

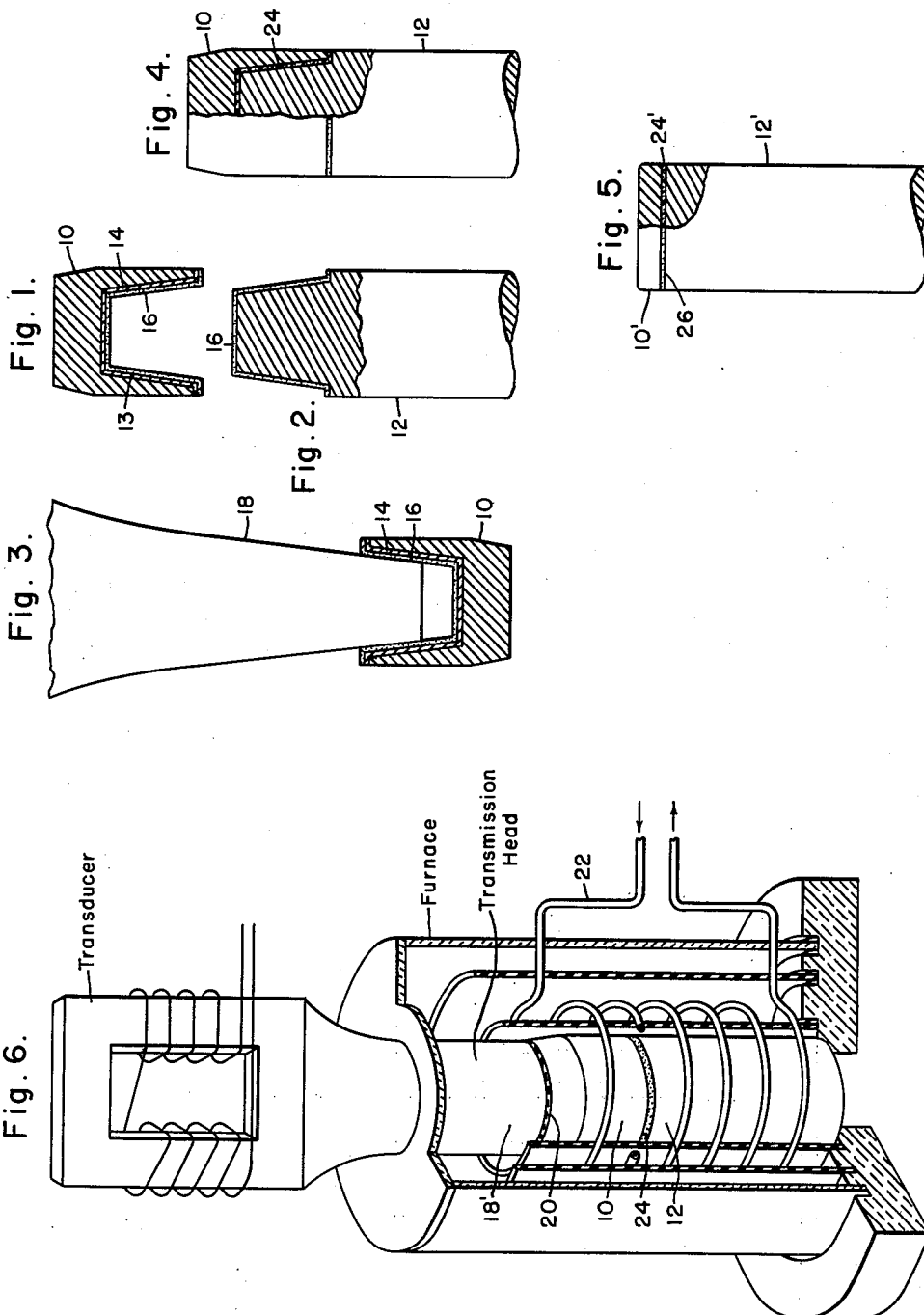
Sept. 25, 1962

W. V. BRATKOWSKI ET AL

3,055,098

BRAZING DISSIMILAR METALS

Filed Oct. 22, 1956



WITNESSES

Robert Baird
Wm. B. Sellers.

INVENTORS

Walter V. Bratkowski &
William H. Fischer.

BY

William S. Addison
ATTORNEY

1

3,055,098

BRAZING DISSIMILAR METALS

Walter V. Bratkowski, McKeesport, and William H. Fischer, Avalon, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Oct. 22, 1956, Ser. No. 617,568

5 Claims. (Cl. 29-492)

The present invention relates to brazing of dissimilar metals which have not been successfully brazed heretofore. The invention has particular reference to processes for securing arc-resisting contact tips of certain refractory metals and their alloys to supporting structures of aluminum and like metals. The invention relates further to electrical contact members made by such processes.

There has been a need for a satisfactory method of brazing refractory metals, such as tungsten, molybdenum and tantalum, and their base alloys, to aluminum, magnesium and their base alloys.

In the electrical industry, for instance, contact conductors adapted for use on high speed circuit interrupters generally are made of copper and copper alloys. Since copper and copper alloys do not have suitable arc-resisting properties, it has been a common practice to secure a tip of arc-resisting material such as silver-tungsten, silver-molybdenum, or copper-tungsten to the main or supporting copper contact member to prevent excessive burning of the member.

It has been desirable to replace copper and alloys thereof with aluminum, aluminum alloys, magnesium alloys or the like to provide members which are lighter in weight, yet which have comparable strength characteristics and electrical conductive properties.

Heretofore, attempts to replace copper and alloys thereof with metals such as aluminum, aluminum alloys, magnesium alloys or the like have not been satisfactory because no completely successful method has been found nor securing the arc-resisting contact tips to such metals. In an effort to obtain satisfactory mechanical and electrical connection of arc-resisting tips to supporting structures of such metals, various mechanical joining methods have been resorted to, such as riveting, threading and swaging, and the like. It has been found, however, that tips fastened according to these latter methods loosen relatively quickly under the repeated impacts resulting from continuous operation of the circuit interrupter. The loosening of the contact tip from the support member, introduces high resistance regions wherein arcing occurs thereby impairing the efficiency of the operation of the circuit interrupters.

It is difficult, when utilizing any conventional brazing technique, to satisfactorily join a tip of arc-resisting material such as silver-tungsten to an aluminum support member because of the presence of a layer of aluminum oxide present on the support member. It is known that such surface oxide coatings can be removed by the application thereto of strong reagents, such as fluorine-containing inorganic acids. As an example, it has been determined, however, that the utilization of such acids in the form of commercially available acid fluxes conventionally used in brazing techniques does not provide a satisfactory means for joining a silver-tungsten tip to an aluminum support member. Corrosion frequently occurs in such joints, due to the inclusion therein of flux, with subsequent failure of the joint resulting.

While the problem of joining refractory metals to aluminum has been emphasized in connection with circuit breaker contacts, it will be understood that there are numerous other instances where similar metal joining difficulties have arisen.

2

The object of the present invention is to provide a brazing process utilizing high frequency sound vibrations for joining refractory metals such as tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof, such as tungsten and molybdenum carbides, as well as mixtures embodying a refractory metal and good electrically conducting metals such as silver, copper and gold, to light, electrically conducting metals such as aluminum, magnesium and their base alloys.

It is a further object of the present invention to provide processes for preparing contact structures wherein arc-resistant tips of refractory metals are secured to support members of aluminum, aluminum alloys, magnesium alloys or the like by brazing techniques utilizing high frequency mechanically produced sound vibrations, to provide joints of maximum mechanical strength and members having excellent electrical conductivity.

Another object of the present invention is to provide improved electrical contact members having arc-resisting tips of refractory metals secured to supporting members by brazing techniques utilizing high frequency mechanically produced sound vibrations whereby members are provided having maximum mechanical strength and electrical conductivity characteristics.

Other and further objects of the invention will, in part, be obvious and will, in part, appear hereinafter.

For a more complete understanding of the present invention, reference is made to the following description taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a side view, in section, of a tip of arc-resisting material adapted for attachment to a support member;

FIG. 2 is a side view, partly in section, of a supporting member adapted to receive the tip illustrated in FIG. 1;

FIG. 3 is a side view, partly in section, illustrating the application of a brazing alloy to a tip such as the one illustrated in FIG. 1;

FIG. 4 is a view, partly in section, illustrating a complete contact assembly;

FIG. 5 is a side view, partly in section, illustrating a complete contact assembly having a structure different from that illustrated in FIG. 4; and

FIG. 6 is a schematic illustration of brazing means including apparatus adapted to mechanically produce high frequency sound vibrations.

It has now been discovered that refractory metals may be joined successfully to light, electrically conducting metals such as aluminum, aluminum alloys, magnesium alloys, and the like by fluxless brazing utilizing high frequency mechanically produced sound vibrations. By refractory metals is meant metals such as tungsten, nickel, molybdenum, tantalum, the platinum group-metals and their base alloys and carbides thereof such as tungsten and molybdenum carbide. Such refractory metals frequently are employed either as alloys or sintered and pressed mixtures of these metals in combination with amounts of other metals such as silver, copper, tin, and cadmium.

In a more specific aspect of this invention it now has been discovered that satisfactory fluxless brazing of arc-resisting tips of refractory metals such as silver-tungsten, copper-tungsten, and the like to support members of aluminum, aluminum alloys, magnesium alloys or the like may be effected by brazing techniques utilizing elements or members adapted to vibrate and mechanically produce high frequency sound vibrations, viz., frequencies of at least 9600 cycles per second. Ultrasonic sound vibrations, i.e., above the audible limit (16,000 cycles per second) and up to and beyond 25,000 cycles per

second also may be used satisfactorily in this invention.

The reason why satisfactory joints are obtained utilizing such high frequency sound vibrations with this brazing technique is not fully understood at this time. However, it is believed to result from the fact that the passage of high intensity or frequency sound waves through a liquid brings about a phenomenon of cavitation, whereby cavities appear at nodal points. When liquid brazing material is subjected to high frequency pressures of increasing amplitude within the liquid, the cavities, generally filled with gas, expand and contract until a point is reached at which a sudden collapse of the cavity occurs. This collapse produces extremely high localized pressure. When the collapse takes place adjacent to the brazing surfaces, small oxide particles are eroded away. This eroding away of oxide particles or layers on the brazing surfaces permits the satisfactory joining of the two surfaces.

It also has been determined that the refractory metal oxides, such as tungsten oxide interfere with the formation of a brazed joint of maximum mechanical strength and electrical conductivity. Therefore, when securing arc-resisting tips of tungsten and alloys thereof to a support member of aluminum, aluminum alloys, magnesium alloys or the like, it is preferable to first clad the joining surface of the tip with a layer of a metal which prevents particles or layers of tungsten oxide from forming on the joining surface. Silver or alloys thereof have been found to be suitable for this purpose.

The following is an example of the process of the present invention. A contact tip 10 (FIG. 1) such, for example, as pressed and sintered mixtures of arc-resisting materials, such as silver-tungsten, copper-tungsten, silver molybdenum or other arc-resistant, electrically conductive refractory metal is formed substantially into the thimble shape illustrated.

Tip 10 is adapted for mounting upon a support member 12 (FIG. 2), one end of which is tapered in the manner illustrated on the drawing. Support member 12 is formed of a light, electrically conducting metal such as aluminum, aluminum alloys, magnesium alloys or the like. In general, member 12 will be made from alloys comprising at least 90% of aluminum with the balance being one or more metals such as zinc, magnesium, manganese, copper, silicon, iron and chromium. When the contact member is intended for use with high speed electrical circuit interrupters, it has been found preferable to form member 12 from a high strength aluminum alloy having the composition: aluminum 97.9%, magnesium 1.0%, silicon 0.6%, copper 0.25%, and chromium 0.25% and has a hardness of at least Rockwell "F" 50. It will be understood, of course, that this is merely one example of many base metal alloys of aluminum, magnesium, and the like which is suitable for use in this invention.

In securing tip 10 to member 12 it is preferred to first clean each member thoroughly, for example, either mechanically as by wire brushing or chemically as by immersing first in trichloroethylene and then in alkali followed by rinsing in water. The cleaned tip 10 then is clad on its joining surface 13 with a layer 14 of a metal which prevents particles or layers of tungsten oxide from forming on surface 13. Silver or an alloy thereof deposited in a thickness of about 2 to 3 mils is suitable for this purpose. One silver alloy which is suitable has the composition: silver 43-45%, copper 26-28%, zinc 11-15%, cadmium 14-16%, phosphorous 0.8-1.2% and impurities 0.15% maximum. The alloy layer 14 may be applied in any desired manner. A suitable method comprises applying the alloy by conventional tinning techniques.

Tip 10, with the layer of silver 14 thereon, then has a layer 16 of an aluminum base brazing alloy applied thereto. An alloy which has been found to be suitable comprises one containing 87% aluminum, and 13% silicon. The brazing operation may be carried out conveniently

as shown in FIG. 3 of the drawing. Thus, thimble tip 10, in an inverted position, is partly filled for instance, about half full, with the brazing alloy 16. The thimble tip 10 then is heated in a furnace of suitable design to a temperature of about 550° C. This temperature is slightly above the melting point of the brazing alloy 16 and is substantially below the melting point of the arc-resisting silver-tungsten tip 10 and the layer 14 of silver alloy. A transmission bar 18 provided with a head of a shape which conforms closely to the shape of the inner joining surface of the thimble 10 then is inserted into the thimble. Means, not shown in FIG. 3, are provided for imparting mechanical vibrations of about 20,000 cycles per second, for example, to the molten alloy. Under these conditions the brazing alloy 16 and silver alloy 14 fuse.

A layer 16 of the same aluminum based brazing alloy also is applied to the joining surface of the tapered end of the support member 12, the member 12 being heated to a temperature of about 550° C., and being subjected to high frequency mechanically produced sound vibrations of about 20,000 cycles per second.

Members 10 and 12 then are ready to be joined to one another. One method by which this may be accomplished comprises slipping tip 10 over the tapered end of member 12 and placing the resultant assemblage in apparatus as illustrated in FIG. 6. A layer 20 of heat-resistant fluid such as a silicone oil is positioned between tip 10 and the contact end of a transmission bar 18'. Means, not shown, is provided for imparting high frequency sound vibrations to the assemblage of members 10 and 12. Heating means 22 is provided to maintain the assemblage at a temperature of about 550° C. Only a few minutes exposure to vibrations on the order of 20,000 cycles per second is sufficient to facilitate the formation of a strong uniform joint 24. If desired, a relatively strong joint may be obtained without using high frequency sound vibrations. Thus, a satisfactory joint may be obtained merely by pressing tip 10 onto member 12 with a slight twisting motion, while alloy 16 is still molten, and then cooling said alloy while maintaining the members under a pressure of only a few p.s.i.

Members 10 and 12 need not be joined immediately after they have been provided with a coating of alloy 16. Thus, they may be permitted to cool to room temperature and then reheated at a later time to about 550° C. and joined to each other according to either of the methods just described.

To restore the original physical properties of support member 12, for example, to return the hardness of member 12 at least to a value of Rockwell "F" 50, which properties have been changed due to heating said member to 550° C., it is only necessary to heat age the completed assemblage, for example, at a temperature of about 350° F. for a period of about 3½ hours in a suitable furnace. When relatively low strength grades of aluminum are used for member 12 this subsequent heat treatment need not be employed.

In FIG. 4 there is illustrated, partly in section, a completed electrical contact assemblage prepared by the method just described. In FIG. 5 there is illustrated, partly in section, a completed assemblage of a contact member having a structure different from that shown in FIGS. 1-4. The structure shown in FIG. 5 is formed of materials as shown in FIG. 4 and is made by the same process and includes a support member 12' with a substantially flat end portion 26 to which a disc or wafer shaped contact tip member 10' is bonded utilizing a suitable brazing alloy 24'.

To test the strength of brazed joints such as illustrated at 24 in FIG. 4, completed contact assemblages such as that shown in FIG. 4 were given a life test of 1500 operations in a circuit breaker with no current passing therethrough. The contact structures then were examined, and it was found that the thimble tip 10 still

was fastened securely to support member 12 and that no appreciable deformation had occurred.

The contact structures then were tested electrically in the circuit breaker. A current of 600 amperes was passed through the contacts, and a drop of 29 millivolts was measured across the contacts through one pole unit. The same test performed on contacts comparable in every way except that they were made of a copper alloy rather than an aluminum alloy produced a 25 millivolt drop.

Equally satisfactory joints may be made without first cladding tip 10 with a layer 14 of silver if the subsequent brazing operations are carried out in a vacuum or in an inert atmosphere. Layer 14 of silver also need not be used if the arc-resisting tip 10 does not contain tungsten or another metal whose oxide inhibits or prevents the formation of a strong brazed joint 24 between tip 10 and support member 12. Tip 10 may be brazed to copper and alloys thereof as well as to aluminum and alloys thereof as described above.

While the present invention has been described with respect to what is at present considered to be preferred embodiments thereof, it will be understood, of course, that certain changes, substitutions, modifications and the like may be made therein without departing from its true scope.

We claim as our invention:

1. A process for joining a contact member of a refractory selected from the group consisting of (1) refractory metals selected from the group consisting of tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof and (2) mixtures of said refractory metals with electrically conducting metals selected from the group consisting of silver, copper, gold, tin and cadmium to a support member of a light, electrically conducting metal selected from the group consisting of aluminum, aluminum alloys, and magnesium alloys which comprises cladding the joining surface of said contact member with silver, heating the members to a temperature sufficient to melt an aluminum based brazing alloy, applying a quantity of said brazing alloy at least to the joining surface of the contact member whereby said alloy melts, subjecting the molten alloy to high frequency mechanical vibrations of at least 9600 cycles per second to apply a coating of said alloy on each of said surfaces, withdrawing the heat and vibrations, and allowing the alloy to solidify and join the members into a unitary structure.

2. A process for joining a contact member of an arc-resisting refractory selected from the group consisting of (1) refractory metals selected from the group consisting of tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof and (2) mixtures of said refractory metals with electrically conducting metals selected from the group consisting of silver, copper, gold, tin and cadmium to a support member of a light electrically conducting metal selected from the group consisting of aluminum, aluminum alloys, and magnesium alloys which comprises cladding the joining surface of said contact member with silver, heating the members to a temperature which is below the melting point of both the silver and the members and which is above the melting point of an aluminum based brazing alloy, applying a quantity of said brazing alloy at least to the joining surface of said support member and to the silver clad surface of said contact member whereby said alloy melts, contacting said molten alloy with a vibrating member vibrating at a frequency above the audible range to apply a molten coating of said alloy on each of said surfaces, holding the contact member and support member in a position whereby the brazing coatings are in contact, and while so holding the members withdrawing the heat to allow the

coatings to solidify and join the members into a unitary structure.

3. A process for joining a contact member of an arc-resisting refractory selected from the group consisting of (1) refractory metals selected from the group consisting of tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof and (2) mixtures of said refractory metals with electrically conducting metals selected from the group consisting of silver, copper, gold, tin and cadmium to a support member of a light, electrically conducting metal selected from the group consisting of aluminum, aluminum alloys, and magnesium alloys which comprises cladding the joining surface of said contact member with silver, heating the members to a temperature which is below the melting point of both the silver and the members and which is above the melting point of an aluminum based brazing alloy, applying a quantity of said brazing alloy at least to the joining surface of said support member and to the silver clad surface of said contact member whereby said alloy melts, contacting said molten alloy with a vibrating member vibrating at a frequency above the audible range to apply a molten coating of said alloy on each of said surfaces, withdrawing the heat and vibrating member and allowing the brazing coatings to solidify, holding the contact member and support member in a position whereby the brazing coatings are in contact, applying sufficient heat to melt the brazing coatings, and withdrawing the heat to allow the coatings to solidify and join the members into a unitary structure.

4. A process for joining a contact member of an arc-resisting refractory selected from the group consisting of (1) refractory metals selected from the group consisting of tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof and (2) mixtures of said refractory metals with electrically conducting metals selected from the group consisting of silver, copper, gold, tin and cadmium to a support member of a light, electrically conducting metal selected from the group consisting of aluminum, aluminum alloys, and magnesium alloys which comprises cladding the joining surface of said contact member with silver, heating the member to a temperature which is below the melting point of silver and the members and above the melting point of an aluminum based brazing alloy, applying a quantity of said brazing alloy at least to the joining surface of said support member and to the silver clad surface of said contact member whereby said alloy melts, contacting said molten alloy with a vibrating member vibrating at a frequency above the audible range to apply a molten coating of said alloy on each of said surfaces, withdrawing the heat and vibrating member and allowing the brazing coatings to solidify, holding the contact member and support member in a position whereby the brazing coatings are in contact, applying sufficient heat to melt the two coatings of brazing alloy while imparting high frequency mechanical vibrations to the members at least in the region of contact of the coatings of brazing alloy, and then withdrawing the heat and vibrations to allow the brazing alloy to solidify and bond the members into a unitary whole.

5. A process for joining a contact member of a refractory selected from the group consisting of (1) refractory metals selected from the group consisting of tungsten, molybdenum, tantalum, the platinum group metals, their base alloys, and carbides thereof and (2) mixtures of said refractory metals with electrically conducting metals selected from the group consisting of silver, copper, gold, tin and cadmium to a support member of a light, electrically conducting metal selected from the group consisting of aluminum, aluminum alloys, and magnesium alloys, which comprises cladding the joining surface of said contact member with silver, heating the members to a temperature sufficient to melt an aluminum based brazing alloy, applying a quantity of said brazing alloy to

the joining surface of the support member whereby said alloy melts and subjecting the molten alloy to high frequency mechanical vibrations to apply a coating of said alloy on said joining surface, applying a quantity of said brazing alloy to the silver clad surface of the contact member whereby said alloy melts and subjecting the molten alloy to high frequency mechanical vibrations to apply a coating of said alloy on said silver clad surface of the contact member, placing the members in contact with each other while maintaining the brazing alloy in the molten condition, withdrawing the heat, and allowing the alloy to solidify and join the members into a unitary structure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,826,860	Armstrong	Oct. 13, 1931
2,397,400	Barwich	Mar. 26, 1946

15

2,426,650
2,539,247
2,569,149
2,602,413
2,621,303
2,676,236
2,682,101
2,686,354
2,741,018
2,752,667
2,753,623
2,790,656
2,819,961
2,833,238

Sivian	Sept. 2, 1947
Hensel	Jan. 23, 1951
Brennan	Sept. 25, 1951
Miller	July 8, 1952
Law	Dec. 9, 1952
Birkbeck et al.	Apr. 20, 1954
Whitfield et al.	June 29, 1954
Lundin	Aug. 17, 1954
Schaefer	Apr. 10, 1956
Schaefer et al.	July 3, 1956
Boessenkool	July 10, 1956
Cook	Apr. 30, 1957
Bartels et al.	Jan. 14, 1958
Jones et al.	May 6, 1958

OTHER REFERENCES

"Aluminum-Steel Bonded Assemblies," Modern Metals, April 1948, pages 13-15.