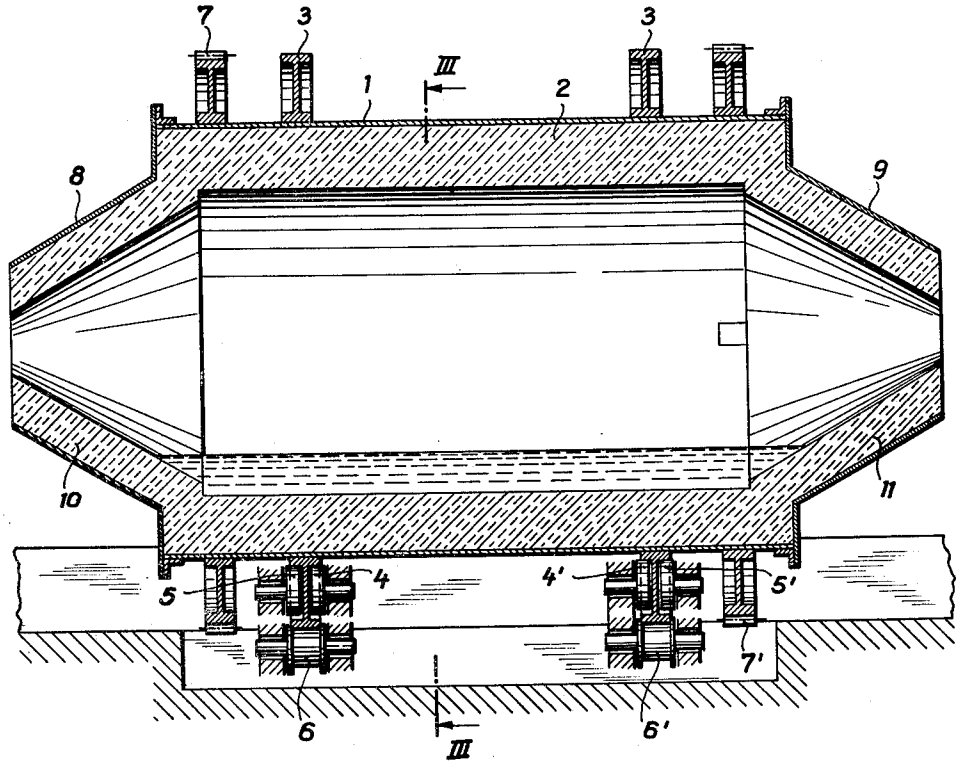
May 15, 1962 P. E. HARDT 3,034,885

METHOD OF REFINING PIG IRON AND A FINING VESSEL FOR PERFORMING THE METHOD

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Fig. 1



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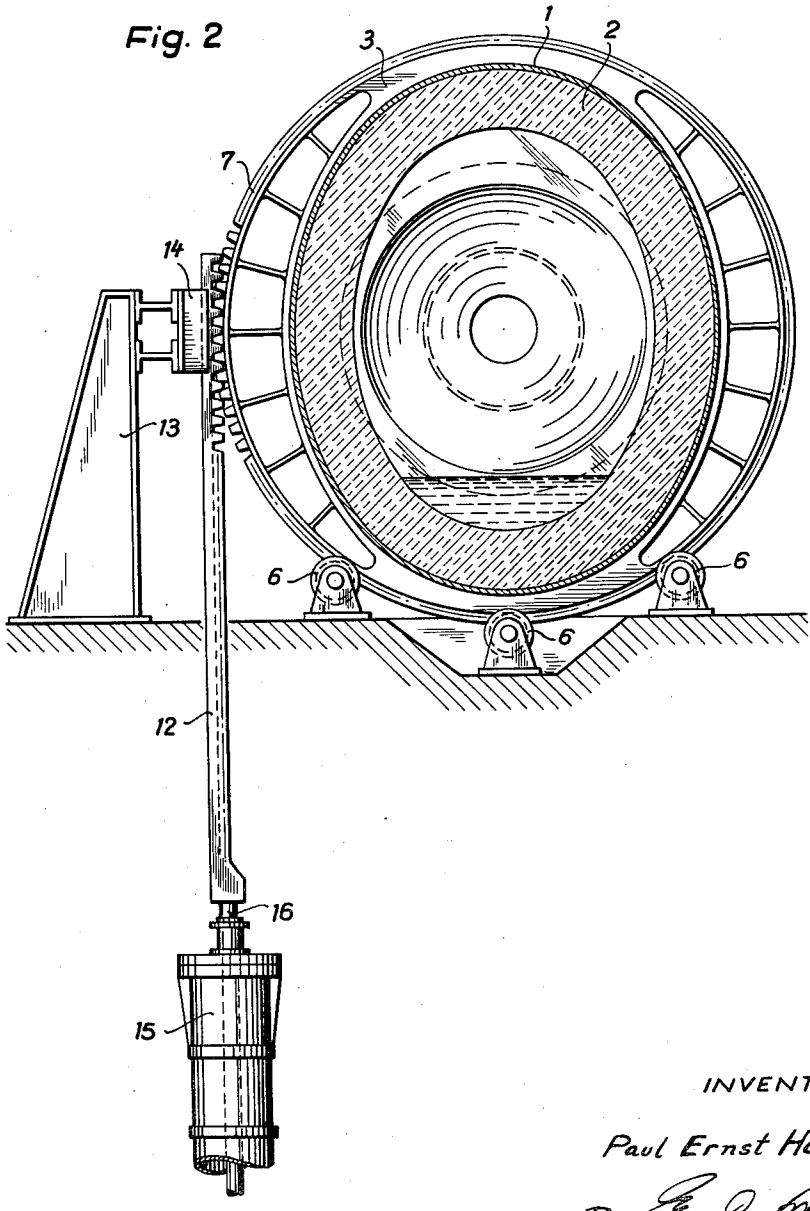
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May 15, 1962 P. E. HARDT 3,034,885

METHOD OF REFINING PIG IRON AND A FINING VESSEL FOR PERFORMING THE METHOD

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Fig. 2



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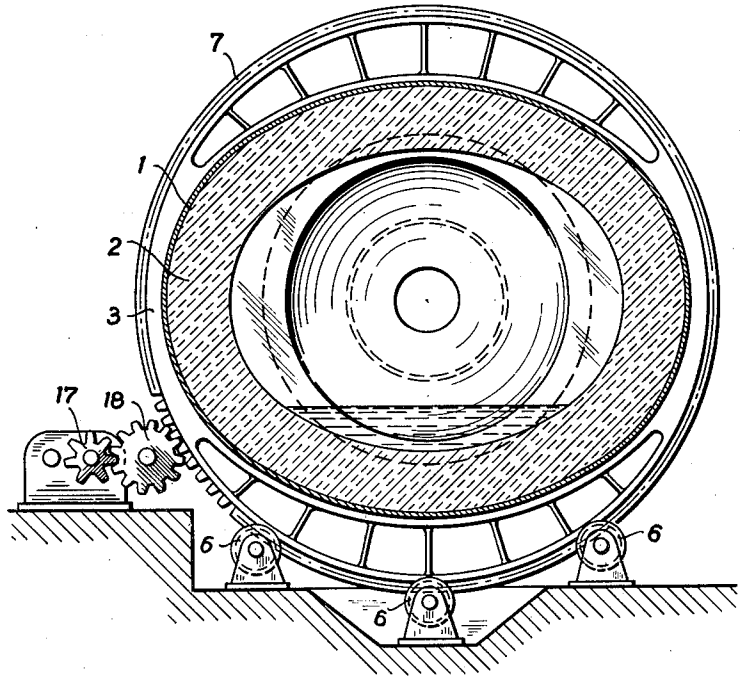
Patent Agent

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METHOD OF REFINING PIG IRON AND A FINING VESSEL FOR PERFORMING THE METHOD

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Fig. 3



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3,034,885

METHOD OF REFINING PIG IRON AND A FINING VESSEL FOR PERFORMING THE METHOD

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7 Claims. (Cl. 75—52)

The invention relates to a method of refining pig iron and to a refining vessel suitable for performing the method.

Apart from the classical blowing method performed in a stationary refining vessel, processes have been developed in recent times in which the refining vessel is rotated about its longitudinal axis whilst the blast, principally oxygen or oxygen-enriched air, is blown on to the surface of the bath. This is intended to mix the slag into the metal bath and to accelerate the course of the reaction.

However, this known procedure very incompletely achieves the intended intimate commixture of metal and slag. In actual fact, when the cylindrical vessel revolves about its horizontal axis, the position of its liquid content is not greatly affected, even if the speed of revolution is high. Merely a layer confined to a small zone adjacent the walls of the refining vessel is entrained a comparatively short distance in the direction in which the refining vessel revolves, but the bulk of the charge fails to participate in the rotary motion.

Moreover, the known process has the drawback of subjecting the refractory lining of the refining vessel to considerable wear owing to friction between the bath and the lining when the vessel rotates. This wear necessitates that the lining be frequently renewed, a circumstance which substantially affects the cost of producing the steel.

The invention proposes to employ a method of purification in a reaction vessel revolving about its horizontal axis, in which the desired result of a thorough swirling commixture of bath and slag is achieved to perfection without entailing the disadvantages inherent in the method hitherto known.

Substantially the proposed method consists in that, during the process of oxidation by blowing a jet of oxygen on to the surface of the bath, a discontinuous, preferably abrupt rocking motion is imparted to the charge contained in the refining vessel.

As a result of these rocking movements which are produced at suitably chosen intervals, slag and metal are intimately commixed and—with a consequent appreciable reduction in the time required for purification—fresh reacting surfaces are continually presented to the refining agent.

The novel method therefore retains the advantages offered by the normal blowing technique in a bottom-blown converter, without sharing its disadvantages which consist, on the one hand, in that during the oxidation of the carbon in the processing of pig iron with a high phosphorus content there can be no appreciable dephoshorization and, on the other, that during the second phase of dephosphorization there is a considerable increase in nitrogen content. According to a further development of the above described principle underlying the present invention the refining process may be further improved if the intensity of the rocking motion imparted to the bath is arranged to be different in the consecutive phases of purification in such manner that during the first phase in which as complete a dephosphorization as possible is required, but a premature oxidation of the carbon is not desired, the latter effect is

retarded by a less intense motion which may even be wholly suppressed, whereas in the second phase the desired complete combustion of the carbon is promoted by a more intense motion and a consequently more thorough commixture of slag and bath.

When blowing begins, the refining vessel preferably first remains stationary, i.e. during the first 2 to 3 minutes, with a view of achieving in this phase as rapid as possible a liquefaction of the lime or other slag-forming materials under the action of the oxidising gas blown on to the bath at a suitable angle from a nozzle disposed at an appropriate distance.

At the end of this initial phase the less intense rocking motion of the bath is begun and continued to the completion of dephosphorization, for instance to the end of 10 minutes, whereafter the rocking motion is intensified until the oxidation of the carbon reaches the point at which the desired final carbon content has been attained.

Again with the aim of slowing down the oxidation of carbon during the first phase the addition of the whole of the cooling materials (scrap or ore) is made preferably at the beginning of, and in any event at an early stage in this phase.

The rocking motion of the bath can be produced in various ways. If a cylindrical reaction vessel is used of a type known as such, then rotary motions in alternate directions through a limited peripheral angle may be imparted to such a vessel.

To distribute wear as uniformly as possible over the entire internal peripheral surface of the refining vessel, the area in contact with the bath inside the refining vessel can be extended over the entire internal surface by rotating the vessel at the end of a certain period of service in such manner that the reaction will now take place within a different peripheral zone of the vessel and thus be always performed in a part of the vessel where the lining is still in the best condition.

However, for performing the proposed method, it is preferred to use not a cylindrical vessel but a vessel of other than circular section, preferably with an elliptical section.

If a vessel of such a shape is employed, a rocking motion will be imparted to the bath both when the vessel is rotated about its axis continuously and also when the vessel is submitted to an alternating reciprocatory movement.

During the revolution of a refining vessel of the preferred shape about its horizontal axis even a very low peripheral speed will produce the desired intense commixture of slag and metal bath and the lining will be subjected to minimum wear.

A particular advantage of a refining vessel with an elliptical section is that by rotating the vessel through 90° a metal bath of greater or shallower depth and of correspondingly smaller or larger surface area can, at will, be produced. This possibility can be utilized with advantage for instance in order to provide a specially large contact area between bath and blast during the initial phase with a view of accelerating the fusion of the slag-forming substances by placing the refining vessel in a suitable angular position.

If such a refining vessel is operated by continuously rotating the same, the preferred method of performing the invention by imparting specific motions of different intensities to the bath in the vessel can be realised for instance by rotating the vessel during the first phase at a peripheral speed of about 1 metre per second, depending upon the ratio of the axes of the ellipse, and during the second phase at twice this speed and at an even faster rate.

When imparting reciprocating rocking movements to

the refining vessel the difference in the intensities of the movement can be adjusted by changing the angular speed of the motion as well as its amplitude.

A preferred form of construction of a refining vessel for performing the method according to the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 represents the refining vessel in longitudinal section,

FIG. 2 is a section taken on the line B—B in FIG. 1, showing an embodiment of the mechanism for producing the rocking motion, and

FIG. 3 is a corresponding section through a continuously revolving refining vessel.

The refining vessel illustrated in FIG. 1 has an elliptical cross section and consists of an appropriately shaped envelope **1** with a lining **2**. The vessel is supported in rings **3** which embrace the envelope but which are of completely circular shape and are adapted to run on stationary rollers **4**, **5** and **6**, and **4'**, **5'** and **6'** respectively (FIG. 1) when the vessel revolves.

Rotary motion is imparted to the refining vessel by means of pinions (not shown) engaging gear rings **7** and **7'** which embrace the vessel as shown in FIG. 2.

The two ends of the refining vessel terminate in conically tapering extensions **8** and **9** which are provided with a refractory lining **10** and **11**, respectively, in the same way as the main body of the vessel.

The elliptical cross section of the refining vessel will be readily seen by reference to FIG. 2 which also shows an illustrative example of drive means for imparting a rocking motion to the vessel. This arrangement comprises a rack **12** sliding in a stationary block **13** and engaging the gear ring **7** which surrounds the refining vessel. This rack is moved up and down in abrupt jerky movements by the piston rod **16** of a hydraulic cylinder **15**, which is only partly shown, and the refining vessel is thus rocked to and fro in conformity with a suitably regulated cycle and within an appropriately chosen angle.

According to whether the major or minor axis of the ellipse of the refining vessel is vertical, the surface area of the bath will be a maximum or a minimum, as will be readily appreciated by reference to FIG. 2.

The form of construction shown in FIG. 3 of a refining vessel which is continuously rotated in operation differs from the previously described vessel only in the type of the driving gear which, instead of a rack **12**, comprises a pinion for engagement of gear ring **7**, the pinion being driven through a gearing **9** by an electric motor (not shown).

It will be readily understood that the elliptical section of the refining vessel can be adapted to circumstances, in other words that the lengths of the major and minor axes can be arbitrarily chosen within very wide limits.

An example of the manner in which the novel method may be performed will now be described with reference to the employment of a revolving elliptical refining vessel as illustrated in FIG. 2.

The vessel was charged with a pig iron containing (by weight):

	Percent
Si	0.37
Mn	0.55
P	1.64
S	0.045
N	0.0075
C	3.85

The entire charge of lime was introduced into the refining vessel at the same time as the pig iron. The vessel first remained stationary whilst pure oxygen was blown obliquely on to the bath from a nozzle introduced through one of the open ends of the vessel, until the lime partly liquefied. At the end of 2 to 3 minutes' blowing, rotation of the refining vessel began at a peripheral speed of about 1 metre per second and this speed was maintained for about 2 to 3 minutes until all the lime had become molten. The cooling scrap was introduced after about 5 minutes' blowing (including the first 2 to 3 minutes' blowing during which the vessel was stationary). At the end of this period the phosphorus content of the iron had dropped to less than 0.6%, whereas the carbon content was still over 3% and thus nearly at the original level.

At the end of a total of 10.5 minutes' blowing, whilst rotation of the refining vessel had been uniformly continued, dephosphorisation had proceeded and the content was 0.017% P, whereas carbon content had still not been very substantially reduced and remained at 2.28%.

At the end of 13 minutes, the phosphorus content had dropped to 0.007% and carbon content to 1.18%.

The speed of revolution of the refining vessel was then raised to nearly twice the former speed and this higher speed was maintained for 2 minutes. During this short final phase the carbon content fell to the level desired in the example, namely 0.05%. The nitrogen content at this stage was 0.003%.

This method of operation can be varied in diverse ways according to the final composition of the steel that is required.

If a high degree of decarburization is not essential, for instance in the production of preliminary metal, the final phase may be appropriately briefer.

If desired, namely for the purpose of producing a steel with a comparatively high content of carbon, it is also possible to operate, without modifying the plant, in such manner that the carbon and phosphorus contents will be reduced systematically at the same time. This merely calls for an intensification of the specific motion during the first phase and a later introduction of the cooling material, possibly omitting the second phase altogether though the total blowing time will always be less than that required in known refining methods.

The oxygen content of the finished steel is lower than that of open hearth steel of similar carbon content. The degree of desulphurisation is always between 60 and 85%.

It will be readily understood that for the purpose of improving the quality of the slag and of the steel or preliminary metal the conventional procedure of slag change can be adopted.

I claim:

1. In a method of refining pig iron in a horizontal refining vessel having a chamber of non-circular cross section by blowing oxygen on the iron bath in said vessel, in combination therewith, the improvement comprising the steps of: rotating said vessel throughout a first phase of the refining operation during which dephosphorization takes place, at a rate which inhibits decarburization of the iron bath; and thereafter, throughout a subsequent phase of the refining operation, rotating said vessel at a substantially higher rate which promotes decarburization of the iron bath.

2. The improvement defined in claim 1 wherein said substantially higher rate during said subsequent phase is approximately twice the rate during said first phase.

3. In a method according to claim 1, said pig iron bath with the addition of slag-forming substances being charged into said vessel and then treated therein by blowing said oxygen on said bath, while said vessel is standing still, until said slag-forming substances are partially fused in said bath, then subjecting said bath to said first phase rotation and adding cooling material to said bath and, after a substantial dephosphorization of said bath has taken place under the action of said oxygen blown on said bath, subjecting said bath to said subsequent phase rotation.

4. In a method according to claim 1 for the production of steel having a relatively high carbon content, the step of adding cooling material at the beginning of said subsequent phase.

5. In a method according to claim 1 wherein said vessel,

if the lining of its chamber is worn through at a certain zone during preceding operations, is turned prior to the start of the refining operation to such a position that said bath is primarily supported by a not-worn zone of said lining.

6. In a method according to claim 1, wherein said vessel chamber has an elliptical cross section and wherein slag-forming substances are added to said bath in said vessel, the steps of turning said vessel to such position that said bath provides a maximum surface area on its top, of blowing said oxygen thereon, while said vessel is standing still in said position until said slag-forming substances are at least partially fused in said bath, and then subjecting said bath to said first phase and subsequent phase rotations.

7. In a method of refining pig iron in a horizontal refining vessel having a chamber of elliptical cross section by blowing oxygen on the iron bath in said vessel, in combination therewith, the improvement comprising the steps of: rotating said vessel throughout a first phase of the refining operation during which dephosphorization takes place, at a rate which inhibits decarburization of the iron bath; and thereafter, throughout a subsequent phase of the refining operation, rotating said vessel at a substantially higher rate which promotes decarburization of the iron bath.

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