Sept. 14, 1937.

L. B. WYCKOFF

MEANS AND METHOD OF MAKING ELECTRODE JOINTS

Filed Dec. 19, 1934

INVENTOR.

LEWIS B. WYCKOFF

BY

ATTORNEY.
The invention pertains to joints in electrically conductive articles composed at least in part of carbon or a carbonaceous material, and more particularly to a means and method of making joints in carbon electrodes such as those used in electric furnaces.

When such electrodes are used in electric furnaces they are gradually consumed, and in order to provide continuous operation and also prevent electrode waste, new electrodes are joined to the old ones when they are partially consumed. A common method of joining such electrodes is to provide each end of each electrode with a threaded recess to receive a correspondingly threaded carbonaceous connecting pin, but such joints are not satisfactory because the electrical resistance is higher than that of an equal length of solid electrode. This high resistance is due to the fact that the contact area of the joint may be less than the cross sectional area of the electrode, and also to the fact that the contact area is not continuous but is made up of a large number of point contacts.

Many expedients have been proposed to lower the resistance of such joints, such as filling the spaces between the contact surfaces with a joint compound composed of a carbonaceous material such as carbon or graphite, or both, and a liquid binder such as glue, molasses, or dextrin. Such compounds have no cementing qualities but are simply fillers, which are only loosely held in the joint after it has been heated. These filled joints are not entirely satisfactory for the reason that when a joint is heated, cracks develop around the recessed ends of the electrodes and due to the lack of cementing quality of the compound, portions drop off. Also, failures and breakage of the joints are often occasioned by the electrical resistance of the contact in the joint which causes local overheating and partial oxidation of the electrode or connecting pin.

Furthermore, there is an energy loss as well due to the resistivity of the electrode joints which detracts from the overall efficiency of the electric furnace.

Therefore, one object of the invention is to provide electrically conductive carbonaceous articles such as carbon electrodes with joints having greater mechanical strength and lower electrical resistivity than joints employed heretofore.

Another object is to provide such electrodes with joints having a plurality of electrically conductive crystals penetrating and interlocking with the contact faces so that portions of the electrodes around the joints will not become separated even though they become cracked into many pieces.

Another object is to provide a process of making such joints wherein an electrically conductive carbide is formed in the joints by which the mechanical strength is materially increased and the electrical resistivity is materially reduced over joints employed heretofore.

Another object is to provide a joint compound for making such joints composed of materials capable of combining into an electrically conducting carbide under the influence of suitable heat, and also having sufficient resistance to the passage of the normal amount of current employed with such electrodes to cause the generation of sufficient heat to form this carbide in these joints.

These and other objects and novel features of the invention will be more fully explained in the following specification and the accompanying illustrations which is a longitudinal sectional view of an electrode joint of the type described.

The invention, which may be employed in electrically conductive joints in carbonaceous materials of various kinds, may be embodied in joints between the abutting ends of carbon electrodes A and B of the type used in continuously operated electric furnaces. Such electrodes may be of any suitable form such as cylindrical, and each end may be provided with a threaded recess 10 in which a correspondingly threaded connecting pin C fits in the aligned recesses of the abutting ends of two electrodes or electrode sections.

The process of forming my improved joint between such electrodes consists in providing a filling of an electrically conducting carbide forming material in the spaces between the abutting contact faces of the electrodes and also between the electrodes and the connecting pin, and then heating the joint to a temperature sufficient to form an electrically conducting carbide in the joint.

In making the joint any suitable silicon carbide forming material may be employed such as silica, silicon or any other suitable siliceous material and this carbide forming material may be applied in any suitable way such as by mixing the material with a suitable binder or adhesive such as tar, molasses, or sodium silicate, and then applying the mixture to the contact faces of the electrodes and connecting pin before they are assembled. The siliceous material may be of any suitable fineness but a material is preferred that will pass through a screen of 30 mesh per inch or
finer, and preferably, a sufficiently fluid binder is employed to form a thin slurry or compound having a consistency suitable for the size and type of joint to which it is applied. In general, the application of a layer of such compound from \( \frac{1}{8} \) to \( \frac{1}{4} \) inch in thickness is satisfactory, and a somewhat thicker layer may be applied to the threaded surfaces than to the plane surfaces on the ends of the electrode and connecting pin.

After the compound has been applied to the contact faces of the joint the electrode may be assembled and the compound is still in a semi-fluid condition so that even distribution over the abutting contact faces will be effected when the electrode assembly is screwed together or otherwise assembled.

A preferred form of the new joint compound that gives suitable results may be made by combining a well known commercial joint compound with a substantially equal weight of carbide forming material such as flour of silica, refined silicon or any other suitable siliceous material. The commercial joint compound may be composed of some carbonaceous binder such as\( \text{cellulose, glucose, molasses, or tar.} \) Other binders may be employed such as sodium silicate. Any commercial joint compound including any binder that is satisfactory in this type of joint when the siliceous forming material is employed is satisfactory when the factory is employed, and although any form of silicon bearing material is satisfactory, ordinary commercial commuted silica, silicon or any other suitable siliceous material is preferred for purpose of economy.

The joint formed and assembled as described may be heated in any suitable way to form the carbide in the joint, and the degree of heat applied may vary with the type of carbide forming material employed. As silicon carbide forms at a temperature of approximately \( 1700^\circ \text{C} \), the joint described above may be heated to this temperature or above and the heat may be applied by a separate furnace, by the furnace in which the electrode is used, or by passing a suitable electric current through the joint.

When the joint is employed in electrodes for continuously operated electric furnaces the current passing through the electrode during normal operation of the furnace may provide the heat for forming the carbide, and it is one of the features of the invention that the joint described produces sufficient resistance in the joint to cause sufficient localized heating to form electrically conductive carbides in the joint by interaction of the siliceous carbide forming materials with the carbon of the electrode or joint compound. After the carbide forming reactions are completed the electrode joint quickly cools to substantially the temperature of the rest of the electrode and the joint is characterized by its low electrical resistance and high mechanical strength. The siliceous material introduced into the heat treated joint forms a double function, in that it provides a high initial resistance in the joint which builds up sufficient temperature to form silicon carbide, and also supplies the silicon with which the silicon carbide is formed.

In a joint prepared according to the process just described, the high strength is due to the fact that the silicon carbide crystals when formed in the assembled joint penetrate into the grain of the carbon, both in the electrode and the connecting pin, and therefore act like a very large number of small dowel pins penetrating the contact faces from different angles. Therefore, the contact faces are not only held against relative parallel movement, but they are also held against separation by the interlocking action of these penetrating crystals. Thus, portions of the recessed end of the electrodes are prevented from falling away even though the ends become cracked into many pieces.

The low electrical conductivity of the joints are due to the large area of contact afforded by the large number of conductive silicon carbide crystals formed in the joint, the approximation of the crystals. It is known that silicon carbide crystals have greater conductivity along one axis than along another, and it is believed that when silicon carbide crystals form under the conditions described above, by the heat developed from the resistance to an electric current passing through the joint, they are oriented in such a direction as to carry the current across the joint along their most conductive axes. Also, the formation of these crystals in the joint provides many additional paths for the current to follow over those existing because they fill spaces that were originally void. This is believed to be the reason why the temperature at the joint drops appreciably after the crystals form even though the current through the joint increases, thus indicating that the joint has a lower resistance than joints known heretofore.

The novel features of the joint described may be employed in forming joints between the contact faces of electrically conductive carbonaceous articles of any kind regardless of the shape or form of the faces. Also, the joints may be formed by processes similar or equivalent to that defined, and other equivalent and well known materials may be employed in place of those described, without departing from the scope of the invention or sacrificing any of the advantages derived therefrom.

I claim:

1. The method of making joints of low electric resistivity between continuous type electric furnace carbonaceous electrodes which consists of coating the interface between contiguous electrodes with a material of the group consisting of silica and silicon; and passing an electric current through said material to form a carbide of silicon along said interface.

2. The method of making joints of low electric resistivity and high mechanical strength for continuous type electric furnace carbonaceous electrodes which comprises the steps of forming a threaded recess in a face of each of two contiguous electrodes; coating said recesses and said faces with a material of the group consisting of silicon and silica mixed with a binder; securing together said electrodes in face-to-face relationship by means of a connecting member threaded into each of said recesses; and passing an electric current through said electrodes, said connecting member, and said material to form a layer consisting of a carbide of silicon between said faces and between the threads of said recesses and the threads of said connecting member.

3. A method of making joints in carbon electrodes comprising the steps of coating the contact faces of said electrodes with a semi-fluid mixture containing a carbonaceous material and a substantially equal weight of comminuted silicon said carbonaceous material including graphite and a binder; assembling said joint while said mixture is in a semi-fluid condition; and then heating said mixture by passing sufficient electric current through said joint to form electrically...
conductive silicon carbide in said joint and thereby reduce the resistance thereof.

4. A continuous type electric furnace electrode comprising at least two carbonaceous electrode members having contiguous surfaces, and a material of the group consisting of silicon and silica, and a binder, disposed between, and covering a substantial portion of said contiguous surfaces.

5. An electric furnace electrode comprising coaxially aligned carbonaceous electrode members having opposed end faces, and a layer consisting of a carbide of silicon between and united to said faces and providing a mechanically strong joint of low electrical resistivity between said members.

6. An electric furnace electrode comprising coaxially aligned carbonaceous electrode members having opposed end faces; and a layer consisting of a carbide of silicon between and united to said faces, said layer being formed from a binder mixed with a material of the group consisting of silicon and silica.

7. An electric furnace electrode comprising coaxially aligned carbonaceous electrode members having opposed end faces and a central threaded recess in each of said faces; a threaded pin fitting in both recesses and cooperating with the threads therein to secure said members together; and a mechanically strong joint of low electrical resistivity between said faces and between such threads, said joint comprising a layer including a carbide of silicon between and united to said faces and said threads.

8. A continuous type electric furnace electrode comprising at least two contiguous carbonaceous electrode members; a threaded recess formed in a face of each of said contiguous electrode members; means threaded into each of said recesses and connecting said contiguous electrodes in face-to-face relationship; and a material of the group consisting of silicon and silica, mixed with a binder, disposed between and in contact with said means, said threaded recesses and the opposed faces of said contiguous electrode members.

9. An electric furnace electrode comprising coaxially aligned carbonaceous electrode members having opposed end faces and a central threaded recess in each of said faces; a layer, comprising a binder and a material of the group consisting of silicon and silica, between and contacting said faces and also coating the threads in such recesses; and a threaded pin fitting in both recesses and cooperating with the threads therein to secure said members together and to compress said layer between said faces and the cooperating threads, the construction being such that said layer is converted to a carbide of silicon upon passing an appropriate electric current therethrough.

10. A joint compound for forming joints between the abutting faces of carbon electrodes comprising a mixture of a carbonaceous material including graphite and a binder, and comminuted silicon, in which the weight of the silicon is substantially equal to the weight of the other ingredients.

LEWIS B. WYCKOFF. 35