ELECTRODE CONNECTING PIN AND ASSEMBLY

Filed Jan. 11, 1967

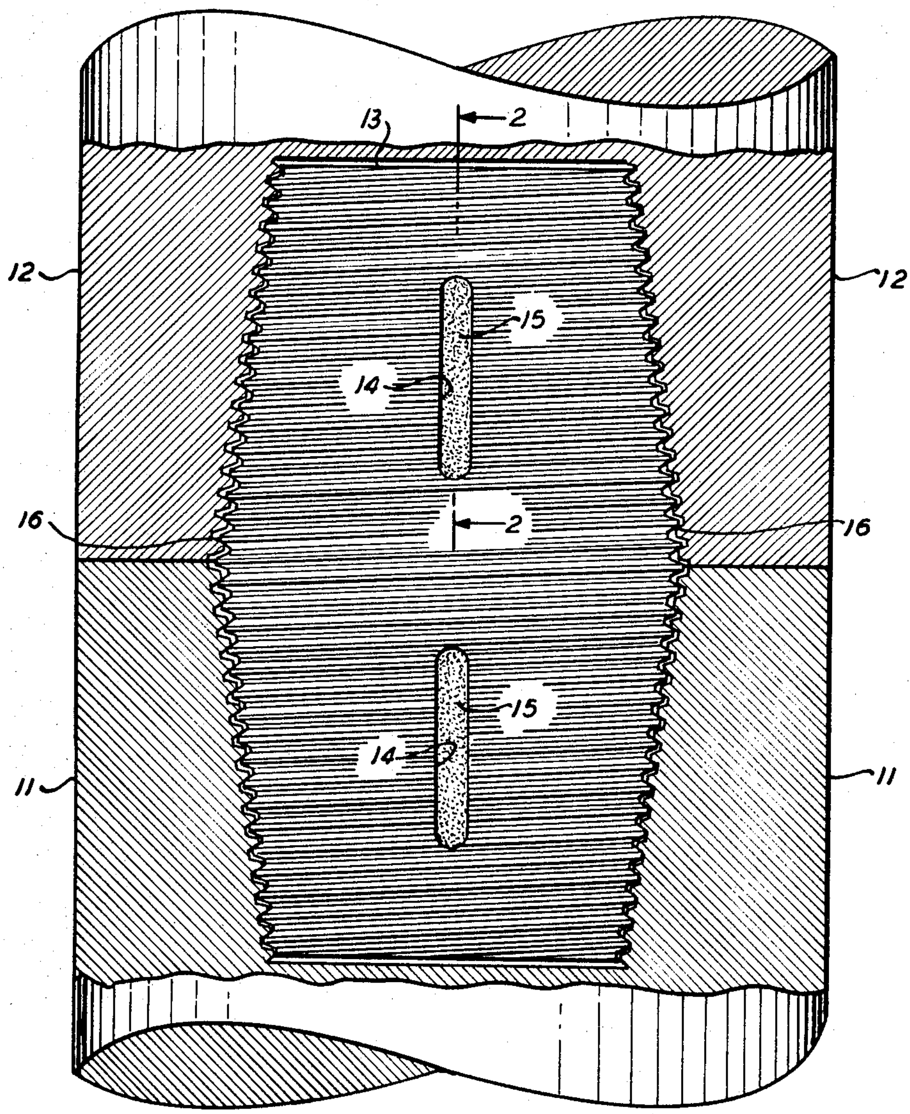

FIG. 1

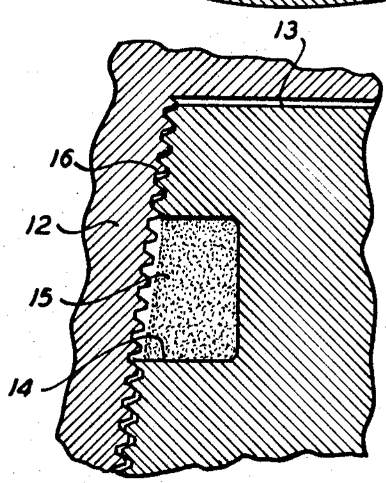

FIG. 2

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FIG. 3

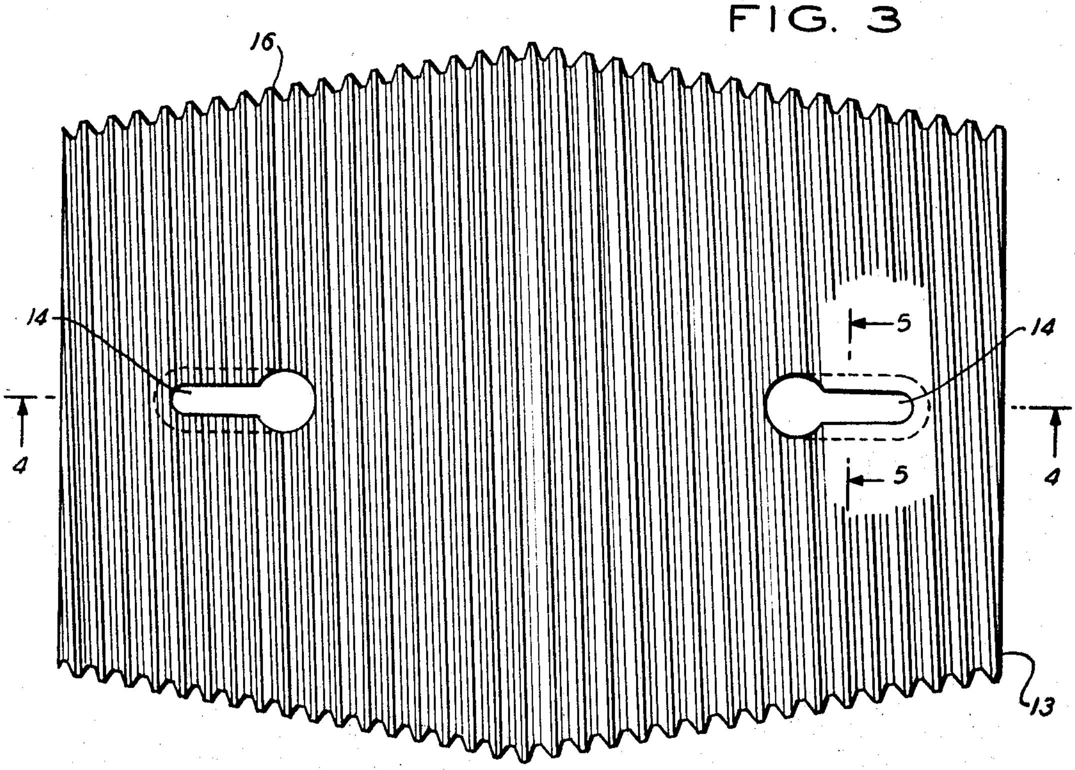


FIG. 4

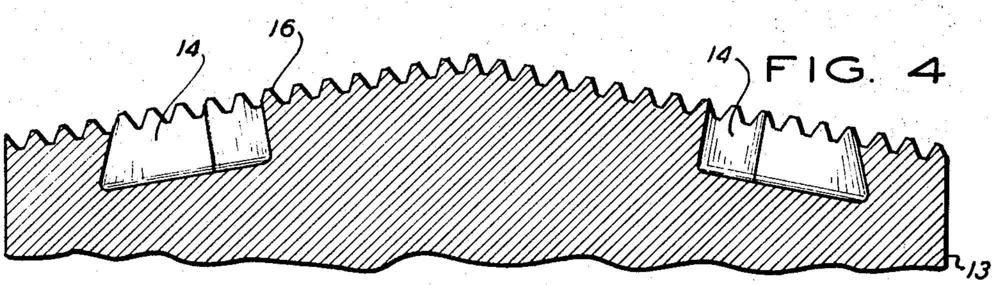
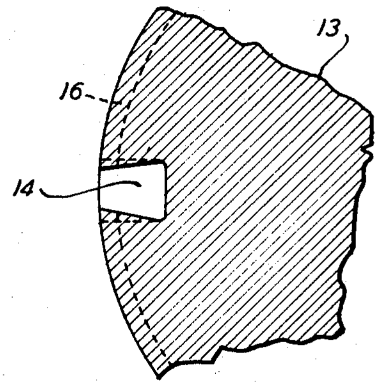


FIG. 5



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United States Patent Office

3,419,296

Patented Dec. 31, 1968

3,419,296

ELECTRODE CONNECTING PIN AND ASSEMBLY

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Continuation-in-part of application Ser. No. 542,094, Apr. 12, 1966. This application Jan. 11, 1967, Ser. No. 608,681
4 Claims. (Cl. 287—127)

ABSTRACT OF THE DISCLOSURE

A threaded connecting pin for the assembly of carbon or graphite electrodes in which pitch is retained in slots cut in the threaded surfaces of the pin to melt and carbonize in the thread clearance spaces to cement the connecting pin to the respective electrodes.

This application is a continuation-in-part of my prior copending application Ser. No. 542,094, filed Apr. 12, 1966, now abandoned.

This invention relates to connecting pins, more commonly known as nipples, for joining cylindrical electrodes made of carbon or graphite in end to end relation. Such electrodes are employed in electric arc furnaces for conducting electric current from a holder through the electrode and by way of an arc at the end of the electrode to metal or minerals, such as ores, being treated within the furnace. Such electrodes may carry several thousand amperes of electric current. In size they may range from little more than an inch up to three feet and more in diameter, and the large ones commonly are five or six feet, or more, in length and may weigh several thousand pounds.

In the operation of the furnace the electrode is gradually consumed at the arc end and this requires a more or less continuous feeding of the electrode into the furnace. In order to eliminate shutdown of the furnace for the purpose of changing or replacing electrodes which have been largely consumed it is customary to provide the ends of the electrodes with axial screw-threaded sockets, so that a new electrode section may be joined or connected, end to end, to the short length by the use of a screw-threaded nipple. Such nipples usually are made of material having substantially the same, or similar, composition to that of the electrodes. As the electrode is gradually consumed at its inner end it will be fed intermittently by short increments into the furnace, and from time to time a new section of electrode will be joined to the outer end of the electrode by a nipple.

For satisfactory operation these joints between electrode sections should have low electrical resistance and it has been found that in order to accomplish this the adjacent ends of the electrodes should meet in a close-fitting face to face relation which should be continuously maintained while the furnace is in operation. During operation of the furnace the electrode will be subjected to severe conditions of temperature and vibration and a permanently tight mechanical joint between the electrode sections is desirable not only to keep the electrical resistance low, but also to prevent relative rotational movement between the electrodes and the nipple which might result in unscrewing of the electrodes on the nipple, or breakage of the socket walls.

In an effort to insure a permanently tight connection between joined sections of electrode under operating conditions, it has heretofore been suggested to apply to the engaging surfaces, or to portions thereof, a pitch or other bonding, binding, or cementing material which will carbonize under the high temperatures to which the electrode will be subjected in operation. The purpose is to

bond and to hold the electrode sections firmly together. A wide variety of materials has been used, and it has been suggested to apply the bonding material to the engaging surfaces in a variety of ways. Different theories have been advanced as to the extent and location of the engaging surfaces to be bonded for best results.

In U.S. Patent 2,510,230 there is disclosed a pitch reservoir in either the electrode or the connecting pin with slots provided longitudinally through the threads to permit the pitch, when melted, to communicate with the threads and cement the connecting pin to the electrode. While connecting pins made according to the said patent prevented accidental disengagement of the joint threads many joints of this type failed because of cracking and fracturing of the connecting pin. U.S. Patents 2,828,162 and 2,735,705 teach that if the number of thread clearances filled with pitch is limited to the order of 10 to 25% of the total, that more flexibility will be retained in the joint and the tendency for the connecting pin to crack will be reduced. To carry out this idea Patent 2,828,162 teaches the use of a flux reservoir or reservoirs along the axis of the connecting pin with communicating ports drilled from the flux reservoir to the threads on the external surface of the connecting pin, the area and number of these communicating ports being so limited as to insure cementing of only a small percentage of the total threads. In Patent 2,735,705 the axial pitch reservoir is eliminated and the pitch is retained in the radial passages communicating with a limited number of thread clearance spaces.

While these designs help eliminate connecting pin fractures many joint failures occur because there is insufficient thread bonding to prevent the pin and electrode from unscrewing under service conditions.

U.S. Patent No. 2,941,828 teaches that bores may be made in either end of the nipple normal to the axis of the nipple and that pitch or other thermosetting bonding material may be inserted into the bores. To insure free movement of the pitch out of the bores and into a sufficiently large number of thread clearance spaces, the areas of the nipples surrounding the bores were machined to a depth slightly below the root of the thread.

Extensive tests and commercial use of nipples having bonding material inserted in bores normal to the axis of the nipple has shown that the pitch in many instances does not reach a sufficient number of thread clearance spaces to provide the locking strength necessary to insure that the electrode joints remain tight during use. Fracture tests of the nipples after use have shown that the pitch often cokes within the bores before a sufficient volume of the pitch can flow out into the thread clearance spaces.

In U.S. Patent No. 2,941,829 an alternative to the bores is provided wherein circumferential grooves in the nipple are provided for holding the bonding material. Commercial use of this nipple demonstrated that mechanical stress concentrated at the circumferential grooves and caused the nipple to break at the point of the grooves.

It is an object of this invention to provide an improved connecting pin for joining electrodes made of carbon or graphite.

It is another object of the invention to provide an improved connecting pin with reservoirs for bonding material arranged to insure that a sufficient quantity of such bonding material will be distributed along the thread surface to provide a mechanically tight joint.

A further object is to provide an improved connecting pin that will not fracture under the stresses encountered in service even though it is firmly bonded by carbonized pitch to the electrodes it joins.

In accordance with the present invention, an arrangement is provided wherein sufficient pitch is carried in reservoirs in the nipple in such a manner that it reliably flows from the reservoir and fills sufficient thread clearance spaces to create a mechanically tight joint. This result is accomplished by carrying the pitch in one or more slots along one or more planes through the connecting pin axis. The bottom of the slot may be, for example, approximately parallel to the axis of the nipple, or in the alternative, approximately parallel to a plane tangent to the threaded surface. The taper of the connecting pin may deviate from that of the socket to prevent pin fracturing even though a large number of threads are cemented with the carbonized pitch.

The means by which the objects of this invention are obtained are described more fully with reference to the accompanying drawings in which:

FIG. 1 is a vertical section of an electrode joint as it appears before exposure to the furnace heat, fragmentary portions of the joined electrodes above and below the joint being shown in elevation;

FIG. 2 is an enlarged sectional view taken along the line **2—2** of FIG. 1;

FIG. 3 illustrates a modification of the electrode connecting pin;

FIG. 4 is a sectional view taken along the line **4—4** of FIG. 3; and

FIG. 5 is a sectional view taken along the line **5—5** of FIG. 3.

Referring to the drawings, FIG. 1 shows the upper end of an electrode **11** and lower end of an electrode **12** joined by the screw threaded nipple **13**. The electrodes may be either carbon or graphite and will sometimes be described herein simply as being made of carbonaceous material. The electrodes **11** and **12** are provided at their ends with axially disposed screw threaded sockets for receiving and engaging the externally threaded nipple **13**. Reservoir slots **14** are provided for holding binding material **15**. In the illustrative embodiment, the sockets are frusto-conical and the nipple tapers down from its longitudinal midpoint toward each end to mesh the sockets. Conventionally, the taper of the socket is about 9°27′45″ on the half angle, although small variations in the taper are common in the industry. It will be understood that this invention is applicable to nipples for joining electrodes with cylindrical sockets as well. Cylindrical sockets are often used in amorphous carbon electrodes, while tapered sockets are usually used for graphite electrodes. The size of the nipple desirably will be proportioned to the electrode size to provide maximum mechanical strength as a whole in accordance with conventional practice. The nipple is a carbonaceous body usually having a composition substantially the same as or similar to that of the electrodes which are to joined.

FIG. 1 shows an electrode joint as it might appear before being subjected to heat sufficient to cause the bonding material contained in the nipple to melt and flow from the reservoirs into the thread clearance spaces **16**, where it will be carbonized by the heat. The thread clearance spaces and the slots are more clearly illustrated in the enlarged sectional view of FIG. 2, taken along the lines **2—2** of FIG. 1. Located between the longitudinal center of the nipple and each end surface thereof is at least one reservoir slot **14** containing bonding or binding material **15**. The slot extends toward the longitudinal axis of the nipple to a depth substantially below the root of the nipple threads. Obviously additional slots in the same plane or in other planes may be used if desired, and preferably two slots are used at each end of the nipple. The reservoirs **14** are substantially rectangular slots extending along a plane through the connecting pin axis and, in this specific embodiment, the bottom of the slot is parallel to the axis of the connecting pin. Obviously it is not essential that the bottom of the slot be precisely parallel to the axis of the nipple, but it may be inclined at slight angles with respect to the nipple axis. For example, the bottom of the slot may be

machined so that the bottom of the slot is parallel to the threaded surface of the nipple. Also, although the slots are shown extending along a plane through the nipple axis, the slots may obviously be slightly oblique to the plane without departing from the scope of this invention.

The slots are made long enough to communicate with a substantial number of the threads and preferably more than 20% of the threads. This assures sufficient bonding to prevent loosening of the joint in service. Whereas it has been found in the past that the nipples tend to fracture if so securely bonded, I have determined that this probability can be virtually eliminated by making the taper angle of the nipple slightly less than that of the socket. A difference in taper angle of as little as 2 or 3 minutes provides sufficient thread clearance in the zone adjacent the center of the nipple to give the joint some degree of flexibility thereby preventing the development of excessive stresses in the nipple even though the electrode and nipple are securely bonded to one another to prevent inadvertent loosening of the threaded joint.

It should be noted that the corners of the slot **14** have a radius to minimize stress concentrations.

In the typical manufacture of the nipples of this invention, liquid pitch or other thermosetting binder is poured into the slot reservoirs whereupon the pitch solidifies. Since the pitch shrinks upon solidification, it may tend to fall out of the nipples of FIGS. 1 and 2. FIGS. 3–5 illustrate electrode joints wherein the nipple slots are dovetailed or otherwise enlarged at the bottom of the slot to insure that the solid pitch cannot fall out of the slot. FIG. 4 is a partial cross section taken along the line **4—4** of FIG. 3 and FIG. 5 is a partial cross section taken along the line **5—5** of FIG. 3. Reference numerals in FIGS. 3–5 are identical with the numerals used in FIGS. 1 and 2.

As in the case of FIGS. 1 and 2, the slots of FIGS. 3–5 have rounded edges to reduce mechanical stress.

It should be noted that although it is preferred to pour liquid pitch into the slots, it is contemplated that solid or semisolid pitch may also be suitably inserted in the slots.

When the nipple becomes heated, the fusible bonding material **15** melts and runs out of the slots **14** and is distributed into the thread clearance space **16**. In order to prevent escape of bonding material between the end surfaces of the electrodes and to the end surfaces of the nipple, the slots **14** are terminated at their inner ends short of the longitudinal center of the nipple and at their outer ends short of the end surfaces of the nipple. This leaves one or more threads at the center of the nipple and at each end of the nipple which serve as dams to inhibit flow of bonding material to either the midpoint or the end surface of the nipple.

Repeated fracture tests of the electrode joints of this invention illustrate that the flow of the bonding material out of the slots **14** is substantially complete in all cases so that a substantial number of the thread clearance spaces are provided with bonding material.

In making electrode joints with the nipple of the present invention, no special techniques or precautions are necessary. Electrodes provided with conventional threaded sockets are screwed tightly together on to the ends of the nipple. As the electrode joint is subjected to heat, the bonding material melts and flows from the slots into the thread clearance spaces. Escape of the bonding material to the end surfaces of the electrodes and to the ends of the nipple where it would have less holding power is effectively prevented, and the bonding material is diverted into the thread clearance spaces. The heat causes the distributed bonding material to carbonize and form a firm connection between the threaded surfaces of the nipple and both electrode sockets.

As an example of the size of the slots, a nipple for a 20 in. diameter electrode is generally about 14 in. in length and 10.75 in. at the major diameter. The taper of the electrode socket is about 9°27′45″ on the half angle and that of the nipple somewhat less, for example 9°25'. For such a joint I have found that the connecting pin should contain a total of 4 slots arranged as shown in the drawing, the slots being about 2½ in. long, about 1 in. wide at the base, and about 1 in. deep.

Of 69 joints industrially tested using the nipple of this invention, there were no joint failures that could be attributed to loosening of the joint and no failures caused by fracturing of the nipple.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the impending claims the invention may be practiced otherwise than as specifically described.

I claim:

1. In an electrode joint in which contiguous electrode sections are each provided with a tapered threaded recess in the contiguous end face thereof, a nipple threaded into said recesses to hold said electrode sections with their end faces in mechanical and electrical contact, the threads of said recesses and said nipple providing clearance spaces therebetween with said nipple tightened in said recesses and, after heating, a thermosetting bonding material being provided in said clearance spaces, the improvement according to which:

(a) the threaded surface of said nipple is provided between the longitudinal center thereof and each of its end faces with at least one longitudinal slot extending substantially along a plane through the nipple axis and intersecting at least 20% of the threads on that half of the nipple in which said slot exists, said slot extending toward the longitudinal axis of said nipple to a depth substantially greater than the root of the nipple threads and being filled to a depth below the root of the threads with a mass of solid fusible thermosetting bonding material, the quantity of material contained in each slot being sufficient to flow directly into the thread clearance spaces of a major portion of the threads intersected by said slot upon heating thereof, and

(b) the threaded surfaces of said nipple are provided with a taper at an angle slightly less than that of the tapered mating threaded recess

whereby the components of said joint will become firmly bonded to one another upon exposure to heat to prevent rotational disengagement without such bonding subjecting the nipple to excessive stress.

2. A nipple for joining two carbonaceous electrodes as in claim **1** wherein said slots are substantially rectangular in cross section.

3. A nipple for joining two carbonaceous electrodes as in claim **2** wherein said slots are dovetailed to retain said thermosetting material in the slots.

4. A nipple for joining two carbonaceous electrodes as in claim **1** in which said fusible thermosetting material is pitch.

References Cited

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