

UNITED STATES PATENT OFFICE

2,431,975

METHOD OF WELDING CARBON TO
MOLYBDENUM

Hubert P. Yockey, Oakland, and James M. Nuding, Berkeley, Calif., assignors to the United States of America, as represented by the Atomic Energy Commission

No Drawing. Application August 31, 1943,
Serial No. 500,650

3 Claims. (Cl. 219-10)

1

The invention relates to a method of making a structure comprised of carbon, such as graphite or other carbon usually in commercial form, welded or united to material, such as carbon or a metal, by intermolecular engagement. The invention is particularly concerned with the welding or union of carbon, usually in graphitic form, with materials such as carbon or metal, particularly molybdenum. It is likewise concerned with a method of uniting carbon with a material, such as carbon or metal, especially the fastening together of shapes or pieces containing carbon or fastening together a shape or piece containing carbon with a shape or piece containing metal for all sorts of general uses, particularly technical and industrial uses.

It is an object of the invention to unite carbon and a material such as other carbon or a metal, as by welding.

Another object of the invention is to provide a method of uniting carbon and a material such as other carbon or a metal, as by welding.

An additional object of the invention is to provide an improved method of joining carbon and a material such as other carbon or a metal.

Other objects, together with the foregoing, will appear from the following description of the invention and the preferred method of practicing it.

In its preferred form, the invention contemplates the provision of a structure comprised in part of carbon, such as graphite, and in part of material such as other carbon or a metal, for example molybdenum, which are intermolecularly united directly or by means of a suitable agent, to effectuate a strong, permanent union in the nature of a weld. Also, the method in its preferred form includes bringing a suitable piece of carbon and a suitable piece of material into close juxtaposition and heating the adjacent portions of the carbon and of the material in the substantial absence of oxygen, and preferably in a reducing atmosphere. If the piece of material is metallic and forms a carbide of the metal under the stated conditions, such carbide is made to contact the carbon and the material. If the piece of material is carbonaceous, a metal such as molybdenum, which forms a carbide of molybdenum under the stated conditions, is brought into contact with the piece of material and the piece of carbon. In either case, the metallic carbide joins the carbon and the material. The assembled parts are then cooled substantially to solidity in the non-oxidizing atmosphere and preferably to a temperature at which no substantial oxidation of the parts will

2

take place after their removal from the non-oxidizing atmosphere.

The usual method, according to the invention, is concerned primarily with what is generally referred to as industrial or commercial graphite. This is made up of graphitic carbon from any suitable source, contains minor amounts of impurities, and is held in integral form by means of a suitable binder. Although commercial graphite is the substance normally met in practice, either pure or considerably adulterated carbon is suitable for the practice of the invention. Any shape of carbon is suitable, although the general contemplation is to utilize graphitic carbon in the nature of a body or integral piece of a size which can readily be handled and manipulated, such as a block, plate, bar, rod, tube or other mechanical shape. In the claims where a "body" or "piece" or "portion" or "part" is referred to, it is intended to include any structure which is suitable for the practice of the invention, as distinguished from finely-divided or molecular particles or particles so small that their individual identity is substantially lost, although sometimes only very small or thin portions of metal are used. Also in the claims where "carbon" is referred to, it is intended to include not only chemically pure carbon or elemental carbon, but also any carbon-containing structure suitable for the practice of the invention, and likewise and more especially, the various commercial forms of carbon including considerable amounts of impurities as binders or otherwise.

In carrying out the invention, a suitable piece of carbon such as commercial graphite is placed in close juxtaposition with a piece of material such as other graphite or such as metal, to which it is to be joined. The reference to metal is primarily to metals which themselves form or are wet by carbides at the temperatures encountered, for example iron, nickel, molybdenum and tungsten. In general, the group of metals includes all metals which are effective under the conditions of operation of the invention to form or to be wet by suitable carbides, that is those carbides which are soluble in the metal used and are readily absorbed in the porous structure of the carbon.

When the piece of carbon and the piece of material are in close juxtaposition, for example with their areas which are to be united in substantial contact, they are heated to drive out contained oxygen and preferably to insure the substantial absence of oxygen, by means of an atomic hydrogen welding apparatus. This welding apparatus is of a standard commercial sort, and is op-

erated in the customary way. Its use produces a reducing action, so that it is possible to use previously uncleaned surfaces. The atomic hydrogen torch is effective to blanket the areas to be joined in a reducing atmosphere or a substantially non-oxidizing atmosphere, and is simultaneously effective to heat the adjacent portions of the carbon and the material to be joined.

If the material to be joined to the carbon is another piece of carbon or is a metal such as tungsten, which under these conditions does not form a carbide but is wet by a carbide, then a welding rod of suitable metal is utilized. A suitable metal is one which forms a carbide when subjected to the temperature produced by the atomic hydrogen torch in the presence of carbon and in a substantially non-oxidizing atmosphere. If the material, for example iron, nickel or molybdenum, to be joined to the carbon is a piece of metal which itself forms a carbide under the stated conditions, it is not necessary to use a welding rod of the type mentioned, although one may be utilized if desired.

It appears that the presence of carbon close to the metal is effective to lower the melting point of the metal so that at an appropriate temperature the metal flows and wets the heated carbon. It is believed that there is a formation of a carbide of the metal which is the principal constituent of the observed metallic liquid. The metallic carbide not only dissolves in heated metal so as to bond therewith, but also flows into the molecular interstices of carbon and bonds or interlocks therewith. The precise mechanism of the junction or union between the metal and carbon is not at present known, but the described actions are those which now seem most likely.

The atomic hydrogen torch is manipulated to produce the condition of fluidity or melting and interengagement of the materials, as described, over the selected area, following which the supply of heat is substantially interrupted but the supply of burning hydrogen is continued as the joined materials cool. This is done substantially to exclude oxygen, and is continued at least until such time as the materials have sufficiently frozen or hardened, and indeed have preferably cooled to a substantially lower temperature so that any subsequent oxidation is inconsequential. At this point, the supply of hydrogen is interrupted, the parts are permitted finally to cool, and it is found that they are firmly and permanently joined.

The nature of the junction appears to be an intermolecular engagement and may generally be referred to as a weld. This weld is very hard and strong. Equally, the process may be referred to generally as welding, although the precise nature of the interaction is not known. It has been found that some metals which do not produce carbides at the temperatures involved, for example copper, apparently are not susceptible to the practice of the invention. Although tungsten apparently does not form a carbide under the stated conditions, it does appear to wet well when a molybdenum welding rod is utilized. It is found that the presence of substantial amounts of oxygen precludes the operation of the method, for attempts to join carbon with metal by using an oxy-acetylene torch have been unavailing. It has been feasible, however, by following the method of the invention, properly to join carbon to molybdenum, to nickel and to iron, and by the use of a molybdenum welding rod to join a piece

of carbon to another piece of carbon or to a piece of tungsten.

In the event it is desired to join carbon to copper or a comparable material, and despite the fact that such cannot be done by this method directly, it can be accomplished by first welding together carbon and molybdenum, for example, as described herein, and then suitably joining the molybdenum and the copper, for example by hard solder. Molybdenum seems to work particularly well, and hence is largely used as an intermediate joining medium for securing carbon to materials whether or not they form carbides under the described conditions. Furthermore, when carbon is united to materials other than metals in the fashion described, for example when pieces of carbon are intermediately welded together by welding one piece of carbon to a piece of molybdenum and welding the other piece of carbon to the same piece of molybdenum, the intervening or intermediate molybdenum can be very minor in amount, so that to all practical purposes carbon is in effect welded to carbon. The intervening piece of molybdenum can very well be the molybdenum which is deposited by the use of a molybdenum welding rod on the two pieces of carbon.

The invention is particularly useful in connection with electric conducting members, in that current flow is facilitated where a welded transition occurs, as distinguished from mere mechanical contact. It is also useful in connection with the mechanical support of carbon members utilized in evacuated, electric arc mechanisms, and in chemical environments where a carbon-metal or carbon-carbon intimate contact is desired.

What is claimed is:

1. The method of welding two contacting materials one of which is carbon and one of which is molybdenum comprising heating the materials with an atomic hydrogen flame at atmospheric pressure while substantially contacting the materials with a molybdenum welding rod.

2. The method of welding two contacting materials one of which is carbon and one of which is molybdenum comprising heating the materials by playing an atomic hydrogen flame upon the pieces thereof to be joined, substantially contacting said pieces with a molybdenum welding rod within said flame, withdrawing said welding rod, and supplying hydrogen to said pieces until they cool to solidity.

3. The method of welding two contacting materials one of which is carbon and one of which is molybdenum comprising heating pieces of said materials to be joined out of contact with the atmosphere, substantially contacting said pieces with a molybdenum welding rod, melting part of said rod onto said pieces, and then withdrawing the remainder of said rod from substantial contact with said pieces.

HUBERT P. YOCKEY.
JAMES M. NUDING.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
898,979	Kuzel	Sept. 15, 1908
2,074,038	Willey	Mar. 16, 1937
2,333,622	McNab	Nov. 2, 1943