July 28, 1931. A. LANGER 1,815,946

EXTRACTING OF IRON

Filed April 6, 1929

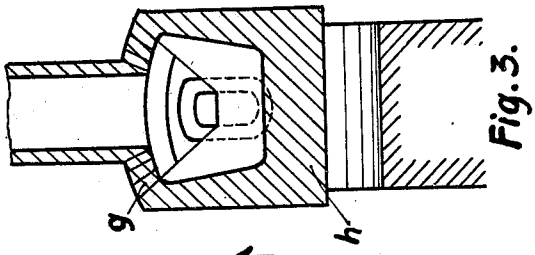


Fig. 3.

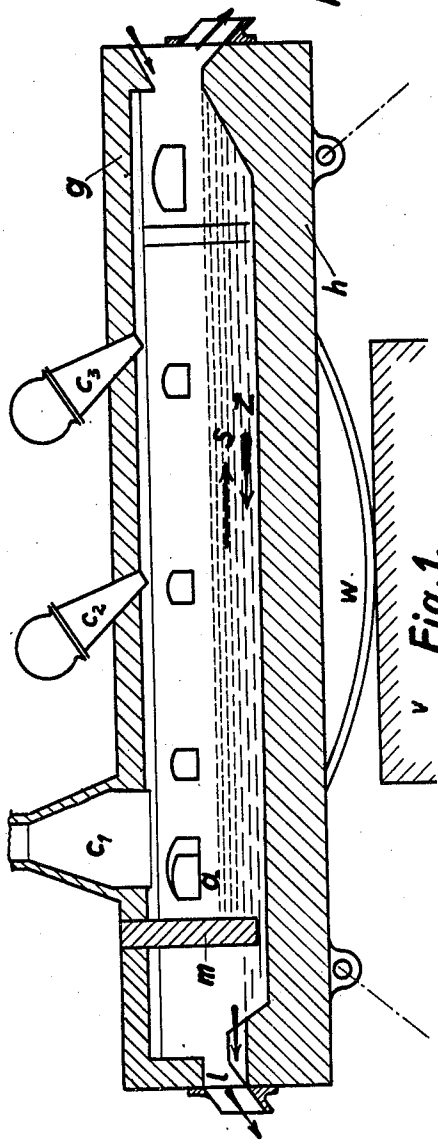


Fig. 1.

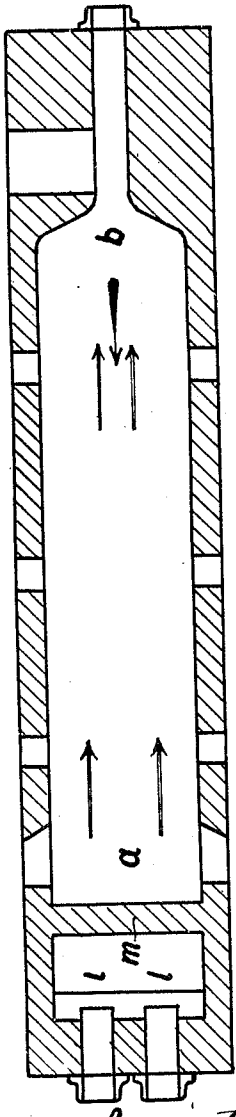


Fig. 2.

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UNITED STATES PATENT OFFICE

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EXTRACTING OF IRON

Application filed April 6, 1929, Serial No. 353,000, and in Austria April 19, 1928.

Applications for this patent were filed in Austria on the 19th April, 1928, and in Germany on November 5, 1928.

The present invention relates to the extracting of iron from its ores and to a process and apparatus therefor.

Numerous processes for the direct extraction of iron from its ores are known. One group of known processes is constituted by the processes employed in blast furnaces and revolving pipe furnaces. These latter are, it is true, generally worked continuously, but the raw materials acting upon one another, particularly the initial raw material, the desired final product, and the slag which separates, all move together and only in the same direction during the reaction.

A second group is constituted by the hearth processes which do not, however, in general even work continuously but run intermittently, i. e. in steps consisting of individual separate distinct melts or operations leading from the starting condition to the end product. To this group belong also those partially direct iron extraction processes which take place in refining processes, i. e. when the limited capability of reduction of the pig iron is utilized for acting on ores. In these known hearth and draught refining processes the operation is not carried out as a continuous reaction, and the materials which are intended to act upon one another only remain adjacent to one another without any continuous counter current motion taking place. This principal characteristic feature of the known processes is not altered even if the slag or the metal bath in individual charges is partly drawn off.

The characteristic feature of all the processes coming into consideration for comparison with the present process is thus the lack of counter current or of continuity of the process, or both. In these known processes all the raw materials are introduced at the same time and they pass through all the reactions and working phases at the same time and in the same manner. In the hearth processes the materials are introduced before the melting operation takes place, and the products are drawn off after the operation. The operations take place intermittently (i. e. in charges). The ore, metal bath and slag separate, it is true, into layers on account of the difference in their specific gravity; but the contact of these materials with one another takes place along stationary surfaces of uniform unaltering nature. The course of the reaction therefore also takes place uniformly along the whole contact surfaces and causes a weakening of the reactive power of all the components in the same manner. As a consequence of this weakening, the reactions are slowed up since the action no longer takes place with the initially operating reactive power. The lack of continuous movement impairs the necessary intimate contact. Furthermore, a layer of weakened products (products which have reacted to the fullest extent) is formed between the substances which are acting upon one another, which layer owing to the absence of any controlled movement cannot be removed and which constitutes an insulating layer. Even when movement is caused by ebullition movement an undesirable weakening of the reactive power takes place.

The attempt has been made partly to eliminate these drawbacks of the stationary baths or the baths which do not flow before and during the reaction in the known processes by the employment of a wasteful excess of the raw materials and by means of superheating. In this way ebullition eddies are, it is true, produced and the contact between the reacting substances is consequently to some extent improved, but the weakening of the action owing to the diminution in reactive power of the products of the reactions cannot be prevented inasmuch as no regulated removal of the same from the reaction zones takes place.

Moreover, the furnace is, as is well known, very sensitive to super-temperatures, and the changes of temperature associated with the intermittent process also cause more rapid wear of the furnace walls. The above enumerated disadvantages of the known continuous flow processes or intermittent processes are eliminated according to the invention by means of a continuous process wherein the materials acting upon one another flow on the

counter current principle. The said materials, namely the ore reduction mixture and the iron bath flow both before and during the reactions in thin layers in opposite directions and are brought by means of the counter current action into constantly changing direct contact with one another. During this operation waste slags tending to act as insulators or weaken the reactions are removed in the direction of discharge so that they cannot do harm.

The introduction of the raw materials into the furnace may take place with the said materials either in the liquid or solid state. In order, however, to cause the prescribed flowing motion, a bath of the nature of the product which it is desired to obtain is poured in, on which bath the desired initial reactions then take place immediately at the appropriate temperature.

A preferred method and apparatus for carrying out the invention is illustrated by way of example on the accompanying drawing, in which:

Fig. 1 is a longitudinal section through a furnace for carrying out the process,

Fig. 2 is a corresponding horizontal section, and

Fig. 3 is a cross section.

The general shape of the furnace in the constructional example shown is elongated, and it is provided with a closed hearth space having a hearth *h* and an arch *g*. The ore together with reducing means, for instance, coal and those additions, which cannot be added later, is introduced at *a*. This can be effected from above or from the side. The slag baffle *m* or a depressed portion of the arch ensures that the slag is discharged on the surface of the bath in the direction running towards *b*. The iron bath which is introduced at *b* moves in the opposite direction Z and runs off at *l* (iron discharge outlet). During the counter current movement on the hearth, the ore floating on the metal bath is reduced by the reducing means which is mixed with it. The ore gradually passes over in its direction of movement into slag which is poorer and poorer in metal content. Fresh reduction means may be added on the way in order to increase the reactive capacity of the latter.

The necessary gas and other fuel is supplied by means of a suitable number of burners *c*1, *c*2, *c*3 from the arch or from the furnace walls. By the employment of several burners for the supply of the gas and fuel the possibility is provided of adapting the temperature and chemical nature to the course of the particular reaction taking place at any given place. Thus, for example, a higher excess of carbon or carbon monoxide may be supplied to the burner *c*1 lying near to *a*. CO is then produced by the roasting of the $FeCO_3$, without having to take up oxygen from the combustion air, and it is thus possible to work with concentrated gases owing to the reduced proportion of nitrogen present. The reactions

$$CO_2 + C \leftrightarrows 2CO$$

are reversible. The reaction $2CO = CO_2 + C$ is strongly exothermic, i. e. takes place with excess of heat given out, and therefore is very important on account of its rendering possible the FeO reduction during the gas phase in the excess heat, and also by means of the carbon formed by the reaction of the CO. This exothermic reaction takes place very violently and causes in blast furnaces the throwing out of the charge and sometimes even explosions, which with the large charges used in blast furnaces may become dangerous.

In the interior of blast furnaces these occurrences, which can only be controlled with difficulty from outside, can only be regulated intermittently after the lapse of some hours. These disadvantages, are however avoided if the reactions take place in thin layers over a considerable length and under the action of freely flowing columns of gas which can be rapidly altered in their chemical constitution. The course of the reactions can, in this case, be controlled immediately by the velocity of flow, the volume of the furnace contents (i. e. the quantity of material in the bath) and the nature of the gas. The reactions can thus be accelerated or retarded. This means of controlling and adjusting the reactions is lacking in all the known blast furnaces and hearth furnaces, because these latter work without the increased forced flow, which forms one of the principal features of the present invention. Through the oxidizing action of the ore at *a* the iron bath flowing thereunder in a thin layer is also thoroughly refined and can be finished after the tapping off of the iron at *l*. For this purpose the hearth space between *m* and *l* may, for example, be correspondingly constructed. In this case, for the better separation of the reactions a part of the ore may be introduced even without reducing means, closer to *m* (i. e. in the direction of discharge of the iron), whilst the reducing means can be introduced at the opposite place, i. e. closer to the reduction zone.

By means of this kind of sub-division of the reactions the end product may also be varied. By using strong refining action, soft easily fusible steel may be produced, but by charging with carbon up to the pig iron stage, harder qualities may likewise be produced, particularly such kinds of pig iron, for the production of which in the blast furnace high temperatures and high expenditure of fuel are necessary, for the reason that the known blast furnace process does not render possible any counter current movement of the materials composing the charge.

A part of the iron bath withdrawn at *l* may with or without alteration of the heat content and carbon charge be poured in

again at *b* or in the hearth, in order to increase the velocity of flow and to accelerate the reactions in the reacting components moving thereon. It is also possible in the employment of several furnace hearths side by side or behind one another to employ again the products withdrawn in the end or intermediate phases, such as iron and slag after the changing-over of the hearth, in order, on the one hand, to utilize still reactive chemical substances, and on the other hand to utilize their cooling action and for operating at definite places for the purpose of varying the course of the reaction.

In order to bring the metal flowing up from *b* into intimate contact with the slag flowing off towards *b*, for the purpose of interchange, a furnace hearth which is narrowed towards the slag discharge outlet may be employed.

As reactions are founded particularly on the intimate contact of the different materials, the acceleration of movement and velocity of flow may be increased by altering the position of the furnace hearth e. g. by inclining same in direction of its longitudinal axis.

Preferably the balancing roller *w* will be provided of such a shape that its point of contact with the sole-plate *v* is, in any position, situated in the axis of gravity of the furnace hearth.

I claim:

1. A process for the direct extraction of iron from its ores by the action of reducing agents on a flowing bath of iron, comprising the passing of the ore reduction mixture and the iron bath in an accelerated counter current over the whole length of the hearth both before and during the formation of iron.

2. A process for the direct extraction of iron from its ores by the action of reducing agents on a flowing bath of iron, comprising the passing of the ore reduction mixture and the iron bath each in a thin stream in an accelerated counter current over the whole length of the hearth both before and during the formation of iron.

3. A process for the direct extraction of iron from its ores by the action of reducing agents on a flowing bath of iron, comprising the passing of the ore reduction mixture and the iron bath in an accelerated counter current over the whole length of the hearth both before and during the formation of iron and repeatedly adding a part of the iron bath drawn off therefrom to the bath flowing on the hearth, whereby the velocity of flow through the furnace is increased and the reaction is accelerated.

4. A process for the direct extraction of iron from its ores by the action of reducing agents on a flowing bath of iron, comprising the passing of the ore reduction mixture and the iron bath in an accelerated counter current over the whole length of the hearth both before and during the formation of the iron and the introduction of heating gases of different composition or temperature from a number of burners above the hearth, whereby differently operating gas zones are formed in such manner that different phases of the process can be carried out directly one after the other on the same hearth.

Signed at Vienna, Austria, this 25th day of March, 1929.

ARTHUR LANGER, INGENIEUR.