Sept. 6, 1938. B. M. S. KALLING ET AL 2,129,007

APPARATUS FOR ELECTRICALLY TREATING MATERIAL IN ROTARY FURNACES

Filed Aug. 24, 1935

Fig. 1.

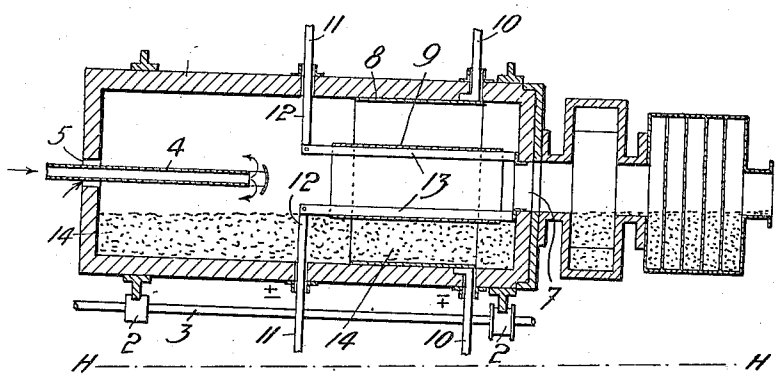


Fig. 2.

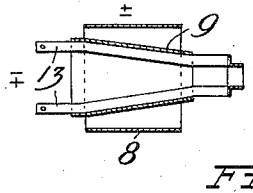


Fig. 3.

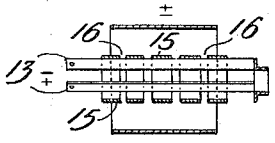


Fig. 4.



Fig. 5.

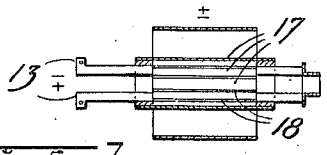


Fig. 6.

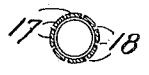


Fig. 7.

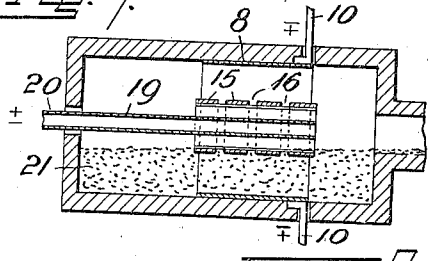


Fig. 8.

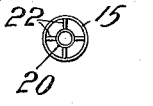
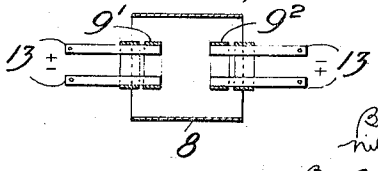


Fig. 9.



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APPARATUS FOR ELECTRICALLY TREATING MATERIAL IN ROTARY FURNACES

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In Sweden September 4, 1934

1 Claim. (Cl. 13—21)

The present invention relates to an apparatus in which electric current may be supplied to materials to be heated without melting, rendering them adhesive, or sintering them, but where the temperature of treatment is, nonetheless, up in the vicinity of the temperature where this usually occurs. A typical example of such temperatures occurs in the reduction of iron ore in admixture with coal into so-called iron sponge, and to this process the invention relates most nearly, although it may also be applied to other processes where the aforesaid temperatures, etc. prevail.

In these processes, the heating is effected in a rotary furnace, the necessary heat being generated in the charge by passing an electric current through the same. The manner in which the current is supplied to the charge is of essential importance in such cases. In the first place, the electrodes employed must be designed in such a way that the risk of leakage of current will be eliminated, as a sudden rise of temperature may easily cause formation of coatings on the walls of the furnace in the current-conveying zone, through which coatings the current then will pass more easily than through the charge, resulting in leakage of current, and since by this, the coating gets hotter than the charge, more and more of the charge sinters onto this place until, finally, the furnace is put out of commission.

The present invention bears upon an altered principle of current supply owing to the use of a novel electrode construction, among other things, and thereby it is rendered possible to obtain, for a given diameter of the furnace, a considerably greater effective electrode area.

The other objects and advantages of the invention will be made manifest hereinafter.

For illustrative purposes and in order to exemplify the invention, there are shown on the accompanying drawing some embodiments of a rotary or continuous heating furnace provided with electrode arrangements according to the present invention.

Figure 1 is a vertical section substantially along the centerline of the furnace.

Figure 2 is a detailed, sectional view of the electrode arrangement where the inner electrode is designed to form a jacket conically tapering towards the discharge end;

Figure 3 is a similar section of the inner electrode where the latter is split up in transversal direction or, in other words, is constituted by a number of ring shaped parts somewhat spaced apart, counted in the longitudinal direction;

Figure 4 is a diagrammatic end view of the arrangement for carrying the ring shaped electrodes;

Figure 5 is a detailed, sectional view of another embodiment of the inner electrode, according to which said electrode is formed as a shell or jacket slotted in its longitudinal direction, or composed of longitudinally extending rods or parts forming together a jacket annular in cross-section, either of cylindrical or conical shape or formed in another manner as a rotary body;

Figure 6 is a diagrammatic, end view of this arrangement of the inner electrode;

Figure 7 is a longitudinal sectional view of a furnace where the inner electrode is carried by a central bar extending through an opening provided in one of the end walls of the furnace, which bar is thoroughly free from the rotary furnace, so that the inner electrode has not to take part in the rotary motion of the furnace;

Figure 8 is a diagrammatic, end view of the arrangement for carrying the inner electrode and said bar or arm; and

Figure 9 is a longitudinal, sectional detail of an arrangement of the central electrode. Said electrode is divided into two parts in such a manner that the current is first allowed to pass from one of the inner electrodes through the charge to the outer electrode and therefrom back through the charge to the other part of the central electrode.

The invention will first be described with reference to Figure 1.

The outer arrangement of the furnace is substantially the same as that described in the U. S. A. Patent No. 1,870,053, although the sluice arrangement shown at the feeding end according to said patent, which arrangement being not included in the disclosure constituting the object of the present invention, is left out of the drawing.

1 designates the revolving furnace proper, which, in a manner known per se, is carried by rotary rollers 2 connected together in pairs by means of a shaft 3 and, in some cases, designable so as to be able to serve the purpose of rotating the furnace. 4 designates a tube for the supply of air, which tube enters the furnace through a feeding opening 5 for the charge provided in one of the end walls of the furnace. 7 designates the discharge opening for the treated product which, upon leaving the furnace, is preferably allowed to pass through a cooling and sluice arrangement similar in construction to that described in said patent. The sluice arrangement is illustrated on the drawing but will not be described in detail,

as it is known and does not constitute an essential feature of the present invention.

H—H designates a horizontal line. As will be seen on the drawing, the furnace is somewhat inclined downwardly from the feeding end towards the discharge end, so that the charge, as the furnace is rotated, will move automatically toward the latter end.

8 designates an electrode provided in the rotary furnace adjacent the inner jacket surface and being, according to the illustrated embodiment, cylindrical; and 9 designates the inner electrode, which, according to Figure 1, is in the form of a cylindrical shell, but may, as will be more clearly described hereinafter, also be formed in another way. The effective surface of the inner or central electrode is substantially designed to form, or does form, a surface of revolution coaxial with the furnace.

10 designates current feeding devices leading to the electrode 8—hereinafter also called the outer electrode—and 11 designates current feeding devices for the inner or central electrode 9, which is carried by stays 12 passing through the wall of the furnace, preferably three in number and disposed at an angle of 120 degrees to each other. 13 designates longitudinal staffs or rods united with said stays and, they while carrying the inner electrode, at the same time, are conductively connected thereto. At the discharge end of the furnace, said rods 13 are secured to the furnace in a manner suitable for the purpose so as to form a reliable support for the inner electrode.

As stated above, the present invention differs in principle from the arrangement of the electrodes and with regard to the conveyance of the current through the charge, described in the aforesaid U. S. patent, in that the current, according to this invention, is caused to pass between a central electrode and an outer electrode located adjacent the wall of the furnace, instead of being caused, as is the case according to said patent, to flow between two electrodes in the longitudinal direction of the furnace. The contact surfaces which will by this means, be made to extend in the longitudinal direction of the furnace, may in that way be made relatively large without the diameter of the furnace having, as a consequence, to be increased.

As stated above, this arrangement of the electrodes and of the current supply also entails the advantage, particularly in the production of iron sponge, that if the charge 14 for some reason, for instance on account of temporarily too high a current density existing, begins to stick or sinter in the current-conveying zone, all those lumps (which are easily formed in the mass and which, if they are allowed to remain, will roll around and around and increase in size and soon cause interruption of operation) will, owing to the positioning of the electrodes according to the present invention etc., without hindrance by the electrodes, accompany the other part of the charge out of the current zone.

As for the rest, reference is made to what has been stated above concerning the construction of the electrodes and the support of the same and the importance thereof for the operation of the furnace.

In Figure 2 is illustrated an embodiment of the inner electrode 9, according to which said electrode forms a jacket or surface of revolution conically tapering in the direction from the feeding end towards the discharge end. This arrangement will, as set forth above, result in a more evenly distributed current during production. If desired, instead of the jacket, the outer casing, may be made conical in a corresponding manner, so that the distance between the outer and the inner jacket or the electrode becomes shorter at the end located most closely adjacent the feeding end than at the opposite end; or both electrodes may be formed in a manner suitable for the purpose.

In Figures 3 and 4 is illustrated an arrangement of the inner electrode, according to which said electrode is split in the transverse direction so as to consist of a number of rings 15 which are spaced apart longitudinally by intermediate spaces 16. These rings are carried and secured in place by means of rods 13 in a manner analogous to that stated above. This results in the charge having a free passage at a number of places, also through the jacket of the central electrode; thus the disadvantage, otherwise capable of obtaining in certain cases, will be obviated whereby, the charge, upon the rotation of the furnace, "hitches" between the central electrode and the walls of the furnace, which, of course, would result in local superheatings.

For the same purpose, also, the central electrode may be slotted in the longitudinal direction in the manner shown in Figures 5 and 6; or it may be constituted by rods 17 arranged parallel to the generatrix, between which are defined longitudinal intermediate spaces 18 of suitable size. In both cases it should be observed, however, that the effective electrode area is not reduced any more than necessary.

The outer electrode may, of course, be split up in a corresponding manner when this is found to be desirable.

Figure 7 shows, as mentioned above, an arrangement according to which the inner or central electrode is carried by a bar or the like 19 passing through an opening 20 provided in the end wall 21 of the furnace in such a manner that the inner electrode does not take part in the rotary motion of the furnace. The inner electrode proper may be designed in any suitable manner according to the principle stated above, but is shown in Figures 7 and 8 as constituted by ring shaped members 15 separated in longitudinal direction by intermediate spaces 16. The current is supplied to said rings via the bar 19 and the stays 22 which carry the ring shaped members or the parts forming the inner electrode. They may be either in the form of rods, as according to Figures 5 and 6, or in the form of rings, as according to Figures 3 and 4; or designed in any other suitable manner. With this arrangement central electrodes may, during the working of the furnace, be kept at rest or be rotated at a velocity other than the velocity of rotation of the furnace, either in the same direction, or in the opposite direction, so that a relative motion between the two electrodes occurs.

The introduction of the charge and of air etc. may be effected according to the same principle as above described with reference to Figure 1, the bar 19 being, in some cases formed as a tube provided with perforations so that air can be introduced via these perforations into the furnace chamber, or air or other gas suitable for the purpose may be introduced via special feeding openings, such as the opening 20.

According to Figure 9, the central electrode is divided, in the longitudinal direction, into two parts 9^1, 9^2, both of which are connected to conductors, the current being allowed to pass from

one of the inner electrodes through the charge, to the outer electrode, and therefrom back through the charge to the other part of the central electrode. For a given effect there is thereby obtained double the voltage and half the current intensity.

The electrodes are shown in Figure 9 as built of ring shaped parts similar to those illustrated in Figure 3, but it is obvious that they may be also arranged in any other manner, for instance according to any of the embodiments above described.

The application of this principle of current supply involves, moreover, another advantage which has proved to be of great importance in the production of iron sponge. If the charge for some reason or other, for instance due to a temporarily too high a current density, begins to stick or sinter in the current-conveying zone, lumps will be easily formed in the mass, which lumps, if they are allowed to remain therein, turn around and round and increase in size little by little and will soon cause disturbance of service. In case of transversely arranged electrodes, the electrodes hinder such bigger lumps from passing on further, whereas the positioning of the electrodes according to the present invention does not in any way hinder them from following the remaining portion of the charge on its way out of the current zone.

A disadvantage involved in the present electrode positioning can, under certain circumstances, ensue because of the difficulty in maintaining an even load all along the electrode, due to the fact that the charge through successively rising temperature and possibly also on account of the successively chemical reaction acquires a varying electrical conductibility during its passage through the current zone. In the production of iron sponge, for example, the reduction brings on an increased conductibility in the charge and since, moreover, the temperature rises in proportion as the reduction of the charge proceeds, an increasing current density may for this reason, ensue in the direction of motion of the charge. However, if an evenly distributed current is desirable, said inconvenience may be compensated by giving one or both of the electrodes a shape somewhat differing from a cylindrical surface, for instance a conical shape, as more closely described in the following.

A further disadvantage sometimes accompanying the use of this electrode construction consists therein that the charge upon the rotation of the furnace hitches between the central electrode and the wall of the furnace, which may lead to super-heating at certain points. On this account, it has proved to be desirable that, for the purpose of avoiding this disadvantage, the central electrode be so designed that the charge has free passages at a number of places also through the shell of the central electrode. To this end, the shell may be perforated in suitable manner, or it may be divided into a number of rings (according to Figure 3 of the accompanying drawing), or into rods parallel to the generatrix (according to Figures 5 and 6), or in other manners, it being to be observed, however, that the effective electrode area should not be reduced more than necessary.

Such a division of the inner electrode or central electrode has proved to be expedient also from another point or view; the less the resistance opposed by the electrode to the motion of the mass, the better the agitation obtained in the charge. It has been found that, at a sufficiently high velocity of rolling or rotation of the furnace, such a thorough mixing can be obtained in the production of iron sponge from a mixture of concentrate and coal powder that the charge obtains nearly the same composition throughout the current zone and, by this, a nearly constant conduction resistance. This possibility is of great importance in carrying out the iron sponge process.

Also the outer electrode, which in its most natural shape consists of a cylindrical shell disposed adjacent the wall of the furnace, may be divided into smaller elements, which, from a structural point of view, may be suitable particularly in the case of greater furnaces.

The upholding of the central electrode is an important structural detail. In case of rather long furnaces, the supporting members may extend from the cylindrical furnace wall at such a distance from the outer electrode that conductance of current along the wall is not to be feared. In case of shorter furnaces, the supporting members may extend from the end wall of the furnace. In some cases it may also be suitable to support the electrode by means of an arm which is entirely free from the furnace and is introduced centrally through one of the end walls of the furnace (Figure 7). The central electrode may then be kept at rest or be rotated at a velocity other than that of the furnace. The current supply, and also the exchange of the central electrode, will be simplified by this design. In connection with charges having a high electrical conductibility it may occur that the electrical working voltage for this electrode construction becomes lower than desirable. In such a case, the central electrode may be split up in axial direction (according to the principle indicated in Figure 9) and the current be brought to flow from one of the inner electrodes through the charge to the outer electrode and therefrom back through the charge to the other part of the central electrode. For a certain effect, the double voltage and half the current intensity will then be obtained. Furnaces having a plurality of electrode systems may also be used.

Having now described our invention we declare that what we claim is:—

In an electrical heating apparatus, the improvement which comprises a generally horizontal, rotatable furnace, having inlet and discharge openings, means for rotating said furnace about its longitudinal axis, an outer electrode in the form of a hollow cylinder mounted adjacent the inner wall of said furnace, an inner electrode mounted within the furnace in spaced relation to the outer electrode and substantially in axial alignment with the discharge opening of the furnace, said inner electrode including a plurality of electrically connected sections spaced longitudinally of the furnace, said inner and outer electrodes forming a cylindrical chamber through which material to be heated may pass, means for passing a charge of material through said cylindrical chamber, and means for passing an electric current between the electrodes.

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