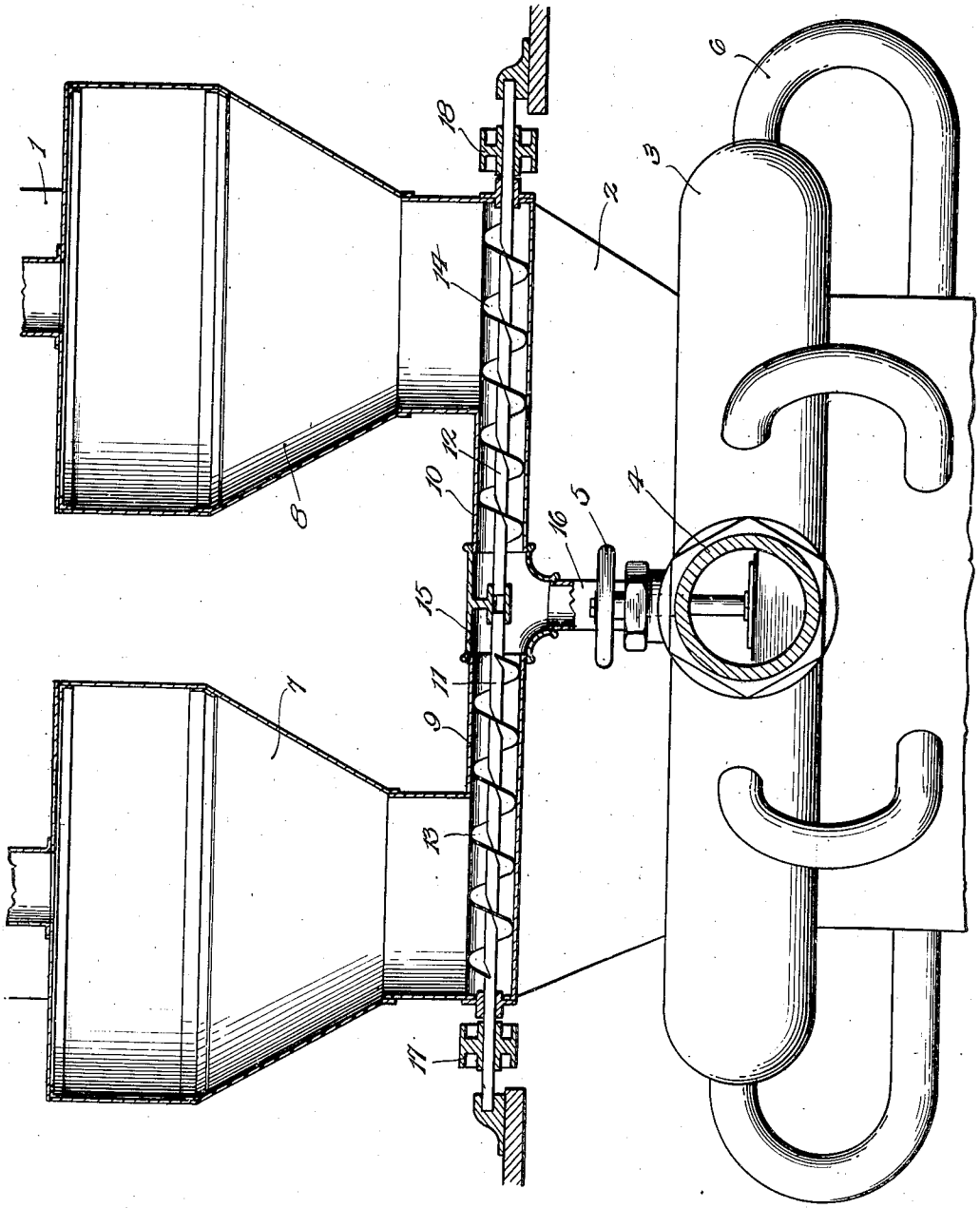
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PROCESS FOR PURIFICATION OF PIG IRON IN BLAST FURNACES

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PROCESS FOR PURIFICATION OF PIG IRON IN BLAST FURNACES.

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To all whom it may concern:

Be it known that we, CHARLES J. SOMERS, GORDON C. TIBBITTS, and EDWARD F. QUINN, citizens of the United States, residing at Jersey City, Somerset, and Brooklyn, respectively, in the counties of Hudson, Montgomery, and Kings, respectively, and States of New Jersey, Maryland, and New York, respectively, have invented certain new and useful Improvements in Processes for Purification of Pig Iron in Blast Furnaces, of which the following is a specification.

It is well known that in reducing iron ore in the ordinary blast furnace, the phosphorus of the charge is not eliminated, and but little of the sulphur. Therefore, in the production of steel it has been found necessary to resort to further refining processes in order to obtain a substantially pure product. The present invention, therefore, seeks to reduce the necessity for these refining processes by the control of the carbon at the smelting zone of a blast furnace to produce an oxidizing zone or reducing zone at will whereby to obtain a refined pig or substantially plain steel in the blast furnace.

We have discovered that by the process hereinafter outlined, the phosphorus and sulphur content of the ore may be substantially eliminated directly in the blast furnace by the use of a carbonaceous agent and a flux, when these agents are injected by the aid of an air blast, and in accordance with the practice hereinafter set forth.

The process of the present invention is carried out in its entirety within the blast furnace, the purpose of the process being, as indicated above, to obtain in the blast furnace, a product substantially free from sulphur and phosphorus. In most respects, the furnace which will be employed will not differ materially from the ordinary blast furnace except, however, that in connection with the compressed air supply trunk from which air is delivered to the bustle pipe of the furnace and then to the tuyères, there will be provided means by which carbon and flux may be drawn in regulated quantities and blown into the boshes of the furnace by and with the blast of air.

The figure of the accompanying drawing is a view representing, partly in section and partly in elevation and in a more or less diagrammatical manner, one type of apparatus which may be employed for the purposes of the invention.

In the drawing, the numeral 1 indicates the blast furnace which in itself is constructed in the ordinary manner and is provided with the usual boshes, indicated by the numeral 2. The numeral 3 indicates the usual bustle pipe which extends about the boshes of the furnace and which is supplied with air under pressure from a trunk pipe 4, the supply of air being regulated through the medium of a manually operable valve 5. The usual branch pipes 6 lead from the bustle pipe 3 into the boshes of the furnace and thus establish communication between the bustle pipe and the said boshes. Arranged above the bustle pipe 3 are two hoppers 7 and 8, in one of which a suitable carbonaceous material or agent such for example as powdered coal, may be contained and stored, and in the other a suitable flux likewise in a powdered or pulverized condition. These hoppers are provided with discharge pipes at their lower ends, indicated respectively by the numerals 9 and 10, and mounted for rotation within the pipes 9 and 10 are shafts 11 and 12 carrying conveyer worms 13 and 14 which, in the rotation of the shafts, serve to convey the material from the hoppers, individually, to a union 15 which is in the form of a T which is placed in communication by a branch pipe 16 with the trunk pipe 4 so that the material delivered from the hoppers 7 and 8 by the conveyers 13 and 14 respectively will be discharged into said trunk pipe and, by reason of the force of the air blast passing from this pipe into the bustle pipe 3, will be discharged into the bustle pipe and then distributed, through the pipes 6, into the boshes of the furnace. Pulleys 17 and 18, or, if preferred, gears, are fixed upon the shafts 11 and 12 respectively, and are adapted to be independently driven from any suitable source of power, means being provided (not shown) for controlling the drive of these

shafts 11 and 12 so that material may be fed from one hopper or the other at the will of the operator or attendant and in regulated quantities as may be found expedient.

Returning now to a consideration of the reactions which take place in the blast furnace, it may be stated that in ordinary blast furnace operations, the carbon in the coke of the charge is so abundant that it is impossible to obtain an oxidizing reaction in the smelting zone and, the furnace reaction is, for this reason, continuously reducing. It has been demonstrated by our invention, however, that a perfect control of the reactions taking place in the smelting zone of the furnace may be accomplished by introducing the carbon directly into said zone instead of by way of the furnace charge, and providing means whereby the quantity of carbon and flux charged during any phase of the operation may be controlled at will.

In carrying out the process, the furnace is first charged and set in operation in the usual manner except that only sufficient coke is introduced at the top of the stack to provide draft, assisted by the use of a coarser ore and flux, if necessary, and in any event, the coke is not introduced in quantity sufficient to reach the smelting zone of the furnace continuously in any great quantity for if this were done the reaction in the smelting zone would be continuously a reducing one and not under control. The present invention, in contrast, contemplates a normally reducing reaction but under perfect control and this is obtained by feeding from the supply hopper into the smelting zone, by means of the air blast, a quantity of carbon sufficient to make up for the carbon eliminated in the charge so that the normal chemistry of the operation of the furnace will be the same as under existing practice. It will be evident that by controlling the speed of rotation of the shafts 11 and 12, the supply of carbon and flux to the boshes of the furnace may be regulated. The carbon supply, as well as the supply of flux, may be, in fact, cut off completely, diminished, or increased as conditions require.

The first operation consists in delivering into the molten metal about the hearth of the furnace, after the process has proceeded to such stage, by means of the air blast delivered through the trunk and bustle pipes, a quantity of powdered basic flux and carbon, the quantity of flux injected being sufficient to render the slag normally basic. In this connection, it may be stated that the carbon employed should be, as nearly as possible, chemically pure. In this operation, the carbon is injected in such proportion with the air that it will be burned completely to carbon dioxid, establishing a local oxidizing zone at a greatly elevated temperature to oxidize the molten metal. The reactions which take place during this operation are expressed as follows:

1. $C+O_2=CO_2$.
2. $CO_2+Fe=CO+FeO$.
3. $8\ FeO+2\ Fe_3P=(FeO)_3P_2O_5+11\ Fe$.
4. $(FeO)_3P_2O_5+3CaO=(CaO)_3P_2O_5+3FeO$.

The advantage of this step of the process resides in the fact that when sufficient molten metal has accumulated in the smelting zone, an oxidizing slag can be formed by diminishing the carbon from the blast, this being done, of course, by reducing the feed of powdered coal or other carbonaceous material from the storage hopper into the air trunk 4. As a result of this step, the phosphorus content of the molten metal will be extracted and retained by the basic slag, the molten metal being protected from excessive oxidation by the covering stratum of slag resting above it in the boshes of the furnace. The ferrous oxide formed in accordance with the first step of the equations given above will also oxidize the other metalloids in the metal similarly to the reaction in the open hearth furnace. The carbon monoxide formed as a result of equation 2 ascends the furnace stack and continues the reducing action on the ore; thus a local oxidizing zone only will be formed in the boshes.

Following the operation above described, a portion of the slag may be drawn off until the desired level has been reached, after which the next operation in the process is carried out and this step consists in reducing the blast of air to a greater or less extent, either by manipulation of the control valve 5 or by, in a sense, choking the supply of air by the delivery into the bustle pipe of the furnace of an excess of carbon or carbonaceous material, and, in fact, it is the delivery of this excess of carbon which constitutes the desirable feature of this step. This excess of carbon is injected into the molten metal by the blast and thus a reducing zone is formed within the molten mass, and the sulphur content of the molten metal is eliminated in accordance with the following equation:

$$C+FeS+CaO=CaS+CO+Fe.$$

In accordance with this equation, the sulphur content of the metal is combined with the calcium content of the injected flux to form calcium sulphide which is taken up by the slag, carbon monoxide being driven off and the metallic iron being set free in a substantially pure state. The carbon monoxid formed during this step ascends the stack of the furnace and continues to effect a reducing action on the iron ore which has been delivered into the stack. Thus, a local reducing zone only will be formed in the boshes in this step.

As a result of the several operations above recited and carried out in accordance with the principles of the present invention, a product of an exceptionally high grade is produced in the blast furnace, being substantially free from phosphorus and sulphur, and having a carbon content of exceptional purity.

From the foregoing description of the invention it will be evident that, whereas, in ordinary blast furnace practice, the reaction within the smelting zone is continuously a reducing one and not in any way under control, we have evolved a process whereby either oxidizing or reducing reactions are caused to take place in the smelting zone and are perfectly under control of the metallurgist, thus enabling him to produce, as a result of the blast furnace operation, direct, a product comparable with plain steel.

Having thus described the invention, what is claimed as new is:

1. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises successively forming oxidizing and reducing slags in the smelting zone of the furnace during the operation thereof.

2. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises forming an oxidizing slag in the smelting zone by introducing a flux attended by an air blast and with a relatively small proportion of carbonaceous material, and subsequently introducing a further quantity of flux and an increased quantity of carbonaceous material in the zone attended by an air blast to produce a reducing slag in said zone.

3. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises injecting a relative small proportion of carbonaceous material into the smelting zone of the furnace attended by a blast of air to effect oxidation, and subsequently injecting an increased quantity of carbonaceous material into said zone whereby to effect reduction.

4. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises charging the furnace as usual but with the employment of a less amount of carbonaceous material, and successively injecting carbonaceous material and basic flux directly into the smelting zone of the furnace in regulated quantity sufficient to produce an oxidizing slag, and then a greater quantity of carbonaceous material to effect reduction.

5. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises charging the furnace as usual but with the employment of a less amount of carbonaceous material, injecting carbon into the smelting zone of the furnace attended by a blast of air, the carbon injected being in quantity sufficient only to establish an oxidizing reaction, and subsequently injecting an increased quantity of carbon into said zone to effect a reducing reaction.

6. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises injecting carbon and flux into the smelting zone of the furnace attended by a blast of air, the carbon being injected in quantity sufficient only to produce an oxidizing slag, and subsequently injecting a further quantity of flux attended by a blast of air and with an increased quantity of carbon whereby to produce a reducing slag.

7. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises injecting substantially pure carbon into the smelting zone of the furnace attended by a blast of air, the carbon being injected in quantity only sufficient to effect an oxidizing reaction, and subsequently continuing the blast of air and increasing the supply of carbon whereby to effect a reducing reaction.

8. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises injecting substantially pure carbon and a flux into the smelting zone of the furnace attended by a blast of air, the carbon being injected in quantity only sufficient to effect an oxidizing reaction, and subsequently injecting a further quantity of flux and continuing the blast of air and at the same time increasing the supply of carbon whereby to effect a reducing reaction.

9. The process of producing refined pig iron or substantially plain steel in the blast furnace, substantially free from phosphorus and sulphur, which comprises charging the furnace as usual but with the employment of a less amount of carbonaceous material, and injecting a carbonaceous reagent and a flux directly into the smelting zone of the furnace in regulated quantities to successively effect oxidation and reduction.

In testimony whereof we affix our signatures.

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