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ORE TREATING MACHINE

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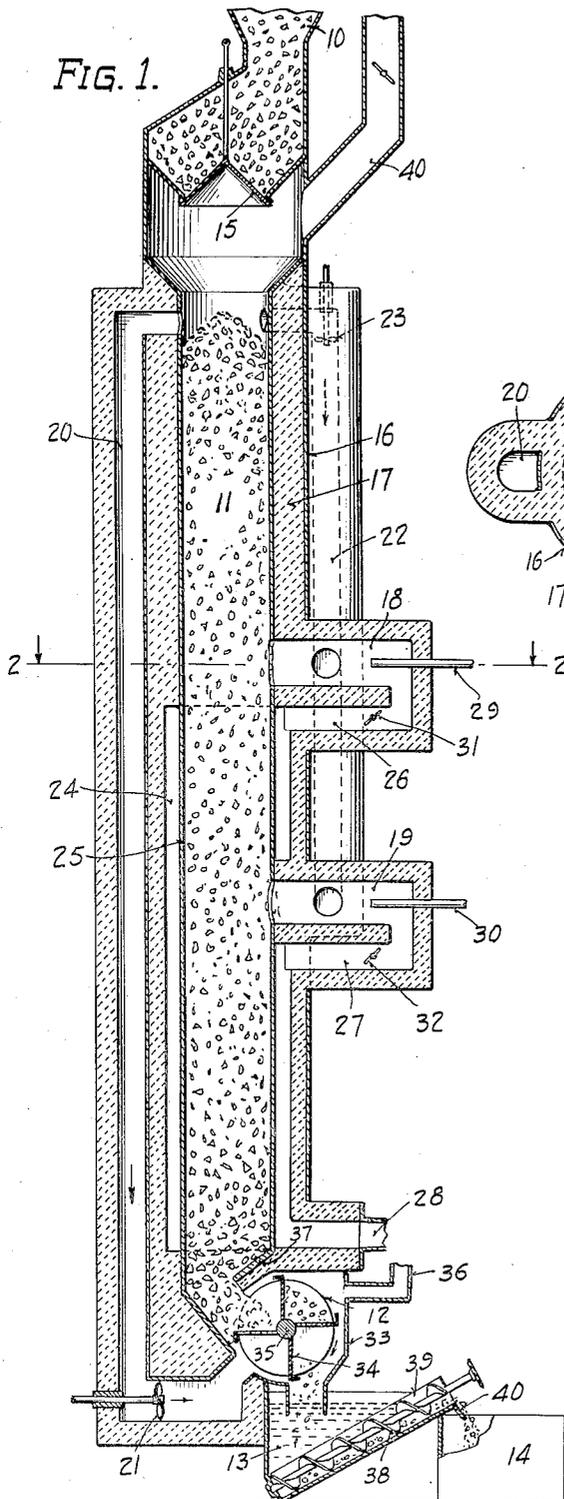
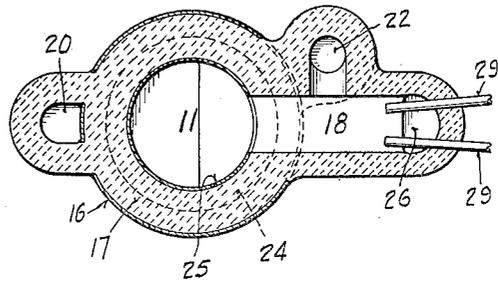


FIG. 2.



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ORE TREATING MACHINE

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11 Claims. (Cl. 266—8)

This invention relates to ore treatment and especially to machines for treating low grade iron ores and preparing them for the purpose of beneficiation.

broken, the ore may be treated in a magnetic separator or by other means which will separate the oxides of iron from the gangue.

For a more detailed description of the invention, reference may be had to the accompanying drawing in which:

Figure 1 is a view in cross section of a machine for treating ores and

Fig. 2 is a view of the machine in cross section, the cross section being taken along line 2—2 of Figure 1.

As shown in the drawing, the machine comprises a hopper 10, a heating chamber 11, an ore removing device 12, a quenching tank 13 and a grinder 14. The hopper 10 which is preferably made from sheet steel is separated from the heating chamber 11 by means of a charging valve 15. Valve 15 is preferably of the bell type and when open, permits free passage of ore from hopper 10 into the heating chamber 11.

The heating chamber preferably comprises a vertically disposed shaft, the walls of which consist of an outer casing of steel 16 and an inner lining of fire brick or other suitable heat refractory material 17.

Combustion chambers 18 and 19 are mounted on the shaft for burning mixtures of air and gas. These chambers discharge heated gases into the shaft to heat the charge to desired temperatures. A heat insulated duct 20, in the lower portion of which a motor driven fan 21 is mounted, extends along the outside of the shaft and opens into the top and bottom of the shaft. A similar heat insulated duct 22 in which a similar motor driven fan 23 is mounted also extends along the outside of the shaft and opens into the top of the shaft and into combustion chambers 18 and 19. An annular air passage 24, the inner wall 25 of which comprises sheet metal having a high melting point, extends around the shaft from the base to the upper combustion chamber 18. Air ducts 26 and 27 in the combustion chambers 18 and 19 are connected with the air passage 24. An inlet 28 which extends through the walls of the shaft connects air passage 24 to a suitable source of compressed air. Air entering through inlet 28 from this source of compressed air circulates through air passage 24 and air ducts 26 and 27 into combustion chambers 18 and 19 respectively where the air is mixed with combustible gas which is forced through fuel injectors 29 and 30 respectively. The amount of air flowing through ducts 26 and 27 into the combustion

5 Heretofore proposals have been made for treating low grade iron ores with a view to preparing them for beneficiation and for utilizing them for the manufacture of iron and steel. In accordance with these proposals, the ore was treated to convert the iron oxides into the magnetic oxide Fe_3O_4 ground, and the magnetic oxide was separated in magnetic separators. In such low grade ores, however, the non-ferruginous material is mingled with the ferruginous material in such a fine state of subdivision that extremely fine grinding is necessary to produce a concentrate which is high enough in iron to permit of its use in the production of iron and steel. While good concentrates could be obtained, the former methods of preparing the ore for grinding were prohibitive from economic considerations because the prepared ore was in such a condition that it was too difficult and costly to grind, and the methods of utilizing heat in the preparation of the ore were wasteful.

One of the main objects of the invention is to provide means for treating low grade iron ores so that subsequent grinding and beneficiation can be brought about in an economical manner.

In accordance with the invention, this and other objects are attained by heating the ore to calcining temperatures in properly controlled atmospheres to decompose the ore and to convert the iron oxides in the ore to the highly magnetic oxide, Fe_3O_4 . During decomposition, the ore becomes porous due to the evolution of gases. While still heated, the porous ore is suddenly quenched, care being taken in the meantime that the heated ore is not permitted to come into contact with oxidizing atmospheres which, if permitted, would reconvert the iron oxides to the practically non-magnetic oxide, Fe_2O_3 . The sudden quenching of the porous ore has the effect of rendering it soft, extremely friable and easy to grind. While in this condition, the ore is ground very fine to break the bond which exists between the ferruginous and the non-ferruginous particles in the ore. The ore is ground preferably while wet since if permitted to dry, it has a tendency to harden somewhat as hydraulic cement hardens, and the grinding is somewhat more difficult and expensive. After the bond between the ferruginous and the non-ferruginous particles of ore is

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chambers is regulated by manipulating valves 31 and 32 respectively.

An ore removing device 12 is housed in a hopper 33 at the base of the shaft and comprises a plurality of blades 34 which are mounted on a motor driven shaft 35. The lower portion of hopper 33 extends below the level of the quenching fluid in tank 13, thereby providing a seal. An exhaust pipe 36 near the top of the hopper 33 permits the escape of steam which may be created during the quenching operation. A metallic baffle board 37 on the top of hopper 33 extends into the interior of the shaft and serves as a guide for feeding the ore into the ore removing device 12.

An ore conveyor is mounted inside the quenching tank for transferring the ore from the quenching tank to the grinding mill 14. Preferably, the conveyor comprises a motor driven screw 38 which rotates within a trough 39, which trough is mounted on a sloping surface which preferably comprises one wall of the quenching tank. As the screw rotates it picks up ore in the bottom portion of the tank and conveys it to the upper edge of the tank from whence the ore flows over splash board 40 under the influence of gravity into grinder 14.

While this type of apparatus is preferably employed, yet equally favorable results may be obtained with other types of apparatus, the essential features in all cases being that the ore shall be rendered magnetic and porous by heating, that the heated ore shall be quenched without coming in contact with oxidizing atmospheres and that the ore shall be conveyed while wet from the quenching tank to the grinding mill.

As a specific method which is illustrative of one manner of practicing the invention, a charge of low grade carbonate such as that which is found in the northern part of Wisconsin and in the Michigan Peninsula, commonly known as Marquette carbonate is fed from hopper 10, through bell valve 15 into shaft 11. Marquette carbonate is a low grade ore comprising approximately FeCO_3 36.5%, Fe_3O_4 19%, Fe_2O_3 1%, silica 33% and the balance mostly the carbonates of calcium, magnesium and manganese. As the ore passes downwardly into that portion of the shaft above combustion chambers 18, its temperature is gradually raised to approximately 650° under the influence of ascending heated gases and under the influence of heat generated by burning suitable mixtures of air and gas in combustion chambers 18 and 19. While natural gas is preferably employed, yet any combustible gas or even powdered coal may be employed. The combustion in chamber 18 is regulated so that the resultant flame is oxidizing and the combustion in chamber 19 is regulated so that the resultant flame is reducing. This treatment decomposes the FeCO_3 in the ore and converts it into the highly magnetic oxide Fe_3O_4 in accordance with the following equations:

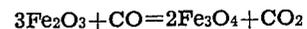


The carbon monoxide burns or combines with the excess oxygen which is introduced into the shaft through combustion chamber 18. The heat from this combustion augments the sensible heat of the gases, such as carbon dioxide and nitrogen, which are given off during the decomposition of the ore. These highly heated gases pass upwardly through the shaft and pre-heat the charge.

As the ore passes downwardly into that portion of the shaft opposite combustion chamber 18 wherein the atmosphere is oxidizing, the excess of oxygen which is introduced into the shaft through combustion chamber 18 combines with the Fe_3O_4 initially contained in the ore and the Fe_3O_4 converted from FeCO_3 and reconverts Fe_3O_4 to Fe_2O_3 . This conversion takes place in accordance with the following equation:



As the ore passes downwardly from the oxidizing zone into that portion of the shaft opposite combustion chamber 19 wherein the atmosphere is reducing, the Fe_2O_3 contained in the ore is converted to Fe_3O_4 in accordance with the following equation:



Preferably the oxidizing zone in the shaft is made as short as possible since its function is simply to provide the necessary oxygen to burn the carbon monoxide released during the conversion of the FeCO_3 into Fe_3O_4 . Under circumstances which permit a short period of exposure to the oxidizing gases, only a thin film of Fe_2O_3 will form around the Fe_3O_4 particles in the ore as they pass through the oxidizing zone. Accordingly the ferric oxide can be reconverted readily to magnetic oxide in the reducing zone.

The heated charge containing the highly magnetic ore passes downwardly from the reducing zone which is opposite combustion chamber 19 to the base of the shaft from whence it is removed under the influence of the rotating blades 34 and dropped through hopper 33 into the quenching tank 13.

Inasmuch as the funnel of hopper 33 extends below the level of the quenching fluid in tank 13, the ore is prevented from coming in contact with oxidizing atmospheres as it passes from the base of the shaft into the quenching tank. If the heated magnetic ore were to be exposed to oxidizing atmospheres as it passes from the base of the shaft to the quenching tank, it would be reconverted into the practically non-magnetic oxide Fe_2O_3 and the subsequent concentration would be much more difficult and costly.

The sudden quenching of the porous ore has the effect of disintegrating the ore and rendering it soft, friable and easy to grind.

After being quenched, the ore is conveyed by the rotating screw conveyor 38 from the base of the quenching tank 13 to the top of the tank from whence it flows over splash board 40 under the influence of gravity into the grinding mill 14. In the grinding mill, the ore is finely ground, say to sizes at least as fine as those which will pass through a 200 mesh screen. A ball mill grinder may desirably be used, but equally favorable results may be obtained with other types of grinders. Grinding the ore to the described fineness breaks the bond which exists between the non-ferruginous and the ferruginous particles in the ore. When the ore is subjected to the action of a magnetic separator a highly concentrated ore is obtained.

The gases given off during the decomposition of the ore pass upwardly through the shaft and preheat the charge in the upper portion of the shaft, the heat of these gases being augmented by the heat produced by the burning of the carbon monoxide which is released during the conversion of the FeCO_3 in the ore to Fe_3O_4 . A portion of these heated gases which are dis-

charged from the upper portion of the shaft are returned by the action of fan 21 through duct 20 to the bottom of the shaft from whence they again pass upwardly through the shaft. As these gases pass upwardly, they are again heated by the descending hot ore, by heat generated in the combustion chambers and by the heat produced by the burning of the carbon monoxide. These reheated gases mingle with the heated gases derived from the decomposition of the ore and they serve to preheat the charge to temperatures above those which would be possible if no other gases than those initially given off during decomposition of the ore were passed through the charge and the same amount of fuel were used. Preheating the charge decreases the total amount of heat needed to be generated in the combustion chambers to heat the ore to calcining temperatures.

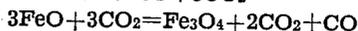
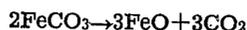
Another portion of the gases which emerges from the charge is returned under the influence of fan 23 through duct 22 to the combustion chambers 18 and 19 to reduce the temperature of the flames in these chambers. Unless the flame temperatures in the combustion chambers are reduced, the ore which passes downwardly through the shaft is apt to be heated to temperatures high enough to fuse the ore. When the ore is fused the subsequent fine grinding is extremely difficult and costly.

The heat radiating from the charge in the lower portion of the shaft, that is, that portion of the shaft along which the metallic lining 25 of the air passage 24 extends, preheats the air circulating through this air passage. Preheating the air entering the combustion chambers 18 and 19 also decreases the amount of heat required to be generated in these chambers to heat the ore to calcining temperatures.

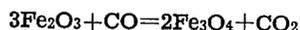
The position of the combustion chambers 18 and 19 is determined by the temperature of the ore that is desired when it is quenched and by the total amount of heat that is desired to be recuperated in order to preheat the charge and to preheat the air which enters the combustion chambers. To obtain the maximum benefit from the quenching operation, the chambers should be located near the base of the shaft. In this case, the ore would be quenched at substantially the highest temperatures that are attained. In general the higher the temperature at the time of quenching the greater the degree of disintegration of the ore. Hence the cost of subsequent fine grinding is correspondingly reduced by increasing the quenching temperature. From an economic standpoint, however, it is desirable to place the chambers some distance from the base of the shaft and to utilize the heat lost by radiation as the charge travels from these chambers to the base of the shaft to preheat the air which enters the combustion chambers. In this case, the economic advantage gained by preheating the air more than offsets the additional cost of subsequent fine grinding when the ore is quenched at lower temperatures. Preferably the chambers are located so that the charge does not cool below 250° C. in its travel from the combustion chambers to the base of the shaft.

In another embodiment of the invention, a single combustion chamber is employed in place of the two combustion chambers 18 and 19 specified in the preferred embodiment. Accordingly, only one of the combustion chambers is operated, the other may be removed if de-

sired. In this embodiment, the combustion in the chamber is regulated so that the resultant flame is substantially neutral. In this case, the ore descends in the shaft and the FeCO_3 in the ore is converted to the highly magnetic oxide Fe_3O_4 in accordance with the following equations:



The carbon monoxide thus liberated instead of being burned to preheat the charge, as is done in the preferred embodiment, reacts on the Fe_2O_3 in the ore and converts it to Fe_3O_4 in accordance with the following equation:



In this embodiment, the exact location of the combustion chamber is determined by the temperature at which it is desired to quench the ore and by the amount of heat it is desired to recuperate to preheat the air entering the combustion chambers.

As in the preferred embodiment a certain portion of the gases are returned from the top to the bottom of the shaft from whence they circulate upwardly and after being reheated again serve to preheat the charge in the upper region of the shaft. Also a portion of the gases are returned from the top portion of the shaft to the combustion chamber to reduce the temperature of the flame in the chamber.

The invention is hereby claimed as follows:

1. In a machine for treating iron ore, a furnace having an upright shaft, means for charging said shaft with ore, a plurality of combustion chambers mounted on said shaft intermediate the ends thereof, means for burning mixtures of air and gas in said chambers to heat said ore, means for returning gases from the top portion of said shaft to said combustion chambers to reduce the temperatures of the flames therein, means for controlling the composition of the atmosphere in said shaft, means for transferring said heated ore from said shaft into a quenching tank, and means for preventing said ore from coming in contact with oxidizing atmospheres during said transfer.

2. A machine for treating iron ore which comprises a furnace having an upright shaft, means for charging said shaft with ore, a plurality of combustion chambers mounted on said shaft intermediate the ends thereof adapted and arranged to discharge products of combustion of air and gas into said shaft to heat said ore, means for controlling the oxygen content of said products of combustion, means for returning gases from the top portion of said shaft to said chambers to reduce the temperature of the flames therein, means for returning gases from the top portion to the bottom portion of said shaft to transfer heat from the lower to the upper portion of the shaft, means for transferring said heated ore from said shaft into a quenching tank, and means for preventing said ore from coming in contact with oxidizing atmospheres during said transfer.

3. A machine for treating iron ore which comprises a furnace having an upright shaft, means for charging said shaft with ore, two combustion chambers located one above the other intermediate the ends of said shaft adapted and arranged to discharge products of combustion of air and gas into said shaft to heat said ore,

means for maintaining an oxidizing atmosphere in that portion of the shaft opposite the upper combustion chamber, means for maintaining a reducing atmosphere in that portion of the shaft opposite the lower combustion chamber, means for quenching said heated ore, and means for preventing said heated ore from coming in contact with oxidizing atmospheres prior to said quenching.

4. A machine for treating ore which comprises an upright shaft arranged to permit the passage of ore therethrough by gravity, means for excluding atmospheric air and charging ore into the upper portion of said shaft, a quenching tank, means to regulate the transfer of ore from the lower portion of the shaft into said tank, means associated with said tank and shaft for excluding oxygen from the discharged ore, and means for introducing heated gases of predetermined composition intermediate the ends of the shaft for heating the ore.

5. A machine for treating ore which comprises an upright shaft arranged to permit the passage of ore therethrough by gravity, means for excluding atmospheric air and charging ore into the upper portion of said shaft, a quenching tank, means to regulate the transfer of ore from the lower portion of the shaft into said tank, means associated with said tank and shaft for excluding oxygen from the discharged ore, a by-pass communicating with the top and bottom portions of the shaft to conduct gases into said bottom portion, means for controlling the flow of gas through said by-pass for regulating the temperature of the discharged ore, and means for introducing heated gases of predetermined composition intermediate the ends of the shaft for heating the ore.

6. A machine for treating ore which comprises an upright shaft arranged to permit the passage of ore therethrough by gravity, means at the ends of the shaft to exclude atmospheric air therefrom, burners adapted and arranged to discharge heated gases of predetermined composition intermediate the ends of the shaft for heating the ore, a by-pass for transferring gases from the top to the bottom of the shaft, and means to transfer gases from the top of the shaft to said burners.

7. A machine for treating ore which comprises an upright shaft arranged to permit the passage of ore therethrough by gravity, means at the ends of the shaft to exclude atmospheric air therefrom, burners adapted and arranged to supply heated gases of predetermined composition intermediate the ends of the shaft for heating the ore, a by-pass for transferring gases from the top to the bottom of the shaft, and means below said burners to transfer heat from said heated ore to gases utilized in said burners.

8. A machine for treating ore which comprises an upright shaft arranged to permit the passage of ore therethrough by gravity, means at the end of said shaft to regulate the discharging of said ore, a quenching tank below said discharge arranged to contain quenching fluid, a hood enveloping said discharge and having an opening beneath the surface of said quenching fluid for excluding air from the shaft and from the ore during its transit from said shaft to said tank, a by-pass for conducting cooling gases into the lower end of the charged shaft, a combustion chamber having a discharge opening intermediate the ends of said shaft having means to burn combustible gases for heating the ore, means below said opening for preheating air for said chamber, and a by-pass connecting the chamber and the space above the charge having means for supplying diluent gas to said combustion chamber.

9. A machine for treating ore which comprises an upright shaft to permit the passage of ore therethrough by gravity having in enclosure at the top for providing a gas space, gas discharge means leading from said enclosure having means to regulate the discharge of gas, a by-pass connecting with the lower portion of the shaft and said enclosure having means to regulate a supply of a cooling gas to the charge, a combustion chamber for generating heated gases having an opening into the shaft intermediate the ends thereof, a by-pass connecting with said enclosure and the combustion chamber having means to regulate a supply of diluent gas to said chamber, and a muffle around the lower portion of the shaft having connections with a source of air and said combustion chamber for cooling the charge and preheating the air.

10. A machine for treating ore which comprises a furnace having an upright shaft, means for charging the shaft with ore, means intermediate the ends of the shaft for introducing hot gaseous products of combustion to heat the ore, means for varying the oxygen content and temperature of the atmosphere in the shaft, means for supplying air for combustion, means for preheating air used for combustion by transferring heat from the heated charge, means for transferring the heated ore into a quenching tank, and means for excluding oxidizing atmosphere from said ore during the transfer.

11. A machine for treating ore which comprises a furnace having an upright shaft, means for charging the shaft with ore, a plurality of combustion chambers on the shaft having openings for discharging hot products of combustion intermediately of the ends of the shaft to heat the ore, means for controlling the oxygen content and the temperature of the atmosphere in the shaft, a quenching tank, means for transferring the ore from the shaft to the quenching tank, and means for preventing the ore from coming into contact with oxidizing atmospheres during the transfer.

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