L. E. SAUNDERS.

METHOD OF CONVERTING REFRACTORY OXID.

APPLICATION FILED APR. 15, 1919.

1,352,387. Patented Sept. 7, 1920.

2 SHEETS—SHEET 1.

Fig. 1.

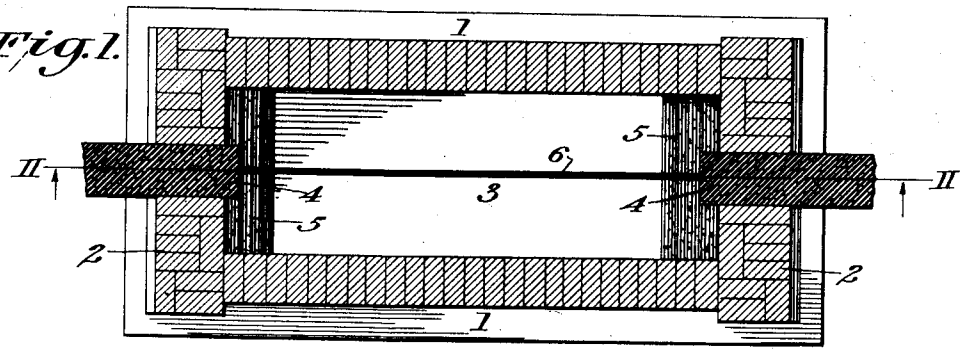


Fig. 2.

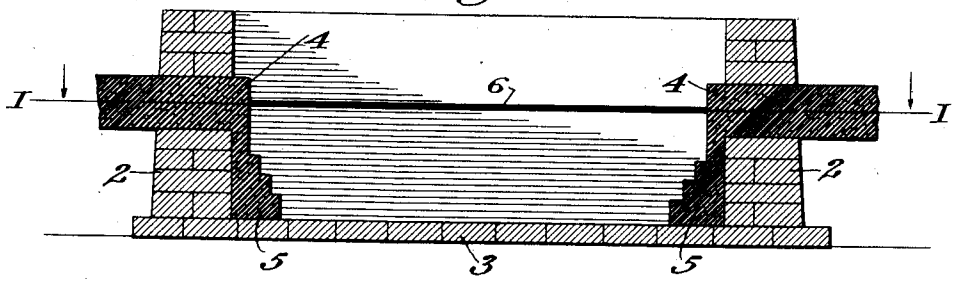
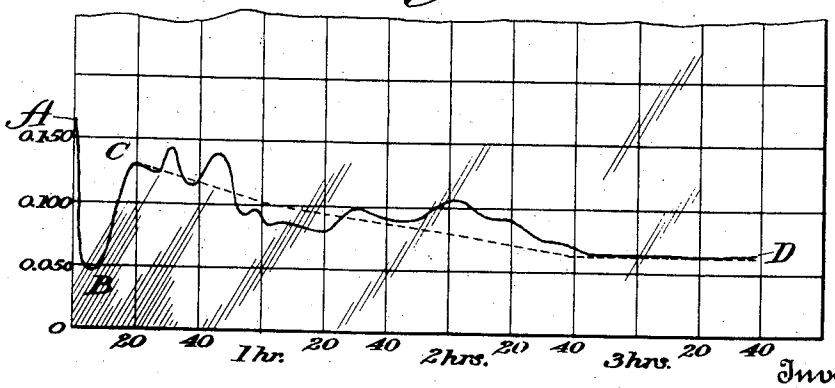


Fig. 3.



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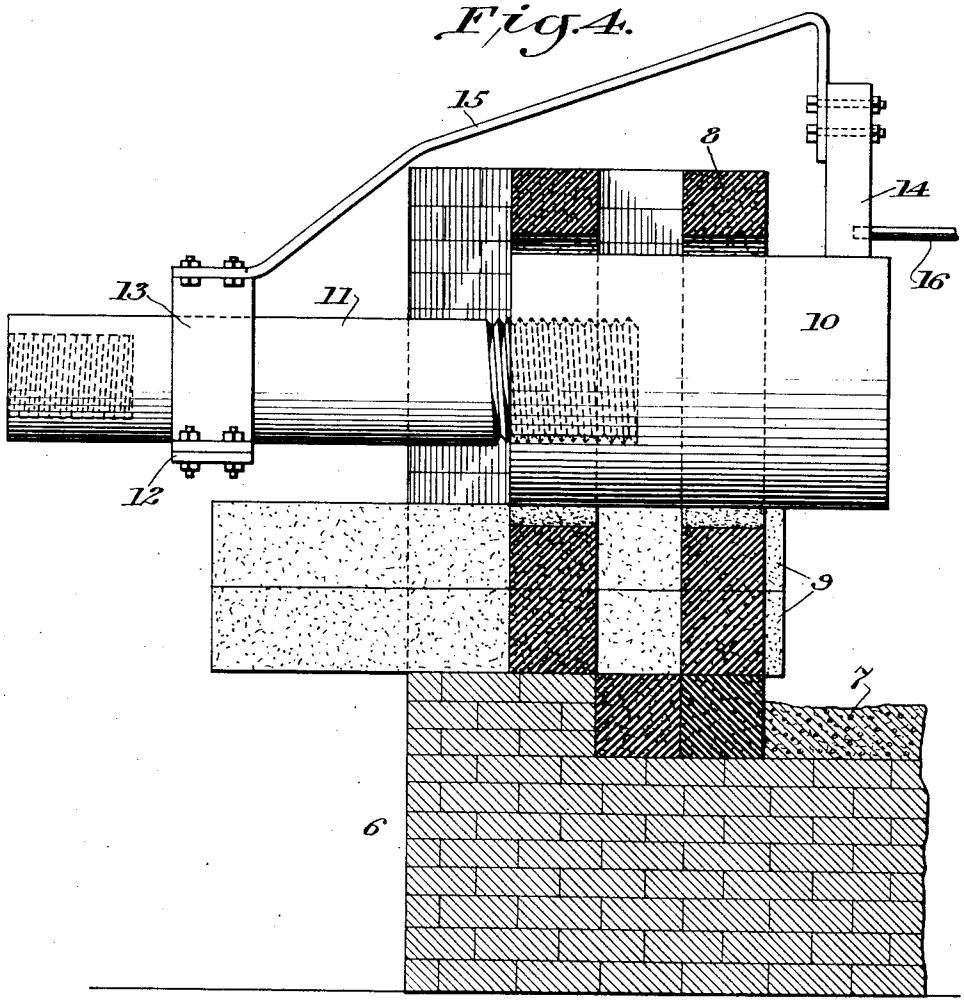
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2 SHEETS—SHEET 2.

Fig. 4.



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UNITED STATES PATENT OFFICE.

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METHOD OF CONVERTING REFRACTORY OXID.

1,352,387. Specification of Letters Patent. Patented Sept. 7, 1920.

Application filed April 15, 1919. Serial No. 290,223.

To all whom it may concern:

Be it known that I, LEWIS E. SAUNDERS, a citizen of the United States, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Methods of Converting Refractory Oxids, of which the following is a specification.

This invention is an electric furnace method whereby various so-called refractory oxids or mixtures thereof may be subjected to any desired temperature up to or above their fusing points. The method is applicable to the conversion (including shrinking, agglomeration, sintering, or fusion) of loose charges of oxids or oxid mixtures, and may be applied at will and with high electrical and thermic efficiency, to very large charges, amounting if desired to several tons. The method is applicable to all such oxids or oxid mixtures as are stable at or somewhat below their melting points and acquire at or below the conversion temperature sufficient electrical conductivity to carry the current necessary for the conversion of the surrounding portions of the charge. For example, the method is applicable to the conversion of such oxids as those of magnesium, aluminum, (including bauxite), zirconium, titanium, chromium, (including chromite), certain iron oxids and oxid mixtures, and the like.

The principle involved in the novel operation is as follows: A conductive path of relatively very restricted cross section is established within the body of an oxid charge, preferably above the median horizontal line of the charge. For example, a thin carbon rod, extending between heavy carbon terminals, may be completely embedded in the upper portion of the oxid or oxid mixture to be converted. Current is then caused to traverse the rod in sufficient volume to agglomerate or fuse the immediately adjacent portion of the charge, and to raise the same to the temperature at which it acquires enough conductivity to carry the electrical load. The carbon resistor is essentially fugitive, and before its disruption, or at about the moment of its disruption the impressed E. M. F. is increased sufficiently to maintain, through that portion of the charge which has become conductive in the initial phase of the operation, current adequate to maintain the required temperature in the initially-produced core, and progressively to convert the adjacent portions of the charge. Under these conditions the conductive cross sectional area progressively increases, and the voltage may be gradually reduced, the electrical conditions being preferably so controlled as to maintain a substantially constant load on the furnace until the close of the heating stage of the operation. In cases where full fusion is reached, as for example in the melting of alumina and other fusible oxids, there is a marked tendency to lateral spreading of the melt, and it is necessary to provide some adequate means for limiting this, as for example by the provision of water-cooled side walls.

At the close of the heating stage the current may be cut off and the converted product permitted to cool at the normal rate; or in cases where slow cooling, or even re-heating are deemed desirable, the load may be gradually reduced or varied, being held for any required time at any desired temperature. In this way a special heat treatment of oxids becomes possible, analogous in some respects to the heat treatment of steels.

A typical illustrative example of the practice of the invention is the shrinking of magnesia, preferably at the temperature at which sintering, agglomeration, or even fusion occurs. The approximate temperature at which the sintering of pure magnesia takes place is 2600° C. Commercial grades of magnesia sinter at a somewhat lower temperature, depending upon the nature and proportion of the impurities present.

The method may be carried into effect in a furnace of the character illustrated in the accompanying drawings, wherein—

Figure 1 is a horizontal section of the furnace on line I—I of Fig. 2;

Fig. 2 is a central longitudinal section on line II—II of Fig. 1;

Fig. 3 is a resistance curve illustrating the sintering of magnesia under specific conditions as described below; and

Fig. 4 is a vertical central sectional view showing one end of a modified furnace construction.

The furnace illustrated in Figs. 1 and 2 has side walls 1, 1, end walls 2, 2, and a base 3, all of which may be of fire-brick or other suitable refractory material, preferably basic in character. Magnesia brick may be used. The terminal electrodes 4, 4 are of

graphite or other form of carbon and may extend from side to side of the furnace, as shown. Below the electrodes 4, 4, the end walls are internally faced with carbon, as indicated at 5, this facing preferably having a step-like formation, as shown, for the purpose of supporting those portions of the charge which are in contact with the terminal electrodes. The carbon rod 6, termed the "starting rod," is of relatively small diameter and extends between the electrodes and contacts therewith. This starting rod may if desired consist of two or more sections which are initially in electrical contact with each other; or in general I may employ any arrangement which will afford a continuous but restricted path for the current between the terminals 4, 4.

The method as carried out in a simple furnace of this kind is as follows: The magnesia, preferably calcined, is charged into the furnace completely filling the same and being packed over and around rod 6 and in close contact with the terminal electrodes 4, 4. A heavy current is then applied, which in the first instance, traverses the carbon rod 6. At the beginning of the operation, the amperage and the voltage of the current are so adjusted with reference to the cross section of the rod 6, that the portion of the charge immediately surrounding the rod is caused to agglomerate and to become electrically conductive. At the high temperatures thus developed in the rod, the carbon disappears completely in the course of a very few minutes, being presumably oxidized by the magnesia, the reduced magnesium being reoxidized to magnesia in the course of its passage through the charge. It is essential to the success of the operation that in the very short interval of time before the rod is destroyed a sufficient cross-section of the surrounding charge should be brought to a sufficiently conductive state, so that the magnesia thus converted may, usually under a somewhat higher impressed voltage, assume the rôle of a resistance body, as the carbon rod fails. As a rule, it is necessary to increase the impressed voltage at a rapid rate as the carbon rod disappears in order properly to maintain the load.

The resistance curve, Fig. 3, will serve to illustrate the changes occurring in a furnace during the course of a particular run, it being understood, however, that such fluctuations as are here indicated are not necessarily characteristic of the practice of the method. In the curve, the solid line represents the actual fluctuations of the resistance, and the dotted line represents a simplified expression of the changes in resistance. In the run referred to, two parallel carbon rods were used, each three-fourths inch in diameter and eighty-eight inches long, each rod consisting of two lengths joined by a sleeve midway between the electrodes. The interior length of the furnace was 94 inches, its width 30 inches, and its depth 37½ inches. The total charge, including additions during the operation, consisted of about 3,500 pounds of a commercial calcined magnesia. The initial current was 365 amperes at 50 volts, and was increased by short stages to 2,330 amperes at 109 volts at the end of four minutes. The resistance then rapidly increased over a period of about 16 minutes, during which the voltage was progressively increased so as approximately to maintain the load, the voltage after 20 minutes being 190 and the amperes 1,460. The resistance then gradually declined, subject to fluctuations, the conditions ultimately becoming approximately constant at 131 volts and 2,000 to 2,100 amperes.

It will be observed that this particular curve indicates three well-defined stages of the operation. It may be assumed that the rapid fall in resistance from A to B corresponds to the increase of conductivity of the carbon rod under the rapidly rising temperature: The following rise in resistance from B to C probably corresponds to the destruction of the rod, by oxidation: From the point C the current was carried chiefly or entirely by the magnesia, the gradual decline in resistance corresponding to the increase in cross-section of the magnesia core, by conversion of the surrounding charge, subject to fluctuations which in part at least are due to temperature changes, and in part to the presence of molten magnesia.

At the conclusion of the run, after cooling the furnace, the magnesia was found in the form of a sintered mass or pig weighing about 1,900 pounds and bedded in the unconverted portions of the charge. The latter portions being unsintered, were easily brushed off, and were immediately available, with the necessary additions, for a repetition of the operation. The pig consisted of fully shrunk material having a specific gravity of 3.547. No vestige of the carbon rod remained.

During the course of the run, the charge decreases gradually in volume, and is preferably maintained by adding further portions of magnesia as required. Such additions under ordinary conditions may amount approximately to the weight of the charge originally taken.

It is of course to be understood that the invention is not restricted to such details of a specific operation as are above given for the purpose of a clear and full explanation of the nature of the invention. The specific operating conditions will of course vary not only according to the particular oxid or oxid mixture to be converted and the temperature to which it is to be heated, but also according to the scale of operations.

For example alumina at or near the fusion point is decidedly less conductive than magnesia at or near its fusing point, so that in order to apply the method to the fusion of alumina it will be necessary to use, as compared with the operation of shrinking magnesia, either a somewhat shorter furnace or a somewhat higher voltage. The essential operating point in either case is however the same, in that the load carried in the first instance by the starting rod, must be transferred to the surrounding or adjacent conductive portions of the charge: As already explained this requires a sufficient increase in the applied electromotive force to effect the transfer before the complete failure of the connection initially established through the starting rod.

It will be observed by referring to Fig. 2 that the stationary rod is located above the horizontal axis or median line of the charge considered as a whole. This is highly desirable on account of the tendency of the conductive portions of the charge to subside, and the arrangement is such that any subsidence of the conductive portions of the mass will tend to bring such portions into the direct current path between the main terminals 4, 5.

A modified arrangement having the same general purpose in view is illustrated in Fig. 4. In this modification, 6 represents the fire-brick base of the furnace, and 7 a bottom lining of magnesia. The sides may be water-cooled metal walls. 8 is a carbon end wall faced with carbon blocks 9, and carrying the main terminal electrode 10, which may be of graphite, and is preferably capable of limited horizontal movement, sliding freely in the aperture of the end wall. 11 represents the graphite leading-in rod, to which the bus-bars 12 may be secured by means of a copper band 13. Loosely mounted upon the inner or working end of the electrode 10 is an auxiliary electrode 14, which may also be of graphite and is electrically connected to the band 13 by means of a flexible metal cable 15. The starting rod 16 is attached to or contacts with the auxiliary electrode 14 and extends to a like terminal construction at the opposite end of the furnace structure.

The operation of this furnace is essentially as described above. The length of the furnace will of course depend upon the conductivity of the oxid or oxid mixture to be converted, the furnace being somewhat shortened for the conversion of oxids of relatively low conductivity at the conversion temperature. The loose oxid or homogeneous mixture is bedded to and above the starting rod, which is kept covered throughout the initial operating stage, and until its disruption or disappearance. As soon as the starting rod has ceased to function the auxiliary electrodes may be swung out of position or removed, and the load will be assumed by the conductive portions of the charge, now forming a continuous circuit between the principal terminals, which may be advanced if necessary to establish or maintain sufficient electrical contact with the conductive core.

This operation may as stated above be applied to a wide variety of oxids and oxid mixtures, including so-called composite oxids (chromite, etc.), as well as natural oxid mixtures such as calcined bauxite. The method presents many advantages as compared with the commonly practised method of fusing such oxids in furnaces of the arc type, having a strongly localized heating zone. Among such advantages may be mentioned the following:

1. The operation is electrically far more efficient, its power requirement being only about $\frac{2}{3}$ that of an ordinary arc fusion of the same oxid.

2. The great bulk of the charge is kept free from contact with or proximity to carbon surfaces, and is hence practically free from objectionable reduction products.

3. The conversion may be carried out under strictly neutral conditions, or under oxidizing or reducing conditions as may be desired; whereas in the arc fusion as commonly practised reducing conditions are unavoidable. This renders it possible in the present operation to incorporate with the charge, consisting for example of alumina, small proportions of reducible oxids, such as oxids of chromium, cobalt, manganese or the like, whether for obtaining special color effects in the product, or for modifying the character of the grain for abrasive purposes, or for other special purposes.

4. It is possible to hold the charge for an indefinite period at the maximum or any other desired temperature; and to control in an absolute manner the rate of cooling. In this way the size and other characteristics of the crystals may be controlled at will, which is often a matter of the utmost importance, particularly in the art of preparing aluminous abrasives.

5. The method is readily and economically applicable both to small and large scale operations, and the operation in either case proceeds smoothly, quietly, and with practical freedom from dust or loss by vaporization.

The present application is a continuation in part of my prior application Serial No. 183,367, filed July 28, 1917.

I claim:

1. An electrical method of converting refractory oxids or oxid mixtures, comprising locally heating the oxid charge under conditions to establish a current path therethrough, and progressively converting fur-

ther portions of said charge by means of an electric current traversing the conductive portions thereof.

2. An electrical method of fusing alumina and similar refractory oxids or oxid mixtures, comprising locally heating an oxid charge under conditions to establish a current path therethrough, and progressively fusing further portions of said charge by means of an electric current traversing the conductive portions thereof.

3. An electrical method of converting refractory oxids or oxid mixtures, comprising locally heating the oxid charge under conditions to establish a current path therethrough above the median line of the charge, and progressively converting further portions of said charge by means of an electric current traversing the conductive portions thereof.

4. An electrical method of fusing alumina and similar refractory oxids or oxid mixtures, comprising locally heating an oxid charge under conditions to establish a current path therethrough above the median line, and progressively fusing further portions of said charge by means of an electric current traversing the conductive portions thereof.

5. An electrical method of converting refractory oxids or oxid mixtures, which consists in establishing a current path of electrically-conductive oxid in the body of a substantially non-conductive charge of the same oxid, and progressively converting said charge by means of heat developed by an electric current traversing the conductive portions thereof.

6. An electrical method of fusing alumina and similar refractory oxids and oxid mixtures, which consists in establishing a current path of electrically-conductive alumina in the body of a substantially non-conductive charge of alumina, and progressively fusing said charge by means of heat developed by an electric current traversing the conductive portions thereof.

In testimony whereof I affix my signature.

LEWIS E. SAUNDERS.