

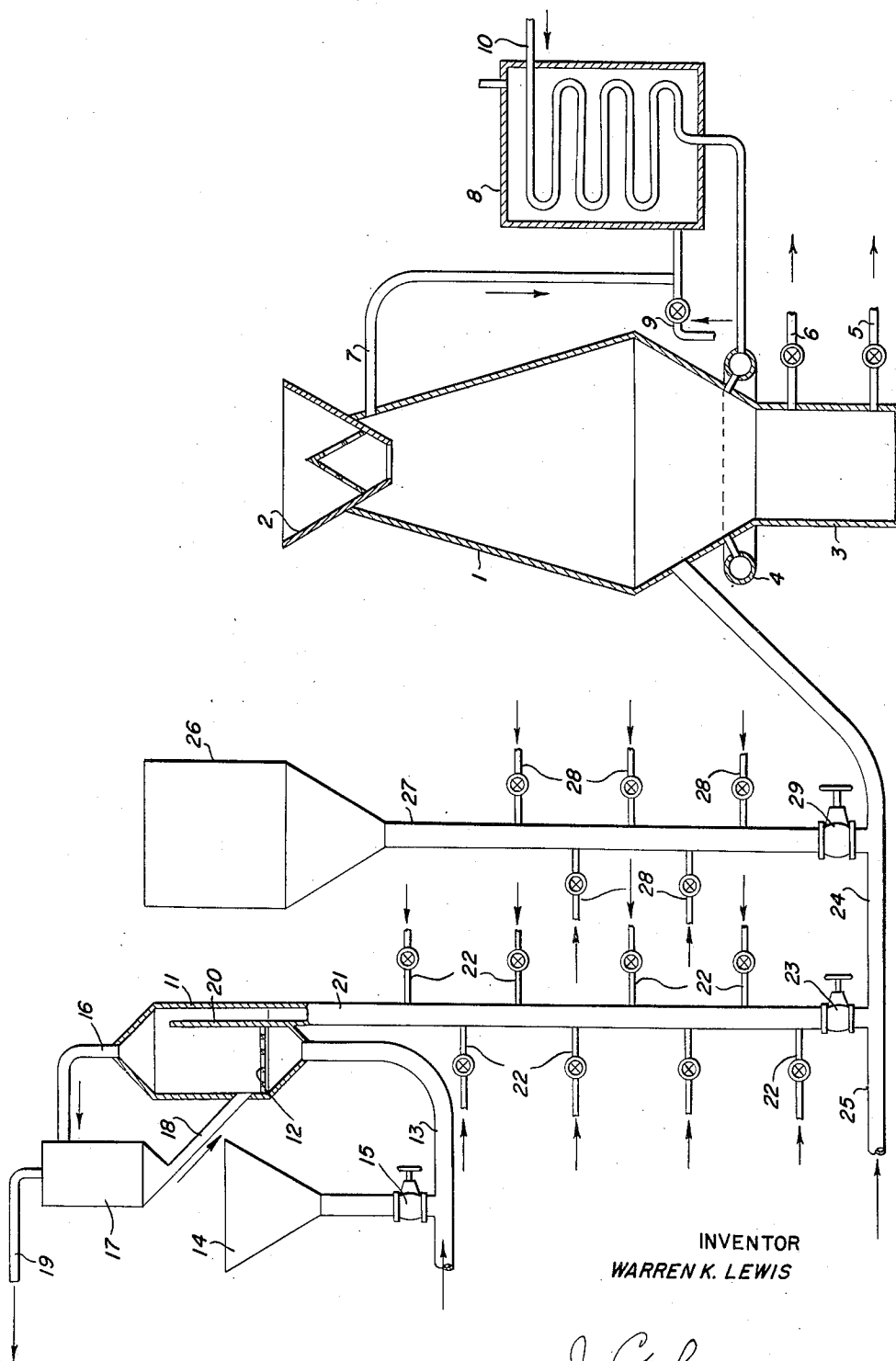
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BLAST FURNACE OPERATION

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BLAST FURNACE OPERATION

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1

The present invention is directed to an improvement in the operation of blast furnaces.

The operation of a blast furnace involves several operating factors which are interdependent to the extent that any change in one which would render the operation more efficient has the effect of requiring an adjustment of one or more others for smooth operation and such adjustment may be in some cases impossible. In other words, blast furnace operation represents, of necessity, a compromise between a plurality of operating factors.

It is generally agreed that the capacity of a blast furnace is limited absolutely by the allowable gas velocity up through the bed without blowing out the charge. Capacities have been increased greatly in recent years by various devices; for example, by sintering to eliminate dust and by using excess pressure at the top of the furnace and by increasing the content of oxygen in the blast and by combinations of two or more of these expedients. It remains true, however, that the capacity limit is set by the velocity that will blow out the charge, the only improvement being that these expedients either furnish a charge harder to blow out or reduce the velocity of the gas for a given amount of combustion. The purpose of the present invention is still further to increase the capacity of a blast furnace even though it may be using one or all of the aforesaid expedients without diminishing in any way the advantages accruing from such expedients.

Briefly, the present invention resides in improving the operation of a blast furnace by taking advantage of the excess heat available at the tuyère level without adversely affecting the temperature at this level and at the same time increasing the output of pig iron by the furnace. This is done according to the present invention by separately reducing iron ore and charging it to the blast furnace at the tuyère level.

In order fully to appreciate the advantages of the present invention one must keep in mind the fact that the blast furnace has a two-fold function. It serves to reduce the ore to metal and also serves to melt the metal produced and separate the molten metal from impurities. The first function is performed fairly easily but the performance of the second function leads to difficulty. The performance of this second function requires high temperature, up to 1500° C., and consumes a lot of heat. In securing this high temperature heat carbon is burned but the nature of the operation is such that the carbon

2

burned can net only carbon monoxide, liberating less than one-third of the heat that would be available if one could burn the carbon to carbon dioxide in the usual way. Hence, the carbon is used very inefficiently as a fuel. In fact, as a result of this partial combustion, the large amount of carbon monoxide resulting from the melting (tuyère) zone has a reducing capacity for ore far in excess of the amount of ore coming down the shaft with the coke. Furthermore, because of this low efficiency of combustion, the heat supply to the melting zone must be and is enhanced by preheating the air supplied as blast.

The quantity of air which may be passed through the charge is fixed by the cross-sectional area of the furnace at a value such that it won't blow out the charge. The quantity of coke is fixed by this quantity of air since in the main this coke must be burned out at the bottom with air. This coke and this maximum permissible quantity of air preheated to the maximum temperature attainable from the combustion of the off-gases from the blast furnace could reduce a certain quantity of ore. Actually, the amount of ore which can be handled is considerably less, dictated by the tendency of the furnace to plug when the ratio of ore to coke exceeds a fairly critical ratio determined by the nature of the ore.

Since the coke is necessary to keep the charge open but only a restricted quantity of ore can be used, and since the temperature at tuyère level must not be allowed to rise above a fixed value determined by the qualities desired in the pig iron, the heat supply at the tuyères must be limited by limiting the preheat of the air. In the ordinary case, this preheat is considerably less than is available from the off-gases of the furnace by a factor of $\frac{1}{2}$ to $\frac{1}{3}$. As a result, in the normal operation of a blast furnace large amounts of potential available high temperature heat are not utilized and the furnace is not used to its potential capacity. This inefficiency is all the more costly because the preheat which is wasted in presently used equipment is that which may be obtained by complete combustion of the off-gas from the furnace and by efficient heat exchange which would leave the stack gases cool. As the operation is presently conducted, much of this cheap heat is lost. Thus the entire operation suffers from the limitations heretofore pointed out.

The present invention minimizes the aforesaid difficulties by imposing an additional heat load on the blast furnace at the tuyère level. This heat load is in the form of freshly reduced ore

which must be purified in any event. By introducing this reduced ore into the blast furnace advantage is taken of the surplus heat there available to purify this ore and thereby increase the output of the blast furnace in pig iron. At the same time the full heat available as heat of combustion of the off-gas from the furnace may be utilized more effectively.

The reduced iron ore which is fed to the blast furnace in the region of the tuyère level but above the air blast, may be produced by any suitable method which does not suffer from the aforesaid limitations on the blast furnace method. In the preferred embodiment of the present invention, however, this reduced iron ore is produced by subjecting finely divided iron ore in a fluidized condition to the action of a reducing gas at a suitable temperature. In practicing this type of reduction the iron ore is ground to a powder, the bulk of which is smaller than 100 mesh and which contains particles of various sizes ranging upwardly from about 20 microns. This powder is maintained in fluidized condition in an enlarged reducing zone by passing reducing gas upwardly through it at a velocity between about .5 and 5 ft./second. This operation may be conducted on the upflow principle as described in my Patent No. 2,343,780 issued March 7, 1944, or on the downflow principle as hereinafter described.

The nature and objects of the present invention will be more fully understood from the following detailed description of the accompanying drawing in which the single figure is a front elevation in diagrammatic form of one type of apparatus suitable for the practice of the present invention.

Referring to the drawing in detail, numeral 1 designates a conventional blast furnace having at its upper end a feed hopper 2 and at its lower end a crucible portion 3. Just above the crucible portion there are provided tuyères 4 for the introduction of blast gas into the furnace. The crucible portion is provided with a conventional drawoff 5 for molten pig iron and a drawoff 6 for slag. At the upper end of the furnace there is an outlet line 7 for gas. This line discharges into a preheating furnace 8 after being suitably mixed with air or oxygen introduced through line 9. The feed line for the blast gas 10 passes through the furnace where it receives heat from the combustion of the off-gas before being fed to the tuyères. Actually in practice this preheating furnace will be in the form of checker-work ovens which are operated in sequence on the fire and run principle.

At one side of the blast furnace is an elevated reduction chamber 11 which is preferably provided with conical ends and with a grid or grate 12 near its lower end. A feed line 13 discharges into the bottom of the reduction chamber. In communication with this feed line is a hopper 14 for finely divided iron ore. Hot reducing gas, such as producer gas, water gas, or the like, is fed into the feed line behind the point of discharge of the hopper and picks up the finely divided iron ore and carries it into the reduction chamber. The leg from the hopper is provided with a slide valve, star feeder or other suitable control member 15. The rate of feed of the powdered ore and of the reducing gas are adjusted relative to each other, the rate of feed of the reducing gas being kept within such limits so as to provide in the reduction chamber 11 a suspension of finely divided material containing at least about 5% by volume of solid material. Generally this suspen-

sion will contain from 15 to 25% by volume of solid material which is maintained in the form of a dense, highly turbulent suspension having the appearance and the properties of a liquid. The reducing gas leaves the upper end of chamber 11 through line 16 and enters a cyclone or other separator 17 from which recovered solid material is returned to chamber 11 by line 18 while the spent reducing gas leaves the system through line 19.

The temperature in chamber 11 is maintained below that at which iron becomes plastic, which will usually be in the range of 900° to 1000° C. Thus a suitable temperature for zone 11 is between about 700° and 900° C., the lower limit being that required to support the reaction between iron oxide and the reducing gas.

It will be understood that the suspension in the reducing chamber 11 will have a level quite analogous to a liquid level. A curved partition 20 is arranged along one side of the chamber 11 so as to form therein a conduit having its top just below the level of the suspension in the chamber whereby the suspension overflows into this conduit and down into a standpipe 21. This standpipe is provided with a plurality of spaced jets or nozzles 22 for the introduction into the standpipe of fluidizing quantities of gas. It is preferred that hot reducing gas be used for this purpose so as to insure completion of the reduction of the iron ore. The bottom of the standpipe is provided with a slide valve or star feeder or other suitable control element 23 which may be manipulated or adjusted to provide for a constant feed of fluidized solid into line 24 into which is fed a stream of carrier gas 25. This carrier gas may be an inert gas or, if desired, a portion of the hot blast gas from line 10, a portion of the gas from line 7, or off-gas from the preheating oven 8, the latter being quite desirable. Line 24 discharges into the blast furnace at a point adjacent the tuyères, either slightly above or slightly below, but not at the gas blast, where the temperature is highest. Preferably, the iron powder is charged to a point as shown in the drawing.

In general, it will be necessary to supplement the supply of slagging constituents, such as lime, in order to accommodate the additional purification load on the furnace. This may be provided for by arranging a hopper 26 in communication through a standpipe 27 with line 24. This standpipe will likewise be provided with suitable jets or nozzles 28 in order to maintain the solid therein, which will be in a finely divided state as heretofore described in a fluidized condition. The feed of this material to line 24 may be regulated by a slide valve, star feeder, or other suitable control element 29 provided near the bottom of the standpipe 27.

In the practice of the present invention, the operation of the blast furnace itself is not changed; that is, the conditions above the tuyère level remain the same. The charge to the furnace may be selected for most efficient operation in accordance with previous practice. The temperature at the tuyères will be maintained at a level determined by the type of pig iron desired as well as by the type of ore fed to the furnace. The only change resides in a more complete recovery of the heat of combustion of the off-gas from the furnace and the supply of this recovered heat as preheat to the blast. The blast may be air, air enriched in oxygen, or oxygen.

It will be apparent that many changes may be made in the arrangement heretofore described,

5

which is purely illustrative, without departing from the scope of the present invention. As heretofore emphasized, the present invention is not intended to place any limitation on the operation of the furnace or to supplant any of the expedients heretofore adopted for increasing the furnace capacity, but rather to supplement such expedients and further increases the capacity of the blast furnace.

The nature and objects of the present invention having thus been set forth and a specific illustrative embodiment of the same given, what is claimed and desired to be secured by Letters Patent is:

1. In the operation of a blast furnace in which ore, coke, and slagging constituents are fed to the top thereof in the usual manner and in which a blast of an oxygen-containing gas is fed to the tuyère level of said furnace, the improvement which comprises reducing finely-divided iron ore in the form of a fluidized bed in a reduction zone, withdrawing reduced ore from said zone and charging it in the form of an elongated fluidized column to said blast furnace at the tuyère level thereof for the purpose of melting and purifying the latter within the blast furnace.

2. The method set forth in claim 1 in which the reduced iron ore is charged to the blast furnace at a temperature of from about 900° to 1,000° C.

6

3. The method of claim 1 in which finely divided slagging constituents are fed with the finely divided reduced iron ore to the blast furnace.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
943,599	Hubbard	Dec. 14, 1909
1,815,899	Brassert	July 28, 1931
2,057,554	Bradley	Oct. 13, 1936
2,249,410	Wilson	July 15, 1941
2,343,780	Lewis	Mar. 7, 1941

FOREIGN PATENTS

Number	Country	Date
699,962	Germany	Dec. 10, 1940
2,852	Great Britain	of 1863
755	Great Britain	of 1904

OTHER REFERENCES

Pages 105 and 111 of "Ferrous Production Metallurgy" by John L. Bray, published 1942 by John Wiley and Sons Inc.