

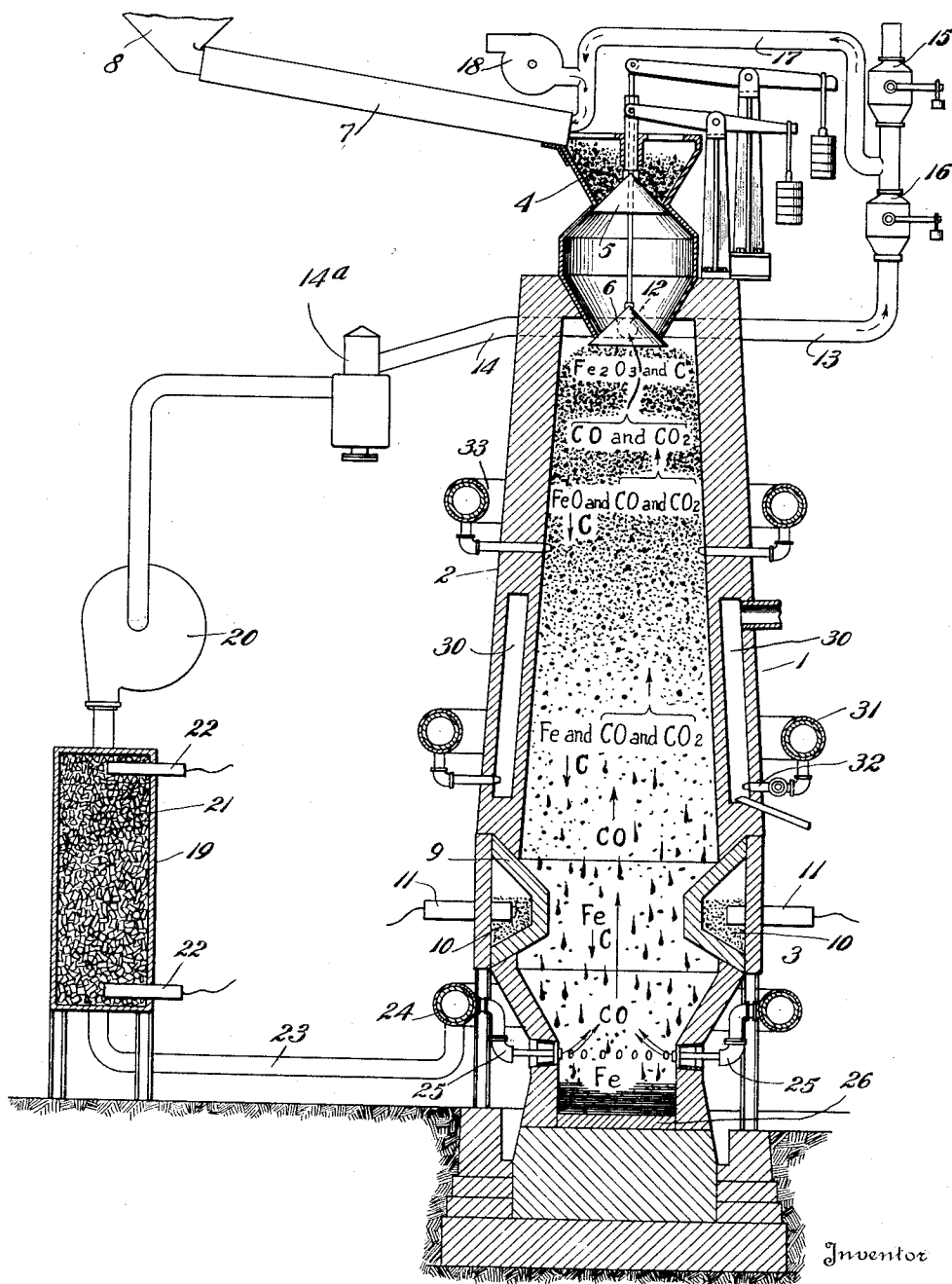
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PROCESS FOR THE REDUCTION OF ORES OF REDUCIBLE OXIDES

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PROCESS FOR THE REDUCTION OF ORES OF REDUCIBLE OXIDES

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This invention relates to a process for reducing ores, in which the solid materials entering the furnace are introduced into the furnace and permitted to fall uninterrupted toward the bottom of the furnace in such a finely divided state that the reduction action takes place by the time they have reached the bottom of the furnace.

It is the usual practice in reducing ores to charge the furnace with lumps of material which are supported by the tapered side walls of the lower part of the furnace, while it has usually been found necessary in order to provide the necessary porosity through the charge to permit the gas to pass therethrough to have large lumps of coke or charcoal intermixed with said charge, for supporting the body of the ore under treatment until it has been fully reduced. Otherwise the body of material under treatment would cake and prevent the passage of the necessary gases for reduction.

It is to be noted that this process contemplates the elimination of the usual air blast required in blast furnace apparatus, the oxygen for combustion being supplied by the oxygen of the unreduced ore, the action taking place as follows:

The finely divided ore in contact with the CO reducing gas burns the CO partially to CO₂, the solid carbon in its finely divided condition charged with the ore and being in immediate proximity to the CO₂ just formed by the reaction mentioned, and being in that part of the furnace whose temperature is high enough to form the reaction, is immediately changed into CO and again attacks any particle of unreduced or partially reduced, finely divided ore.

In carrying out the present invention, the ore and carbonaceous material are falling or floating continuously downward through the furnace in a powdered state, the reducing gas being passed upward through the descending pulverized material, entirely surrounding each particle of the finely divided ore, producing an almost instantaneous reduction of the same.

The objects of the invention may be attained by the use of an apparatus illustrated

in the drawing, in which is shown a vertical, sectional view of a blast furnace of usual type equipped with an auxiliary electric heating means and otherwise converted to operate the improved process of reduction of ores.

Similar numerals refer to similar parts throughout the drawing.

The blast furnace is shown generally at 1 and may comprise the usual stack 2 and bosh 3, although the latter need not be restricted in its lower portion for the present purpose, the same being illustrated merely to show the manner in which the usual blast furnace may be converted for operating the improved process of reduction.

The charging hopper 4 may be of usual construction and may be provided with the double bells 5 and 6 so adjusted as to produce the desired rate and character of feed or any other well known feeding mechanism may be provided for producing a substantially continuous feeding of the finely divided charge.

A preheater which may be in the form of an inclined tube 7, preferably communicates with the charging hopper 4, a hopper 8 being connected to the upper end of said preheater to receive finely divided ore and carbon in the form of powdered coal or the like.

An annular gas-tight chamber 9 may be formed in the wall of the furnace at a point near the bottom thereof, for the purpose of containing an auxiliary heater which may be in the form of an electric resistance element, comprising carbonaceous material in granular form, such as indicated at 10, electrodes 11 extending into the same.

A gas take-off 12 is provided in the upper end portion of the stack and communicates with the pipes 13 and 14, the pipe 13 having a relief valve 15 at its extremity and a back pressure valve 16 at a point spaced therefrom, the pipe 17 communicating with said pipe at a point intermediate said valves and extending into the lower end of the preheater, a fan 18 being preferably provided near the entrance to the preheater.

The pipe 14 communicates with a carbon monoxide regenerator 19, a fan 20 being pref-

erably located in said pipe between the take-off 12 and the regenerator. This regenerator may comprise an air tight tank filled with coke as shown at 21, and may be heated in any desired manner as by an electrode 22 extending into each end portion of the tank for heating the coke sufficiently to cause the CO_2 gas passing through the regenerator to be transformed to CO at the desired temperature for introducing it into the furnace.

It may be desirable to superheat the CO in order to maintain the same at a higher temperature in the lower part of the furnace, so as to assist in producing molten material if desired, and another object of introduction of the regenerated gas is to insure the lower part of the furnace being always under a strictly reducing atmosphere, as the particles of reduced iron might otherwise be oxidized if any admixture of CO_2 with CO is present in the lower part of the furnace.

The regenerator is connected by a pipe 23 with the bustle pipe 24 surrounding the lower portion of the furnace and communicating therewith at intervals by tuyères 25 in the usual manner. When it is desired to produce pig iron, the hearth 26 at the bottom of the furnace may be constructed in the manner of usual blast furnace apparatus.

In operating the apparatus to reduce ore by the improved process, finely powdered ore or oxygen compounds utilized as ore, mixed with finely powdered carbon, in the form of pulverized coke or the like, are passed through the hopper 8 and preheater 7 into the charging hopper of the furnace.

This powdered material will contain a smaller proportion of carbon than is required in the usual blast furnace practice, this being due to the fact that reduction takes place with the oxygen of the ore entirely, instead of as in the usual blast furnace apparatus where oxygen is admitted in the form of air which contains inert nitrogen which must be heated up and a large part of its sensible heat derived from combustion of the coke is subsequently lost in hot blast stoves or other combustion devices.

In reducing iron ore, as the mixture of powdered ore and carbon is discharged substantially continuously from the charging hopper into the upper portion of the stack of the furnace, it will be in the form of $\text{Fe}_2\text{O}_3 + \text{C}$. As it goes into the stack, it first forms FeO and $\text{CO} + \text{CO}_2$ and is partially reduced, the partially reduced ore and ungasified carbon descending to a lower level which may be maintained at a higher temperature. In this reaction and reduction zone substantially all of the ore is reduced by the CO gas therein, forming Fe and CO_2 with an evolution of heat as in the previous operation.

At the same time, the CO_2 thus formed, is transformed into CO again by the presence

of the solid particles of carbon, this latter reaction absorbing only a slight amount of heat in excess of heat produced by the former reaction, in which oxide of the ore formed CO with an evolution of heat.

The CO gas coming up through the lower part of the furnace from the tuyères insures a complete absence in the lower part of the furnace of any CO_2 thus maintaining the reduced metal in the reduced state at which it came from the upper zone of the furnace. By charging an excess of solid carbon over that required for the chemical reaction above mentioned, a portion of this carbon will find its way to the bottom or hearth of the furnace where, by solid contact with the completely or incompletely reduced iron, the final reduction will take place on the hearth and at the same time this excess of carbon will provide the necessary carbon for producing molten pig iron if desired.

The CO and CO_2 gases will be forced to the top of the furnace and the large part of their sensible heat absorbed by the down coming charge of ore and the solid carbon.

These gases will be taken off at the top of the stack through the take-off 12, into the pipes 13 and 14, a portion of the gases passing up through the pipe 13 and being forced into the preheater, the surplus gas passing off through the relief valve 15, while the remainder of the gas will be drawn down through the pipe 14 and dust collector 14^a and forced through the regenerator by the fan 20, the CO_2 portion of the gas being regenerated to CO, and superheated if desired, after which it is forced through the tuyères into the lower portion of the furnace.

Since in one method of operating all of the oxygen required for the process may be introduced into the furnace, in a solid condition chemically combined with the ore, this equipment can be operated under a considerable pressure without extra power requirements such as required in usual blast furnace practice, since the only power required in the operation will be that required by the fan for the regenerator, and the only power for this is that necessary for overcoming the friction of the gas as it passes through the regenerator, the outlet in the tuyères being substantially under the same pressure.

Since there may not be sufficient oxygen chemically combined with the ore to burn a quantity of carbon sufficient to produce the necessary heat for the reaction, this difference of heat may be supplied by the auxiliary heater such as the electric resistance element 10 or by superheating the CO gas in a regenerator as above described, or a heating chamber 30 may be provided in the walls of the stack which may be heated by combustion of gas supplied through the bustle pipe 31 and tuyères 32.

However, if it is desired to operate the

process without any of the auxiliary heating devices mentioned, additional oxygen for combustion of the carbon may be supplied in the upper portion of the stack as by the bustle pipe 33 and tuyères.

The advantage of maintaining the furnace under an appreciable pressure is that the carbon monoxide for reduction by being under pressure, more pounds or a greater quantity of reducing gas will be in the furnace at a time, thus facilitating the reactions.

While this process contemplates the use of solid carbon introduced with the ore at the top of the furnace to provide the necessary carbon for carrying on the reaction, this equipment may be operated without the use of solid carbon charged with the ore, by introducing other reducing agents, such as oil, or by the addition to the equipment of reducing gases made externally to the furnace, in which case the furnace instead of being operated under a considerable pressure produced as mentioned previously, would preferably be operated at only slightly above atmospheric pressure.

From the above, it will be obvious that the improved process for reducing ores has considerable advantages over the usual blast furnace practice, in that the reduction takes place almost instantly, relatively only a small body of ore being under treatment in the furnace at a time.

Since the particles of ore are so small, the reduction action takes place in a relatively short time as compared with other processes where the material is in large pieces, which require usually several hours for the reducing gases to completely penetrate the mass of each piece, in which case the furnace must be so designed that the charge under treatment will be supported by the lower side walls of the furnace, a porous carbon being introduced to support and maintain free spaces for the passage of gases for reduction.

I claim:—

1. The method of reducing ores which consists in floating pulverized ore and carbon through a furnace chamber, passing a reducing gas in opposite direction through the descending pulverized material and superheating the lower portion of the chamber by electric means.

2. The method of reducing iron oxides to pig iron which consists in floating pulverized oxide and an excess amount of carbon over that required for the chemical reactions, through a furnace chamber in the presence of a reducing gas flowing counter to the descending material and maintaining a molten bath of iron at the bottom of the chamber.

3. The method of reducing ore which consists in charging finely powdered ore and carbon into the top of a furnace and floating the charge downward through the furnace, taking off CO₂ gas near the top of the fur-

nace, regenerating the gas into CO and introducing the same at the bottom of the furnace and passing the CO gas upward through the furnace counter to the descending material.

4. The method of reducing iron oxides to pig iron which consists in floating pulverized oxide and an excess amount of carbon of that required for the chemical reactions through a heated chamber, passing a reducing gas through the heated chamber counter to the oxide and carbon, and reacting the reducing gas, oxide, and carbon to form pig iron and carbon compounds.

5. The method of reducing oxides which consists in floating pulverized oxide and an excess amount of carbon of that required for the reduction through a heated chamber, passing a reducing gas through the heated chamber counter to the oxide and carbon and reacting the reducing gas, oxide and carbon to form carbides and carbon compounds.

6. The method of reducing oxides to carbides which consists in floating pulverized oxide and an excess amount of carbon over that required for the reduction of the oxide through a furnace chamber in the presence of a reducing gas flowing counter to the descending material and maintaining a molten bath of the reduced oxide at the bottom of the chamber in the presence of the excess carbon to form a carbide.

In testimony that I claim the above, I have hereunto subscribed my name.

THADDEUS F. BAILY.