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B. L. BAILEY

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CARBON ELECTRODE

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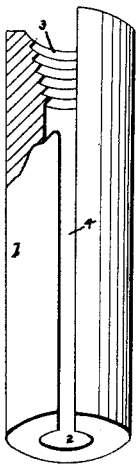


Fig. 1

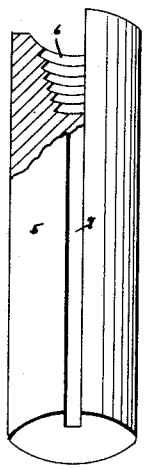


Fig. 2

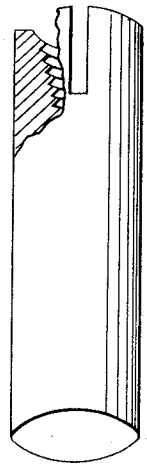


Fig. 3

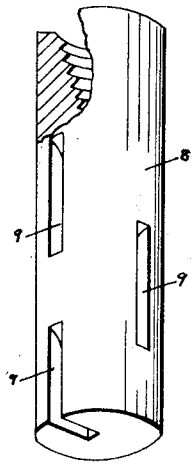


Fig. 4

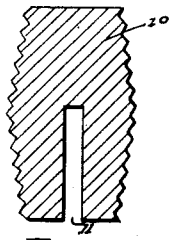


Fig. 5

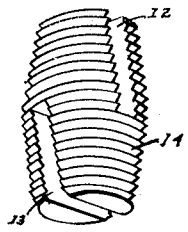


Fig. 6

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CARBON ELECTRODE

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5 Claims. (Cl. 13—18)

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This invention relates to improvements in carbon bodies which are suitable in the manufacture of electrodes. More particularly this invention relates to improvements in carbon electrodes which are primarily intended for use in metallurgical and electrothermal furnaces.

The use of carbon electrodes which may be either amorphous or graphitic in nature in electrothermal processes is well established. For example electrodes consisting of amorphous carbon are widely used in the manufacture of calcium carbide as well as in the manufacture of ferroalloys and other alloys in which the carbon content is not critical. Graphite electrodes find particular utility in the manufacture of special alloy steels. In either event, the product to be manufactured is subjected to a high temperature in an electrothermal or metallurgical furnace, the heat in said furnaces being supplied by passing an electric current of high amperage through an air space between two or more carbon electrodes. The resultant high temperature arc produces the melting, smelting or other electrothermal action desired.

The use of carbon electrodes in electrothermal processes as described above is accompanied by an oxidation of the carbon electrodes due to atmospheric oxygen and any oxides present in the composition being treated in the furnace. Another source of deterioration of electrodes results from the mechanical and thermal shocks to which the electrodes are subjected while in use. Thermal shock to which electrodes are exposed has been referred to in the trade as "spalling," this being best defined as the development of fissures of varying length and depth probably caused by unequal thermal expansion of the electrode at the point where the arc strikes the electrode. These fissures gradually increase in length and cause progressive weakening of the electrode. In many instances sections of the electrode will separate therefrom and drop into the molten composition. This not only is disadvantageous from the standpoint of the life of the electrode, but is also distinctly harmful in the event that a low carbon end product is desired. It is the usual practice to employ continuous electrodes in electrothermal or metallurgical furnaces, this being accomplished by fitting together sections of amorphous carbon or graphite electrodes, each section having machined female threads in each end in a central screw seat. The latter are concentric with the longitudinal axes of the electrodes and a connecting pin or nipple, constructed of substantially the same material as the electrode, is provided for joining the sections together thereby forming a continuous electrode. The spalling previously referred to is particularly objectionable at the joint sections inasmuch as

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such sections naturally form the weakest portion of the continuous electrode.

It has previously been proposed to diminish the extent of spalling of the electrode by employing a hollow or tubular section in place of the conventional solid electrode. While this innovation has been successful in reducing the spalling in a small degree, the electrodes nevertheless continue to deteriorate not only due to the spalling effect but also due to the increased rate of oxidation of the electrode due to the greater surface area afforded by this particular type of construction.

It is an object of this invention to provide improved carbon bodies which are useful in the construction of electrodes.

It is a further object of the invention to provide improved carbon electrodes which exhibit a marked improvement in resistance to thermal and mechanical shocks to which such electrodes are subjected in electrothermal processes.

It is a further object of the invention to provide improved carbon sectional electrodes having a longer life in electrothermal furnaces such as those employed in the production of electrothermic steel.

The above objects as well as other which will become apparent upon more complete understanding of the invention as subsequently herein described are accomplished by manufacturing a rigid carbon body, said body containing at least one slot which is substantially parallel to the longitudinal axis of said body. It has now been found that in constructing an electrode consisting of either amorphous or graphitic carbon, the useful life of such electrodes may be substantially increased by placing one or more slots, in a manner as subsequently herein described, in said body substantially parallel to its longitudinal axis.

Reference should be had to the accompanying drawings which diagrammatically illustrate a number of embodiments of the invention.

Figure 1 is a front elevation of a cylindrical, hollow carbon electrode 1 having a screw seat 3 shown in section at one end of the electrode and having a hollow section 2. A slot 4 of suitable size traverses the entire length of the electrode.

Figure 2 is a front elevation of a solid carbon electrode 5 having a screw seat 6 and a slot 7 of suitable size traversing the entire length of the electrode.

Figure 3 is a front elevation of a solid carbon electrode similar to that shown in Figure 2, except that the figure indicates that the threaded portion of the electrode of Figure 2 has two slots substantially traversing the threaded portion of the electrode.

Figure 4 is a front elevation of a solid carbon

electrode 8 having a screw seat at one end, the body of the electrode containing three slots 9, one of which is terminal with respect to the butt end of the electrode.

Figure 5 is a front elevation cross section view of a carbon nipple which is used as a connector for sections of carbon electrodes having screw seat ends. Into the body 10 of this nipple a slot 11 of suitable width is cut along the longitudinal axis of the nipple.

Figure 6 is a front elevation view of a carbon connecting pin or nipple which may be used to assemble electrode sections into a continuous electrode. Two suitable slots 12 and 13 are cut through the body 14 along the axis of the nipple. The slots are at an angle to each other and each slot preferably extends past the middle of the nipple.

It has been found that by placing a slot in a solid or hollow carbon electrode which is composed of either amorphous or graphitic carbon that the resultant electrodes or electrode connectors exhibit marked improved properties with respect to resistance to mechanical and thermal shocks to which such electrodes are subjected in electrothermal processes. These slots may be placed in the carbon bodies by any suitable means, for example by employing a circular saw having diamond studded teeth when it is desired to place slots in amorphous carbon electrodes or dowel pins. In the case of electrodes or nipples consisting of graphite a machining operation by which slots are produced in the graphite body may be conducted with machine tools.

A broad embodiment of the invention comprises preparing a carbon electrode by mixing together carbon aggregate of such carbons or carbon-producing materials as calcined petroleum coke, anthracite, graphite, electrode carbon scrap or the like with a sufficient amount of pitch or bituminous material to serve as a binder. The mixing operation is usually conducted above the melting point of the binder in order to insure uniform distribution of the binder throughout the carbon aggregate. Small amounts of viscous petroleum oils may be added as a lubricant, especially in the event that the electrode is to be prepared by extrusion through a die. The extruded or molded "green electrode" is baked in order to carbonize the binder, after which the baked carbon body may be subjected to higher temperatures in order to graphitize the carbon and the carbonized binder which comprises the electrode body. The electrode may then be machined at one or both ends in order to provide a screw seat which is concentric with the longitudinal axis of the electrode. The electrode may then be machined, for example by employing a circular saw, in order to produce at least one slot therein which is substantially parallel with respect to the longitudinal axis of the electrode.

The slot in the electrode described above may substantially traverse the entire electrode, the threaded portion, or the unthreaded portion thereof. The formation of an electrode containing one or more slots in the threaded portion, said slots extending through the wall of the electrode at the threaded portion, results in an electrode which, when coupled with a dowel pin and another similar section of electrode, results in a continuous electrode for electrothermal processes which has greatly improved resistance to spalling as well as to oxidation, which conditions usually exist in electrothermal furnaces.

The number, length and depth of the slots in the carbon electrodes will depend upon various factors such as the length, diameter and overall size of the electrode, the wall thickness of the electrode which may be either solid or hollow, the density of the electrode, the wall thickness at the machined or screw seat end, the temperatures to which the electrodes are subjected and upon other factors which will be apparent to those skilled in the art.

In a preferred embodiment of the invention a "green electrode" is prepared as described above employing a die which will produce a hollow, tubular "green" electrode. The latter is then baked at temperatures up to 1000° C. for a suitable period of time, after which the baked amorphous electrode may be graphitized by heating to temperatures of between 2400° to 3000° C. for a suitable period of time. The resulting graphitized electrode is then subjected to a sawing operation whereby a slot of suitable diameter will be produced substantially traversing the entire length of the electrode along its longitudinal axis. When several sections of such an electrode are coupled with a suitably threaded graphite nipple, a continuous electrode for the production of electrothermic steel is produced which exhibits a marked decrease in spalling. This not only greatly increases the life of the electrode, but minimizes the number of particles of graphite which separate from the electrode and contaminate the steel.

In a further embodiment of the invention a threaded dowel pin or nipple is machined from either amorphous carbon or graphite stock, the diameter and pitch of the threads in the nipple being such as to properly engage the screw seat end of the sections of amorphous carbon or graphite electrodes. A slot of suitable diameter is introduced along the longitudinal axis of the nipple and substantially parallel thereto by means of sawing. The depth or length of the slot in the nipple may be varied to suit the properties of the final sectional electrode. It has been found that the slot having a depth between 25 to about 60% of the vertical diameter of the nipple is particularly useful. Alternatively, a second slot may be placed in a nipple originating in the opposite end thereof and which is substantially at right angles to the first slot. The depth of this slot may be similar to or at variance with the length of the first slot. Geometric combinations other than the one here described whereby the slots are placed in the nipple to achieve a maximum of strength will occur to those skilled in the art.

As previously mentioned herein, the number and depth of the slots in a solid or hollow electrode will depend upon various factors. In the case of a solid electrode, a singular slot substantially parallel to the longitudinal axis of said electrode and penetrating the electrode radially to a depth of between 25 and about 75% of its horizontal axis has been found to be particularly suitable. Alternatively, a number of slots may be placed in the electrode by suitable means as previously herein described, said slots being substantially parallel to the longitudinal axis of the electrode body. It has been found advantageous to have at least one slot terminating at one or both ends of either the solid or hollow electrodes. When a plurality of slots are placed in the carbon body, for example in a solid electrode, it is preferable but not essential to place them radially with respect to the horizontal axis of the

electrode and in a staggered pattern to prevent undue weakening of the electrode in any particular region. The diameter or width of the slot in any particular case will be dependent upon certain features of electrode construction as previously herein set forth. The slot will usually be rather narrow, for example between about 1/64 to 3/8'' for electrodes having a diameter up to about ten inches, the slot having a width of between about 1/32 to 1/2'' in electrodes having a diameter between about 10 and about 40 inches. If a single slot is employed it may, of course, be wider than any particular slot in the event that a plurality of slots are employed.

In order to more fully illustrate the nature and character of the invention, but with no intention of being limited thereby, the following examples are set forth:

Example I

A hollow split electrode having a size approximately 20'' in diameter and 72'' in length was prepared as follows: a mixture of carbon particles having a mesh size between about 0.5 inch and about 0.001 inch was mixed with electrode pitch in a ratio of about 100 to about 25 parts by weight. The mixing operation was conducted at a temperature of about 150° C. for about 30 minutes. The resulting mix was then extruded through a die having a center of solid section, at a temperature of about 100° C. and a pressure of about 2000 lbs. per square inch. The resultant hollow "green" electrode was then baked in a temperature cycle beginning at 20° C. and finishing at about 1000° C. for a period of about twenty days. The resulting baked, amorphous carbon electrode was machined at both ends in order to provide a screw seat, the machining being done so as to align the seats concentric with respect to the longitudinal axis of the electrode. The wall of the resultant electrode was then cut so as to provide a slot of about 3/32'' width, said cut traversing the entire length of the electrode and being made substantially parallel to its longitudinal axis.

Two of the electrode sections prepared as described above were fitted together by means of an appropriately machined carbon nipple. This type of electrode forms the basis of the continuous electrodes useful in the production of ferroalloys and calcium carbide in electrothermal furnaces. It has been found that electrodes of this construction have a useful life about 10% and greater than that of electrodes used heretofore which did not incorporate the novel features of the present invention.

Example II

A baked amorphous carbon electrode of the type described in Example I was graphitized by heating at a temperature between 2400° and 3000° C. for about five days. The resulting graphite electrode was then subjected to a sawing operation whereby a slot having a diameter of about 1/16'' was made through the wall of the electrode, traversing the length of the electrode substantially parallel to its longitudinal axis.

Sections of graphite electrodes as described above which are coupled with appropriately machined graphite nipples constitute a distinct improvement in continuous graphite electrodes for use in metallurgical and low carbon steel electrothermal processes. When placed in use in an electric furnace for low carbon steel production such an electrode has a life about 10% and

greater than that normally expected of graphite electrodes of conventional construction.

While the electrodes referred to in the above examples are restricted to a description of hollow electrodes having a single slot which traverses the entire length of the electrode substantialy parallel to its longitudinal axis, it is to be understood that it is not intended to limit the invention to such a construction. Depending upon the properties desired for an electrode in a particular electrothermal process, a plurality of slots may be placed in the electrode, either in the threaded, the unthreaded, or entire portions thereof. The electrodes may be molded or extruded in various shapes and sizes depending upon the operating conditions and type of the electrothermal furnace. Furthermore, it is also within the contemplation of the invention that a carbon electrode which is built up of a plurality of concentric hollow carbon bodies of decreasing diameter which may be fitted together and baked to form a substantially solid electrode may also be appropriately slotted, thereby providing an electrode with improved properties with respect to resistance to thermal and mechanical shock.

Having thus described the nature and character of the invention, what I claim is:

1. A carbon eelctrode having at least one inwardly tapering screw socket end, and having at least one slot which is substantially parallel to the longitudinal axis of said electrode, said slot traversing substantially only the socket portion and intersecting the wall of the electrode.

2. A carbon electrode having inwardly tapering screw socket ends and having at least one slot which is substantially parallel to the longitudinal axis of said electrode, said slot traversing substantially only the socket portion and intersecting the wall of the electrode.

3. An electrode according to claim 2 wherein only one of the socket ends is slotted.

4. A graphite electrode of a structure as defined in claim 2.

5. A carbon electrode having at least one inwardly tapering screw socket end, and having at least one slot which is substantially parallel to the longitudinal axis of said electrode, said slot traversing a portion only of the electrode including the socket and intersecting the wall of said socket.

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