to the treatment of individual parts. Wire terminals of the type described are produced and used by the millions annually, however, and some attention should be given to treating such parts on a volume basis. Plating is no problem; procedures for plating large numbers of small parts are well known and needn't be elaborated on here.

During reduction heating, and in some instances during oxidizing, the parts will obviously bond together if they are treated in bulk, i.e. if they are touching. However, it is a relatively simple matter to load parts into plates having a large number of depressions sized to hold a single part. Parts are poured over the plate and brushed away, leaving a single part in each depression. This may be done prior to oxidation, with unloading following reduction. Parts may, of course be oxidized in bulk if no liquid phase is going to form. It is to be noted that orientation of parts during both heat treatments is of no concern. Apparently the plated layers are so thin that surface effects, surface tension and/or capillary action, are much stronger than gravitational effects.

Parts can be both oxidized and reduced in bulk, provided that they are coated with a suitable parting compound prior to heat treatment. The economic advantages of this procedure are such that perfect protection is not required. If sticking (i.e. rejected parts) is kept to an acceptable minimum it is obviously to be preferred. One parting compound which has been employed is a mixture of diatomacious earth and Silocell (trademark). The parts are agitated in this material to provide a fine surface coating prior to oxidation.

Parts treated in accordance with the present invention have brazed grooves of excellent quality. It has been found that if a punch is driven into the finished part across the brazed area, the underlying copper tears before the braze tears.

It will be appreciated that while the present invention has been described with reference to the brazing of wire terminals, it is applicable to other copper-copper (or copper alloy) brazing situations. Various changes in the details, materials, steps and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as defined in the appended claims and their equivalents.

What is claimed is:

**1.** The method of closing the groove or gap found between opposing distal edges of a metal wire terminal comprising:

plating the terminal with a thin layer of silver, tin or both;

oxidizing the terminal at a temperature in the range of about 600° to 800° F. for from about 15 to 120 minutes; and

heating the terminal in a reducing atmosphere to a temperature in the range of about 500° to 1,600° F. for a short period to reduce the oxide and form a metallurgical bond between said opposing distal edges.

**2.** The method as claimed in claim **1**, wherein said plating is no more than about three ten thousandths of an inch thick.

**3.** The method as claimed in claim **1**, wherein said oxidation is carried out for about **30** minutes in air.

**4.** The method as claimed in claim **1**, wherein said plating is tin, and said heating in a reducing atmosphere is at a temperature in the range of 500° to 1,200° F.

**5.** The method as claimed in claim **1**, wherein said plating is silver, and said heating is a reducing atmosphere is at a temperature in the range of 1,350° to 1,600° F.

**6.** The method as claimed in claim **1**, wherein said plating is both tin and silver, and said heating in a reducing atmosphere is at a temperature in the range of 800° to 1,500° F.

**7.** The method as claimed in claim **1**, wherein said heating in a reducing atmosphere is completed within about ten minutes.

8. The method as claimed in claim 1 and additionally comprising coating said terminal with a thin layer of a parting compound prior to said heating in a reducing atmosphere.

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