J. B. NAU.

METHOD OF REFINING MOLTEN PIG IRON.

APPLICATION FILED JAN. 18, 1911.

991,633.

Patented May 9, 1911.

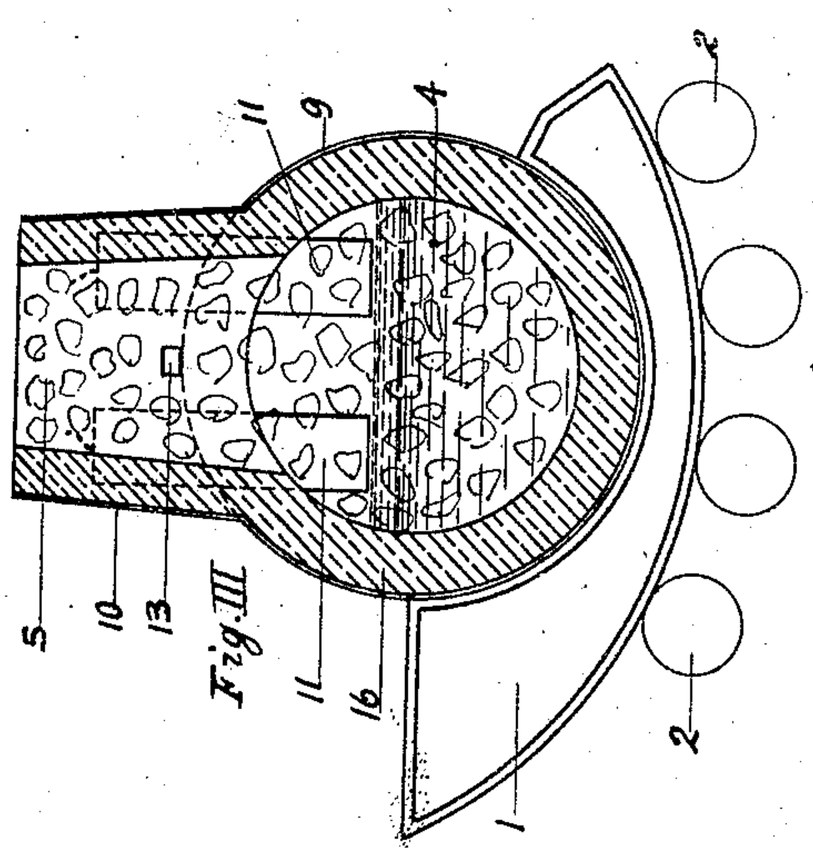

Fig. III.

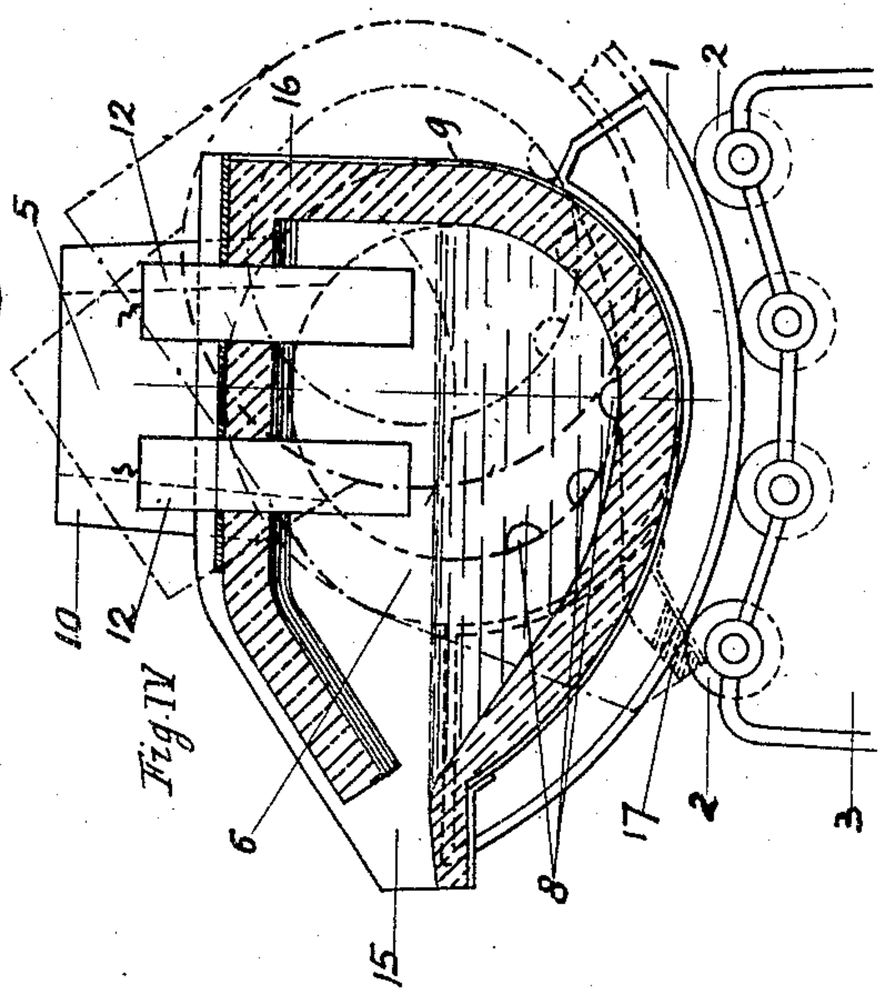

Fig. IV.

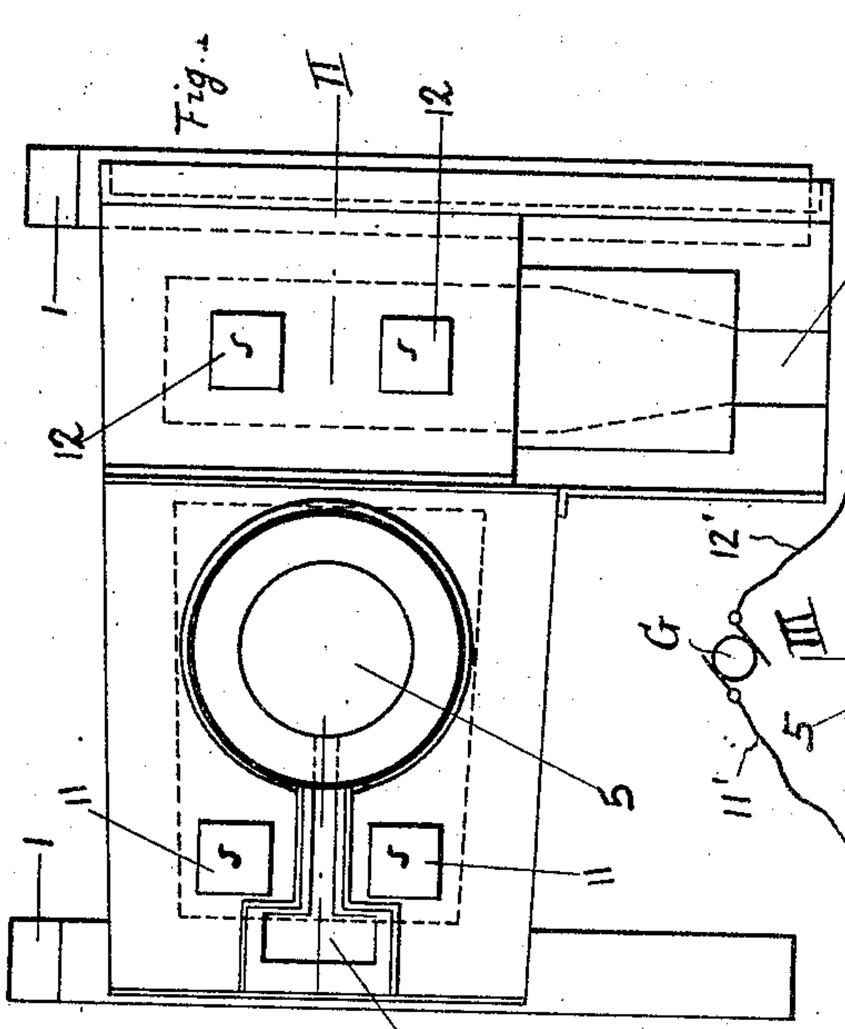

Fig. II.

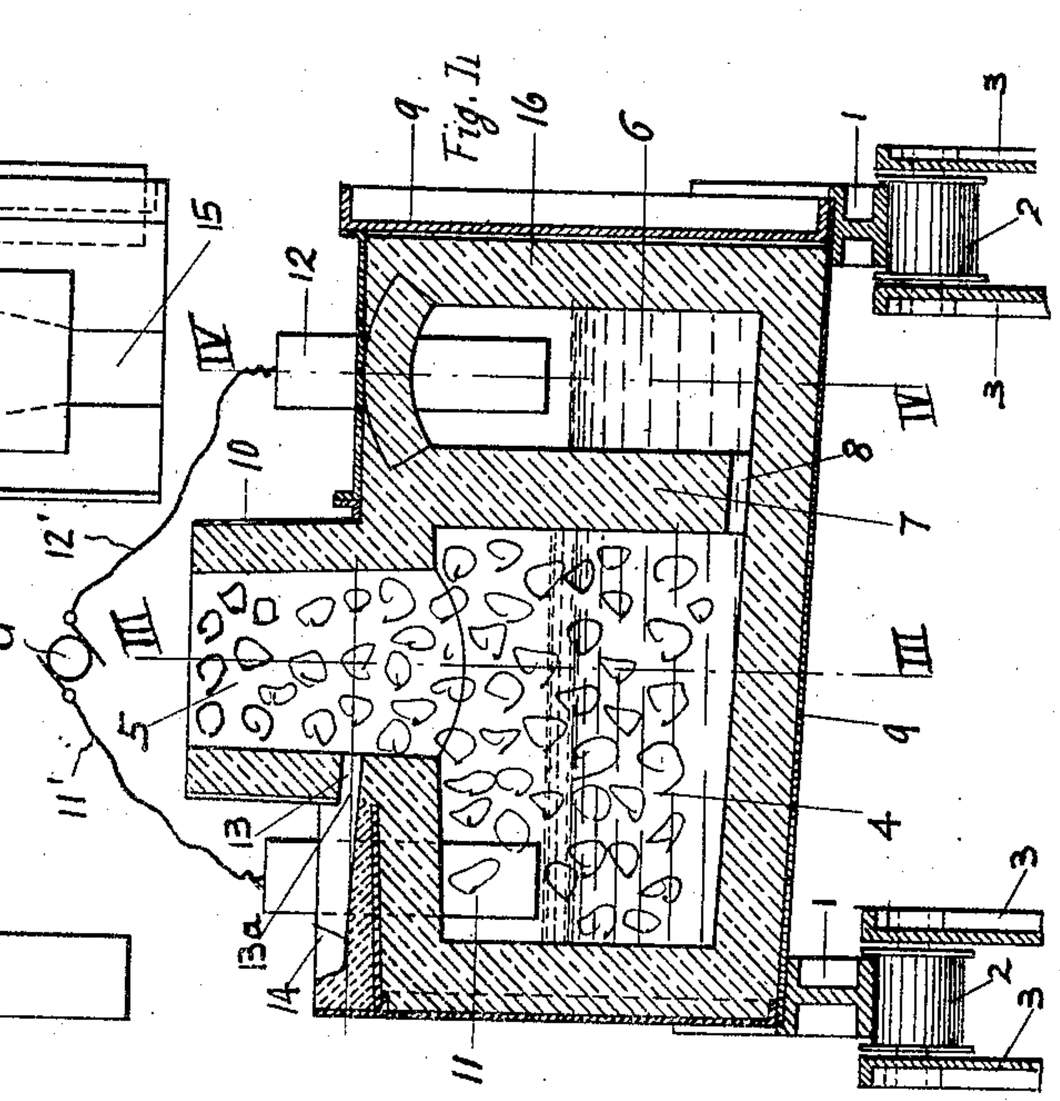

Fig. I.

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METHOD OF REFINING MOLTEN PIG-IRON.

991,633. Specification of Letters Patent. **Patented May 9, 1911.**

Application filed January 18, 1911. Serial No. 603,335.

To all whom it may concern:

Be it known that I, JOHN B. NAU, a citizen of the United States, and a resident of the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Methods of Refining Molten Pig-Iron, of which the following is a specification.

The object of my present invention is to provide methods whereby undesired elements, such for example as silicon, phosphorus, sulfur, etc., may be removed from such iron with greater certainty within a less time, and with greater economy, than heretofore. I accomplish these objects by the methods of treatment hereinafter described, the understanding of which will be facilitated by reference to the accompanying drawings showing some forms of apparatus devised by me as adapted to facilitate the practice of my said novel methods, and for which apparatus I have made application for Letters Patent, Serial No. 590,037, filed October 31, 1910.

My present invention relates particularly to the elimination, within limits, from molten pig iron of such undesired elements as above referred to by bringing the same, as contained in said iron, into the presence of and intimate contact with oxygen compounds of iron, such for example as contained in iron ore. In Letters Patent No. 786,048, granted to me March 28, 1905, I have described and claimed such processes, and likewise in my pending application, Serial No. 518,014, filed September 16, 1909. In both of these instances the refining method is practiced by aid of stationary crucibles and either a stationary fore-hearth or a stationary reservoir, these methods therefore sometimes necessitating undesired interruptions in the continuity of the process, and moreover also relatively less perfect and extended contact of the oxids with the iron, during a given time, than is attainable by my present methods hereinafter described. Moreover, in cases in which it is desirable to accumulate a very considerable body of resulting products including partially refined iron, and oxid containing slags for use in further refining operations, or other purposes, it may prove desirable to maintain the contents of the fore-hearth or reservoir, throughout their entire extent, at higher temperatures than sometimes practicable by means described in my said patent. My present methods are addressed to the satisfying of such requirements, and, in their broadest aspect, comprise the imparting during the operation, and without intermission thereof, such simultaneous movement, or oscillation, to the oxids and the metal as to promote to a higher degree than heretofore desired reactions, insure constant movement of the oxids toward the positions required, separation from the latter of the resulting refined metal and slag products and evacuation of the same from the apparatus when required without interrupting the continuity of the operation, meantime maintaining in the resulting baths required temperature.

Referring now to the drawings showing forms of apparatus adapted to the practice of my present methods, Figure I is a plan view of the apparatus; Fig. II is a cross-section on line II—II of Fig. I; Fig. III is a cross-section on line III—III of Fig. II; Fig. IV is a cross-section on line IV—IV of Fig. II.

I show in the drawings an organized apparatus which is one form of means capable of employment in the practice of my present methods and which may be designated as an electric tilting furnace comprising special features devised by me to facilitate, and insure the operation of, my process. This furnace is movably supported by means of strong circular slides 1, fastened to the lower part of the furnace frame 9, on two parallel lines of rollers 2, carried in their turn by strong supports 3, only partly shown. The tilting of the furnace is obtained by any suitable tilting device, which, owing to its style being immaterial for the understanding of my present invention, is not shown in the drawings.

The furnace proper is mainly composed of two parts, of which one is a crucible 4, which crucible may be designated as movable owing to the movability of the furnace containing same. Said crucible is surmounted by an ore-shaft 5, open on top and preferably widening below. The other part of the furnace referred to is a fore-hearth 6, separated from crucible 4 by means of partition 7 and provided with an outlet pouring spout or opening 15 or other suitable pouring device. One or more openings 8 of convenient size and located in convenient places in the partition, establish communication between crucible 4 and fore-hearth 6 for purposes

hereinafter shown. Crucible 4 and fore-hearth 6 are inclosed in walls 16 of fire-bricks or other refractory material inside the iron casing 9 of suitable shape. Ore-shaft 5 also has preferably, but not necessarily, a refractory lining inside an iron shell 10. Ore-shaft 5 is provided furthermore with a pig iron inlet 13 establishing communication between the inside of ore-shaft 5 and inlet spout 14 suitably placed where shown on top of compartment 4. The center of rotation of the furnace may be placed at any suitable height, but I consider it best to place it on or near the center line 13^a of spout 14.

The electric current necessary for heating purposes in the furnace passes through electrodes 11 and 12 and may travel from either one to the other. I have shown two sets of electrodes placed vertically of which electrodes 11 of one set enter the crucible through its top and electrodes 12 of the other set enter the fore-hearth through its roof. The number of electrodes thus placed in one compartment may thus vary from one upward. Their location also may vary provided that the relative location remains such that the electric current going from one set to the other passes through the molten contents of the two compartments 4 and 6 and of openings 8 in either direction. G indicates a source of electricity and 11′ 12′ conductors connecting same with said electrodes.

My present improved method of refining molten pig iron is practiced as follows. In any convenient suitable movable support or container as for instance the crucible 4 I support in, and above, it as shown in the drawings as by ore-shaft 5 a normally continuous therefrom upwardly extending column of refining material consisting of a pervious aggregation of independently movable pieces of substance containing oxid of iron as for instance preferably rich iron ore in solid pieces, or in the shape of concentrate ore briquets, resting upon the bottom of said crucible and piled up therefrom to any required height in said shaft. I then direct into said column of pieces of refining material a stream of molten pig iron in any convenient manner as for example by pouring said iron from the source whence derived, as for example the blast furnace, into spout 14, whence it passes through inlet 13 and is projected thence by gravity through the underlying portion of said column and into the crucible. The iron is thus caused to percolate in a number of small streams through the ore column whence it will be accumulated in the crucible in the presence of the aggregation of ore pieces contained in the latter. During and by these operations the iron will be, to an extent, mingled with and sufficiently brought into the presence of and contact with the oxids of iron contained in the substance composing said column to produce in part the to be expected reactions between the oxygen of the said oxids and the silicon, phosphorus, sulfur, etc., desired to be removed from the iron, as will be understood by those skilled in the metallurgical art. The constantly accumulating pool of resulting molten products, including partially refined iron, and slags containing oxid of iron, besides oxygen, and other, compounds of the impurities mentioned, I next segregate or strain as far as practicable from out of said pieces of substance containing oxid of iron in the crucible in any convenient manner as for instance by permitting said products to pass or flow through the openings 8 in the partition 7 and thence into the fore-hearth 6, the partition 7 thus operating to substantially confine the bulk at least of the refining material in the crucible, the comparatively few pieces of refining material which may pass into the fore-hearth 6 being either there soon reduced or proving innoxious for the purposes to which the product is to be applied, and this without interfering with the satisfactory performance and effects of the refining operations intended to take place in the crucible proper. While the foregoing operations are taking place I may, whenever and to the extent required, raise the temperature of the contents of the crucible and of the fore-hearth simultaneously to such extent as required to insure under all conditions the degree of fluidity required for the uses to which the final product is to be applied. Such raising of the temperature is, in this instance, accomplished, as will be readily understood, by causing the electric current to pass, in required degree, from the electrodes 11 to the electrodes 12, which is accomplished by turning on the current, the path of which will pass downwardly and horizontally through the molten iron and slags contained in crucible 4, thence through those contained in the holes 8 and thence horizontally and upwardly through the products contained in the fore-hearth to the cathodes 12, the resistance of the said contents thus causing generation of heat to the required extent throughout their midst.

While the foregoing operations are occurring I may impart movements to the refining material, to the iron, to the partially refined iron and to the resulting products by in this instance intermittently tilting or oscillating in alternately reverse directions and together and simultaneously the said crucible, fore-hearth and shaft and thus their respective contents. By means of the movements thus imparted I cause the direction of the streams of molten iron down-flowing through the refining material to vary their courses relatively to the latter, thus insuring at this stage better and more complete contacts between the two than heretofore, with consequent promotion of desired reactions, and

not only this but I likewise insure by the said movements the required continuous descent of the pieces of refining material through the shaft and into their position where required in the crucible which movement it will be observed is thus insured without the necessity of completely voiding the crucible. Moreover, by the said movements I am also enabled to evacuate to any desired extent the partly refined iron and slags accumulated in the crucible and in the fore-hearth. It will thus be observed that I am by my present method for the first time as I believe enabled to practice the refining desired in a substantially continuous operation and process, it being necessary only to keep up constantly the supply of unpoured molten iron and the charge of refining material in the shaft.

It will of course be understood that any convenient means may be employed for imparting to the refining materials, iron, and resultant products, and in this instance to the particular apparatus shown the required tilting or oscillating movements. It will also be understood by those skilled in the art that preliminarily to the inception of the operation it is desirable in any usual and convenient manner to preliminarily heat the apparatus as well as the refining material as for instance in this case by burning gas or other appropriate fuel through the outlet 15 after the refining material has been charged or the refining material may be preliminarily heated before charging. It will also be understood that a plurality of holes or passages 8 in the partition 7 is not absolutely essential, a single aperture of sufficient size being, owing to the construction and the aforesaid movements, competent to withdraw both the iron and the slag and segregate or strain them substantially from the main bulk of the refining material left in the crucible. It will also be understood that in cases in which the storage of the partly refined product and accompanying slags is not required, the fore-hearth 6 may be dispensed with and the substantial segregation of the said products from the bulk of the refining material and their evacuation from the crucible proper effected by eliminating the partition 7 and by regulating the aperture of the outlet 15 so as to retain within the crucible during tilting substantially the entire body of the refining material. When the apparatus is tilted or oscillated as far as to the position 17, substantially all accumulated liquid contents, including slag as well as iron, will be evacuated completely through the spout 15. This not only simplifies evacuation of the slag, but renders it possible to pour it, being of an excellent refining nature, together with the iron, and thus take both together from the refining apparatus to the open-hearth furnace or other apparatus to be used in further refining operations. Thus the slag itself becomes, by my method, a valuable product, ready to be used at once to the best advantage in its liquid state. The location of the center of the inlet 13 approximately on the axis of rotation of the apparatus 13^a renders it possible to tilt or oscillate the furnace so as to empty it completely of accumulated molten products without stopping the inflow of the metal to be treated, since, with the exception of the rotation around its center, spout 14 and inlet 13 remain stationary.

My present improved method also comprises inducing when required the descent of the refining materials toward and into the pool in which the lower portion of the aggregation of said refining materials is immersed by manipulation of the body of the pool so as to cause the same without substantial addition of molten material to alternately immerse the said lower portions of said aggregation to greater and less depths. This, as will be perceived, I am easily able to accomplish by means of the construction shown in the drawings, as for instance by tilting the apparatus toward the right sufficiently to raise the outlet 15 above its position shown in Fig. IV, which will, owing to the shape of the parts, result in quickly raising the level of the pool in the crucible 4, thereby correspondingly increasing pressure from below upon the aggregation of refining materials and also contact of the molten iron therewith, after which, by tilting the apparatus in the opposite direction, the immersion of the refining materials in the pool is quickly diminished, these movements both tending to impart impulses to the aggregation of refining materials which assist in insuring renewed contacts and also descent thereof into the crucible and to the positions therein required for most effective operation.

What I claim as new and desire to secure by Letters Patent is the following, viz:—

1. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, and intermittently oscillating together, relatively to a common center, said iron and said refining material, whereby desired reactions are promoted, descent of said refining materials insured, and segregation of refined iron and resulting products from said refining material simultaneously effected.

2. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently

movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, accumulating said stream in a pool immersing the lower part of said aggregation of refining materials, segregating said pool from the bulk of said refining material and in the meantime intermittently oscillating together, relatively to a common center, said iron and said refining material, whereby desired reactions are promoted, descent of said refining material into said pool insured, and segregations of refined iron and resulting products from said refining materials simultaneously effected.

3. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, accumulating said stream in a pool immersing the lower part of said aggregation of refining materials, passing through said pool a current of electricity, and intermittently oscillating together, relatively to a common center, said iron and said refining materials, whereby desired reactions are promoted, descent of said refining materials into said pool insured, and segregations of refined iron and resulting products from said refining materials simultaneously effected.

4. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, accumulating said stream in a pool, immersing the lower part of said aggregation of refining materials, segregating partly refined iron and resulting slag products from the bulk of said refining material and intermittently oscillating together, relatively to a common center, said iron, said refining materials and said segregated iron and resulting products, whereby desired reactions and said segregation are promoted, descent of said refining materials into said pool insured and intermittent deliveries of said partly refined iron and resulting products effected.

5. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, accumulating said stream in a pool, immersing the lower part of said aggregation of refining materials, segregating partly refined iron and resulting slag products from the bulk of said refining material, passing a current of electricity downwardly and horizontally through said pool and horizontally and upwardly through said segregated iron and resulting products, and intermittently oscillating together, relatively to a common center, said iron, said refining materials and said segregated iron and resulting products, whereby desired reactions and said segregation are promoted, descent of said refining materials into said pool insured and intermittent deliveries of said partly refined iron and resulting products effected.

6. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, intermittently accumulating said stream in a pool immersing lower portions of said aggregation, and intermittently withdrawing said pool from said aggregation whereby descent of said refining materials toward positions where required is facilitated.

7. The method of partly refining molten pig iron which comprises movably supporting a normally continuous upwardly extending pervious aggregation of independently movable units of refining material containing oxid of iron, directing into said refining materials a stream of said iron, accumulating said stream in a pool immersing lower portions of said aggregations and then without materially adding to said pool imparting thereto changes of shape whereby it is caused alternately to more or less deeply immerse said refining materials.

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Witnesses:
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