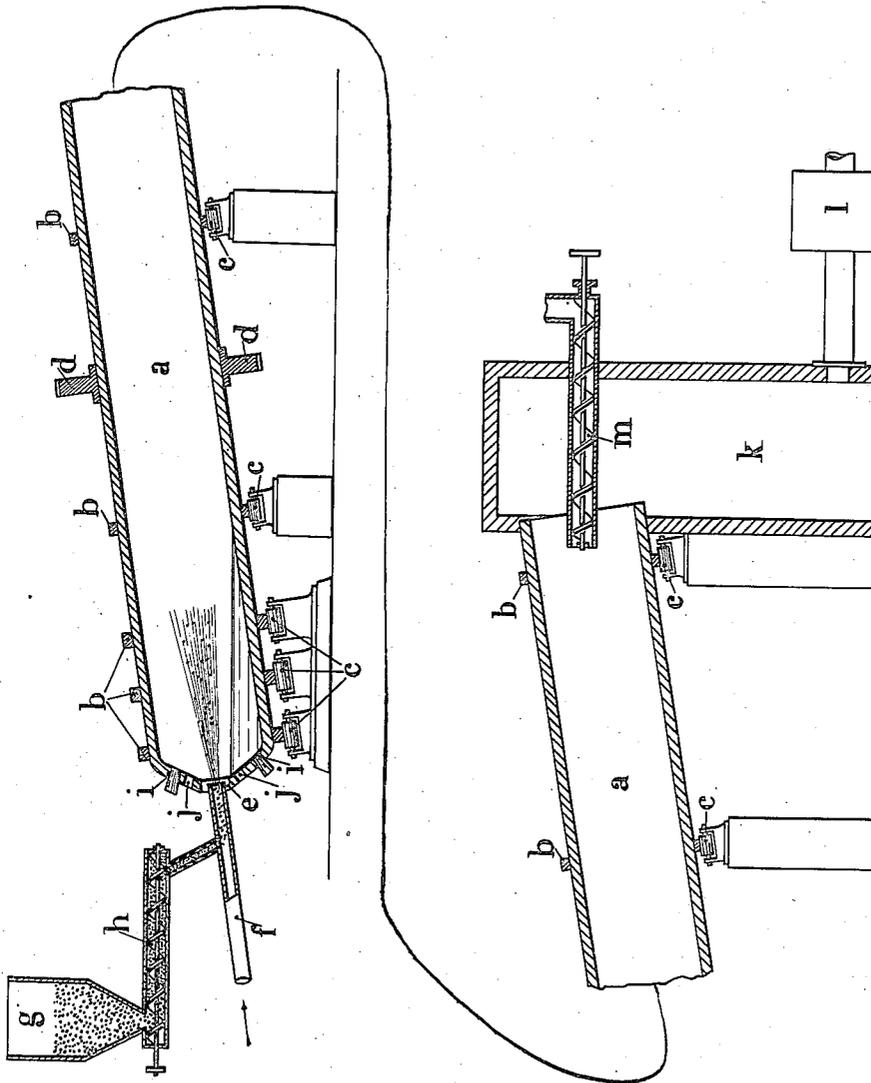


L. P. BASSET,
PROCESS FOR THE DIRECT MANUFACTURE OF IRON AND STEEL,
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Inventor
L. P. Basset,
By Marks Clerk
Attys.

UNITED STATES PATENT OFFICE.

LUCIEN PAUL BASSET, OF PARIS, FRANCE.

PROCESS FOR THE DIRECT MANUFACTURE OF IRON AND STEEL.

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To all whom it may concern:

Be it known that I, LUCIEN PAUL BASSET, of Paris, France, have invented a certain new and useful Process for the Direct Manufacture of Iron and Steel (for which I have filed applications in France Feb. 24, 1920; Belgium May 1, 1920 and Luxemburg April 28, 1920), of which the following is a specification.

In the manufacture of cast-iron in the blast furnace by the ordinary well known processes, it is not possible to obtain a product free from foreign metals and impurities.

Various foreign bodies are present, capable of being absorbed by the metal. These bodies have different properties relatively to the burden, and it is possible, by giving to the slag a predetermined composition, to prevent the absorption by the metal of one body or of a group of bodies having some one or more common reactions. But such regulation of the slag has no effect on the action of other impurities or groups of impurities present. Hence in the manufacture of cast-iron, many of the impurities can be gotten rid of, only by removal from the iron, by a subsequent operation, (refining operation).

Thus, it is not possible, by the usual metallurgical processes heretofore known, to directly obtain a metal both desulfurized and dephosphorized, as, in these processes, the desulfurization and dephosphorization are two rather dissimilar operations, requiring different conditions; the first being a deoxidizing, (reducing) operation and the second an oxidizing operation.

Generally, a metal is required from the blast-furnace practically free from phosphorus. For that purpose, by the addition to the ore of calcareous fluxes, a basic line slag is produced which combines with the sulfur to form calcium sulfid. This calcareous slag being difficultly fusible, it is necessary, for causing it to melt, to operate at a high temperature, but, at this high temperature, the coal mixed with the ore, acting as the heating agent as well as the reduction agent, strongly reacts with all of the elements of the burden, which, apart from lime and alumina, are thus partially or entirely reduced; it therefore, follows that the metal produced, contains as impurities, silicon, manganese, phosphorus, etc. At this very high temperature, the slag is nearly completely free from oxide of

iron; in fact, the latter, which is the most easily reducible of the oxides present, is the first to be reduced to metal, and hence eliminated from the slag.

For preventing the reduction of silica, manganese compounds and phosphate of lime, it would be necessary to operate at a lower temperature and consequently, to provide a more easily fusible slag, containing oxide of iron, but such a slag would be more highly siliceous than that above referred to, and accordingly, would not have so good desulfurizing properties.

It will, therefore, be seen that the desulfurizing and dephosphorizing operations cannot be carried out together in the blast furnace, owing to the fact that the coal acts at the same time as fuel and as reducing agent, and it is not possible to separate these two functions.

My present invention has for its object a process of directly producing iron and steel, which will produce these metals in a form in which they can be directly used, that is to say, practically free from sulfur and phosphorus.

This process consists, substantially:

(a) In heating in a furnace a mixture of ore and iron, coal and basic fluxes, if necessary, by means of a flame produced by the combustion of either coal pulverized to the condition of flour (i. e. in the form of an impalpable powder) or of a finely pulverized hydrocarbon, such fuel being burned in preheated air in carefully regulated proportions, whereby this combustion gives practically only carbon monoxide;

(b) In regulating the reducing conditions in the furnace, so that the basic calcareous slag may contain a small quantity of oxide of iron, proportional to the quantity of phosphorus contained in the ore and inversely proportional to the calcic-basicity of the slag.

In this process, the small quantity of oxide of iron left in the basic slag, checks the phosphoration of the metal, the reduction of silica and of manganese oxide, while maintaining the desulfurizing function of the calcareous slag.

Besides, the heating and reducing operations, contrarily to what takes place with the ordinary processes in the blast furnace, are kept distinct from each other, and it is easy to modify the working of one of these operations without modifying the other.

By means of the present process, the sulfur and phosphorus, (present as impurities in the ore), are fixed and taken up by the slag, before they can be absorbed by the metal, and as this fixation of the sulfur and phosphorus is produced at the same time as the production of the free metal, the production of the latter in a pure state, is not delayed by a subsequent refining operation, such operation being unnecessary.

In order that the invention may be clearly understood, I will describe, by way of example, a method for carrying out the present process in a rotary furnace constituted as diagrammatically illustrated in the accompanying drawing which shows the furnace in longitudinal sectional view in two separated sections.

As shown in the drawing, this furnace comprises an inclined rotary cylindrical furnace *a* of great length, (for instance, a length of 50 meters and a diameter of 2.5 meters). This cylinder has an internal refractory lining and external rings *b* running on rollers. A toothed gear *d* imparts a rotary motion to the furnace *a*.

At the lower end of the furnace *a* is provided an orifice *e* through which enters a nozzle *f*; through the latter are injected hot air and pulverized coal in the form of an impalpable powder; the coal coming from a hopper *g* is regularly discharged by a feed screw *h* of regulated speed, so that the supply of coal may be carefully regulated to give the necessary proportion for causing the combustion of this coal in the cylindrical body *a* to produce practically only carbon monoxide.

The air injected by the nozzle *f* is previously heated in a heat exchanger operated by a portion of the combustible gases issuing from the furnace.

The furnace *a* is provided, at its lower end with tap holes *i*, *j*, the tap holes *i* being arranged near the periphery of the furnace *a* and the tap holes *j* nearer the axis of the latter. The tap holes *i*, for the metal, are normally closed but are opened periodically; the tap holes *j*, for the slag, remain always open.

If it is desired to continuously tap small quantities, one of the tap holes *i* will be left permanently open; both metal and slag being tapped at each revolution, when this tap hole is at low points of its revolution.

At its other end, the furnace *a* opens into a brick-work chamber *k* for receiving the combustible gases. These gases are sent by a fan *l* to points of use, a part being burned for heating the air to be injected by the nozzle *f*.

The iron ore to be treated, mixed with fluxes and with the quantity of coal just short of the proportion sufficient for the complete reduction of this ore, is fed in at

the upper end of the furnace by a feed screw *m* or other suitable device.

The operation is conducted in the following manner:

The furnace is first heated up by means of fagots introduced at the lower end of the furnace. When the wood is well burning, air is gently blown in and the screw *h* is put in motion; fine coal is blown by the nozzle into the furnace *a* and is ignited by coming in contact with the burning wood. The temperature of the furnace rises and when it attains cherry red the coal continues to burn alone. When the lower end of the furnace *a* is at white heat, the operator ascertains if the proportions of air and coal are suitable for giving only carbon monoxide. If this is not the case, these proportions are adjusted to give this condition. Then, by means of the screw *m* the iron ore is introduced into the furnace; the iron ore is preferably finely crushed and is mixed with suitable fluxes for obtaining a calcareous slag and with the quantity of coal necessary for effecting the reduction of about 95% of the iron oxid in ore.

As previously stated, the quantity of iron oxid which is to be left in the slag, will be proportional to the content of phosphorus in the ore and reversely proportional to the lime in the slag. Generally, an ordinary basic calcareous slag containing 5% of iron oxid is amply sufficient for dephosphorizing the ores.

Under the effect of the inclination and rotation of the furnace, the mixture regularly advances towards the hearth and is heated, the iron oxid is reduced in the proportion of 95% and the slag is formed, taking away with it the 5% of iron oxid which have not been reduced, the metal melts in the hottest zone and the metal and slag are tapped as above described.

In the present process, the only object of the flame is to heat. This flame gives essentially a mixture of nitrogen, carbon monoxid and of the hydrogen contained in the coal, and hence cannot exert any oxidizing action on the metal produced and it exercises only a small part of the reduction of the iron ore.

The reduction is therefore effected substantially entirely by the coal mixed with the ore. It is therefore possible, by modifying the proportion of this coal, to vary the percentage of the iron oxid, which will be reduced, and hence the non-reduced fraction which goes into the slag.

This slag, containing a small and readily controllable proportion of iron oxid, prevents by its oxidizing function, the phosphoration of the metal, the reduction of silica and oxide of manganese and, by its basic function, the sulfuration of the metal.

Moreover, in the present process, the tendency to sulfuration is much less in the blast

furnace process, since the sulfur comes from the fuel and the quantity of coal used as fuel, in the present process, is about 30% of the weight of the steel produced, while in the blast furnace process one ton of coal per ton of steel is the usual ratio.

The small proportion of iron oxid, which must be contained in the slag, may also be obtained by the following process:

10 With the ore is mixed a quantity of coal sufficient for effecting complete reduction of this ore, the whole of the ore is thus reduced to the metallic state, then a small quantity of metallic iron is re-oxidized, so as to provide in the slag the required small quantity of iron oxid. For that purpose a small excess of air is supplied to the hearth relatively to the coal projected by the nozzle, the flame produced by the combustion of this coal, will then contain a small proportion of carbon dioxid and water vapor; both of which are powerful oxidizing agents for iron at the temperature of the furnace, and they will accordingly re-oxidize a small portion of the metallic iron produced.

It is thus possible, by a judicious regulation of this additional air, to limit the reducing action of the coal mixed with the ore and to leave the desired quantity of iron oxid in the slag.

The use of a rotary furnace has been indicated above as a preferred means for carrying out the present process, but it is to be understood that the latter can be carried into practice in other types of furnaces.

The process forming the subject-matter of this invention permits the direct production of iron and steel. If it is desired to obtain semi-hard or hard steel, that is to say, richer in carbon, the desired excess of coal can be added with the ore, or better still, coal or cast iron can be added in the required quantity in the ladle.

I claim:—

1. A process of producing refined iron and steel direct which comprises heating a mixture containing iron ore and a solid carbonaceous reducing agent, by means of a flame free from substantial amounts of carbon dioxid and water vapor, in the continued presence of a basic slag containing a small amount of iron oxid, whereby said slag prevents reduction of phosphorus, silicon and manganese compounds and the passage of these elements into iron, and

also prevents the passage of sulfur into the metal.

2. A process of producing refined iron and steel direct which comprises heating a mixture containing iron ore, lime, and a solid carbonaceous reducing agent, by means of a flame free from substantial amounts of carbon dioxid and water vapor, in the continued presence of a basic slag containing a small amount of iron oxid, whereby said slag prevents reduction of phosphorus, silicon and manganese compounds and the passage of these elements into iron, and also prevents the passage of sulfur into the metal.

3. A process of producing refined iron and steel direct which comprises heating a mixture containing iron ore, lime, and a solid carbonaceous reducing agent, by means of a flame free from substantial amounts of carbon dioxid and water vapor, agitating and progressing the charge toward said flame, during such heating operation, in the continued presence of a basic slag containing a small amount of iron oxid, whereby said slag prevents reduction of phosphorus, silicon and manganese compounds and the passage of these elements into iron, and also prevents the passage of sulfur into the metal.

4. In the process of claim 1, the improvement which comprises heating said charge by the combustion of finely comminuted solid carbonaceous fuel, in a blast of pre-heated air, the relative proportions of these being so adjusted as to produce substantially only carbon monoxid, to the substantial exclusion of carbon dioxid and water vapor.

5. In the process of claim 1, mixing the iron ore with coal as the reducing agent.

6. In the process of claim 1, the step of mixing the iron ore with an amount of coal which is slightly less than that amount which would be necessary to reduce all of the iron oxid to metal.

7. In the process of claim 1, the improvement which comprises conducting the operations in an inclined rotary furnace, the ore being fed at the upper end and the flame being supplied at the lower end.

The foregoing specification of my "Process for the direct manufacture and refining of iron and steel", signed by me this 9th day of February 1921.

LUCIEN PAUL BASSET.