H. N. TRACY.

APPARATUS FOR REDUCING ORES.

APPLICATION FILED MAR. 1, 1917.

1,279,181.

Patented Sept. 17, 1918.

2 SHEETS—SHEET 1.

Fig. 1.

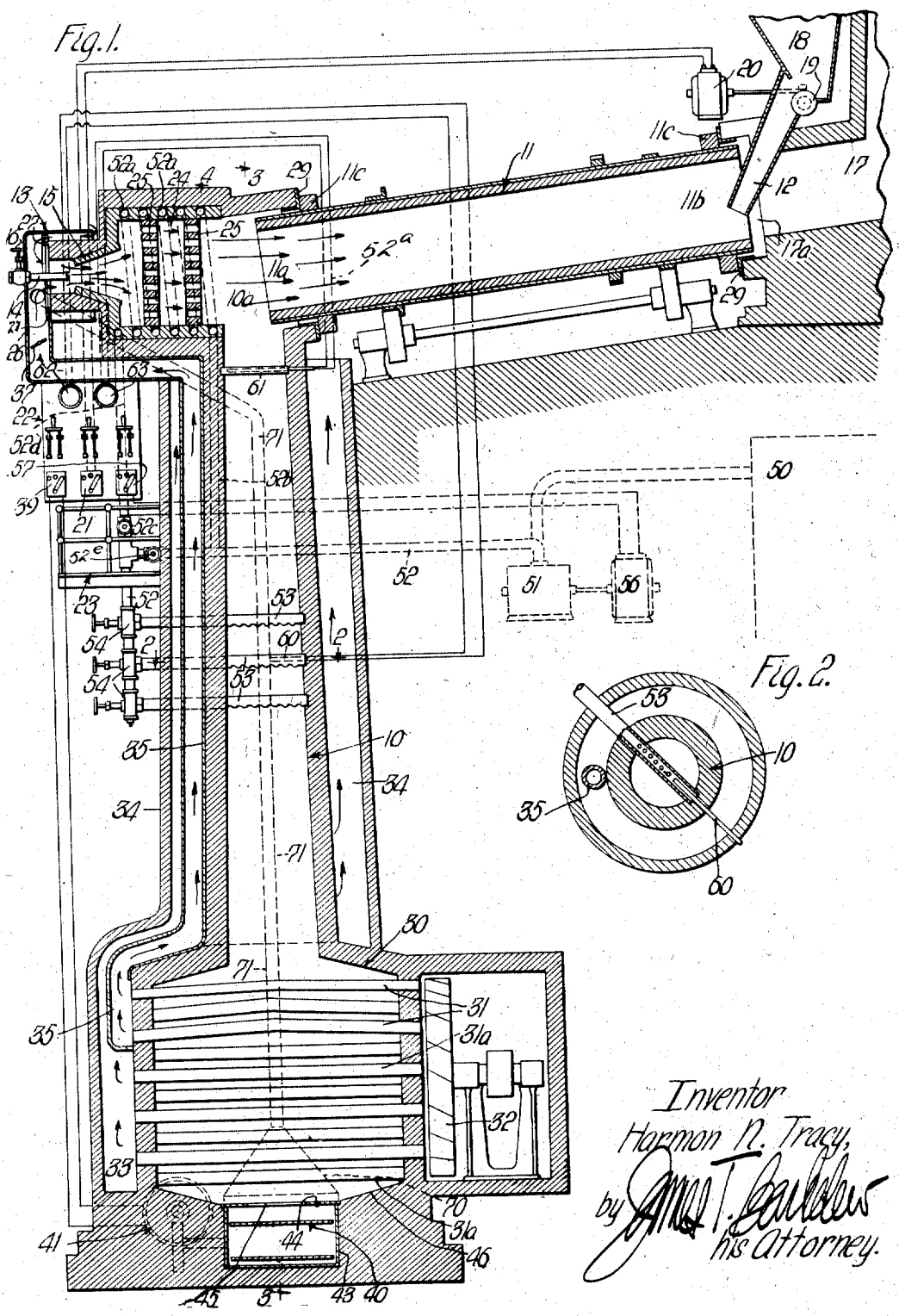


Fig. 2.

Inventor
Harmon N. Tracy,
by James T. Gardner
his Attorney.

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2 SHEETS—SHEET 2.

Fig. 3.

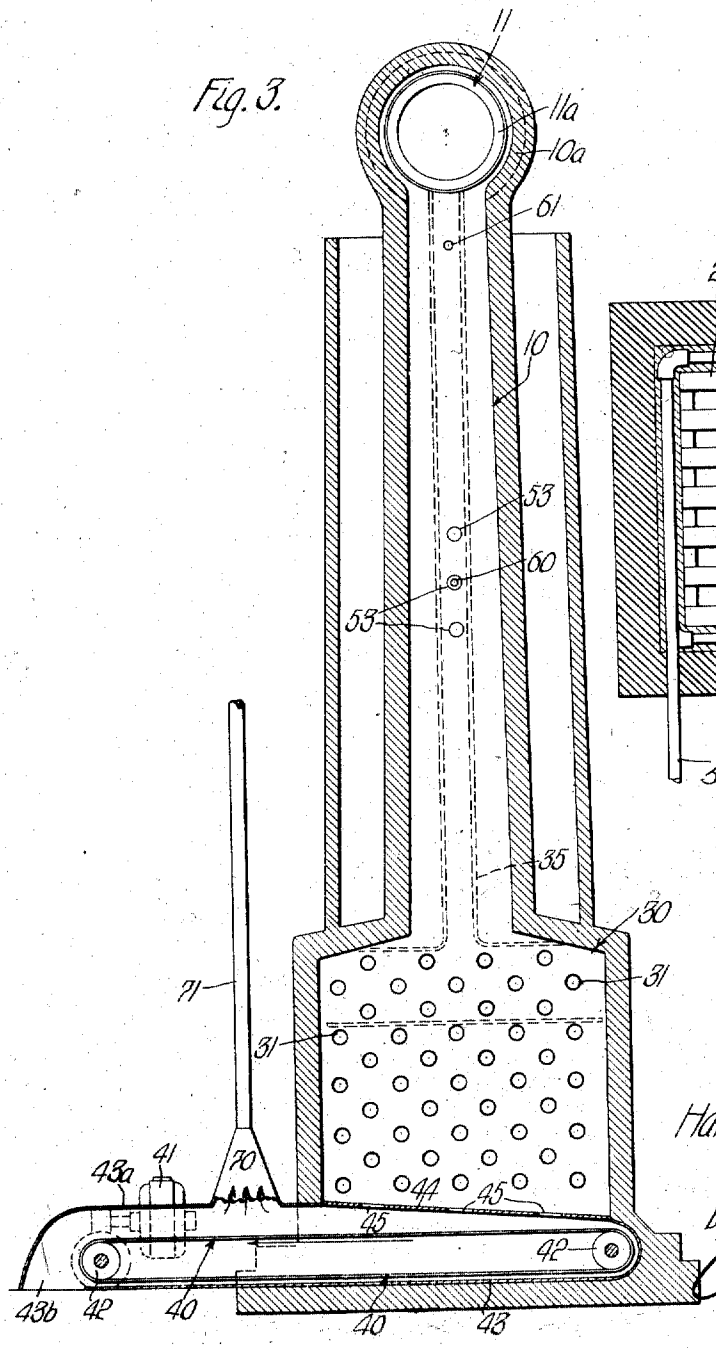
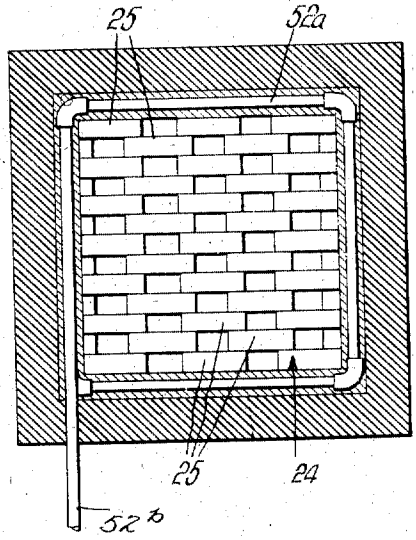


Fig. 4.



Inventor
Harmon N. Tracy,
by James T. Pendleton
his Attorney.

UNITED STATES PATENT OFFICE

HARMON N. TRACY, OF LOS ANGELES, CALIFORNIA.

APPARATUS FOR REDUCING ORES.

1,279,181. Specification of Letters Patent. Patented Sept. 17, 1918.

Continuation of application Serial No. 23,548, filed April 24, 1915. This application filed March 1, 1917 Serial No. 151,629.

To all whom it may concern:

Be it known that I, HARMON N. TRACY, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles, State of California, have invented new and useful Improvements in Apparatus for Reducing Ores, of which the following is a specification.

This invention relates to apparatus for reducing ores; and the object of this invention is to provide an improved apparatus of the general character shown in my application S. N. 23,548, filed April 24, 1915, on apparatus for reducing ores, and in my application S. N. 141,820, filed January 11, 1917, on apparatus for reducing ores; and to provide an improved apparatus for carrying on that process for reducing ores explained in my application S. N. 136,645, filed December 13, 1916. This application is a continuation in part of my said application S. N. 23,548; and whereas in my said application S. N. 141,820, I claim those features of my apparatus that refer particularly to the shape, formation, etc., of the ore reducing stack, the introduction of reducing agent, etc., in this present application I carry on and specifically claim those matters that, in my former application S. N. 23,548 referred particularly to combination of the stack with the cooling chamber and various other subsidiary parts. And, further, I herein explain and claim certain improvements in the apparatus over that shown in said application, S. N. 23,548.

My present invention will be best understood from the following detailed description of my improved and preferred form of apparatus. For this purpose reference is had to the accompanying drawings, in which: Figure 1 is a vertical section showing my improved apparatus; Fig. 2 is a cross section taken on line 2—2 of Fig. 1; Fig. 3 is a vertical section taken on line 3—3 on Fig. 1, and Fig. 4 is an enlarged section taken as indicated by line 4 on Fig. 1.

In the drawings I have shown a relatively long and narrow vertical ore stack 10. The stack is made slightly larger at the bottom than at the top in order to facilitate the free passage of ore downwardly therethrough without choking. It is one of the features of my invention that the ore passes through the stack 10 under gravitational influence in such a manner that the stack can be constantly kept full of ore; and for this purpose I prefer to make the stack vertical, although it may extend diagonally vertically and still have the advantage of the ore moving therethrough under gravitational influence. It will be noted that the stack continuously and uniformly expands from top to bottom and that it is free from top to bottom from constrictions or substantial obstructions of any sort. Some ores, upon being treated as herein provided, physically expand; and some ores become pasty, tending to clog and choke if there are any constrictions in the stack.

I provide a means for heating the ore which is delivered to the upper end of the stack and I prefer to heat the ore as close to the upper end of the stack as possible and to deliver the ore directly into the stack with the least loss of heat. Preferably, for this purpose, I provide a revolving roasting drum 11 of any preferred design, the discharge end 11^a of the drum projecting into the upper end 10^a of the stack. The drum is placed at a suitable incline so that ore fed into its upper end 11^b from the feed spout 12 will pass downwardly through the drum. A furnace or burner apparatus 13 supplies heat to the roasting drum, said burner apparatus preferably being in the form shown in Fig. 1, and embodying a fluid burner 14, for gas or liquids, discharging into a conical member 15, as illustrated, air being drawn into this member around the flame, as indicated in the drawings. Control of the burner is had by valve 16 or any other suitable means. The flame in the conical member 15 discharges into a furnace chamber 24 which may have one or more cross walls of brick checker-work, as indicated at 25. From this furnace chamber 24 the flame discharges across the upper end 10^a of the stack into the heating and roasting drum 11. The air for the furnace may be drawn in through a jacket 26 surrounding the outer part of the furnace structure, the air passing over the exterior part of the furnace and thereby being preliminarily heated; and the amount of air may be controlled by any suitable means, as by a damper located at 27, which is of the type found in U. S. Patent 246,606. A draft stack is shown at 17 connecting with the upper end of the roasting drum 11. The spout 12 leads from

any suitable bin 18 and the feed of ore is controlled by a revolving roller 19 operated by motor 20, which motor is controlled by a controller 21 on the switch board 22. Switch board 22 is mounted in a convenient position on the platform 23, said platform being preferably supported at the upper end of the stack. As hereinafter explained, the operation of my apparatus is under control of a single man on the platform 23.

The ends of the drum 11 preferably project into the upper end 10^a of the stack 10 and into the part 17^a of the draft stack 17; and the drum 11 is provided with joint closure rings 11^c of any suitable heat resistant material bearing against stationary flanges 29 on the parts 10^a and 17^a. The rings 11^c may be of asbestos or the like and are made to slip, more or less tightly, on the drum 11. As the drum expands longitudinally with the heat, the rings are shoved back from the ends of the drum and remain in position to bear against the flanges whenever the drum is heated to working temperature.

The drum 11 and furnace 13 not only perform the function of heating the ore directly prior to its delivery to the upper end 10^a of the stack 10, but also perform the function of roasting and oxidizing the ores which must preferably be changed to oxids before they are reduced in the reducing stack 10. However the ores are delivered to the drum 11, it will be presumed (for the purpose of this specification) that they are delivered to the upper end of the reducing stack in the form of oxids and the oxidized ores are discharged into the upper end of the reducing stack in suitably heated condition. The temperature of the ores is governed by conditions hereinafter stated. But for the certain ores, where sulfur is present, I may or may not oxidize; I may see to it that no excess air is present in the roasting drum.

At the lower end of the stack I provide an accumulating cooling chamber 30 of suitable capacity for holding such a quantity of reduced products that cooling can be effectually carried out before the final product is taken out to atmosphere; that is, cooling to a temperature below the point of oxidation. The cooling chamber 30 is at least as large as, and preferably larger than, the stack in horizontal section; so that no impediment is offered to the hot ore passing downwardly into the cooling chamber. In fact the cooling chamber may be described as a preferably enlarged lower extension or continuation of the stack. After the reduced ores are cooled they may then be removed from the cooling chamber through a constricted opening, there being then no special tendency to clog or choke. I prefer to arrange the cooling means as indicated in the drawings, comprising a number of transverse tubes 31 and 31^a rising toward the center as shown at 31, or may extend straight across the chamber as shown at 31^a. The inclined tubes aid in the even distribution of the material over the whole chamber 30. I prefer to make at least the upper rows of tubes in this shape. At one end of the tubes I may employ a blower fan 32 of any preferred design to provide a forced draft through the tubes; and the other end of the tubes may communicate with a chamber 33 from which a draft stack 34 arises. This draft stack extends upwardly around the central reducing stack; the natural draft therethrough may be utilized without the fan to draw air through the cooling tube; and the hot air passing upwardly through the draft stack aids materially in keeping the reducing stack at proper temperature and in keeping the ores at or near their original temperature as they move down the column; forming an insulation zone around the reduction stack. The ends of some of the uppermost tubes 31, the ones which are at the highest temperature, may connect with a draft pipe 35 which extends upwardly and discharges into the air jacket 26 of furnace 13. The air thus delivered to the furnace is highly heated; and I may preferably supply all the air to the furnace 13 in this manner, providing a damper 37 which may be controlled by the operator on platform 23. The heat carried into the furnace by this heated air is thus utilized in the heating and roasting process in the drum 11. It will be noted that, by the arrangement herein described, I return a considerable part of the heat carried by the reduced products to the unreduced ores, this part of the heat remaining in the system and not being lost.

At the lower end of the cooling chamber 30 I place a suitable discharge conveyer 40 operated by motor 41 controlled by suitable controller 39 on switch board 22. When my apparatus is in operation the attendant on the platform 23 has full control of the introduction and withdrawal of ore to and from the stack 10; and by regulating the introduction and withdrawal he also regulates the rate of flow of ore through the stack, and thus regulates the time period for passage of ore through the stack and through the reduction zone; this time period being dependent upon the time element of the reducing action; and this time period also depending, in any given plant, or for different classes of ores, on the time elements of heating, oxidizing and cooling. The introduction and withdrawal are so regulated that, with the proper rate of flow, the stack 10 is kept constantly full of ore which moves downwardly under the influence of gravitation at a uniform rate, moving downwardly into the reduction zone and then on downwardly out of the reduction zone into the

cooling chamber below, and thence out through the conveyer 40 into any suitable conveying means or storage bins or the like. The conveyer 40 may preferably be a belt or link chain conveyer running over drums 42, within an inclosing casing 43. This casing has a sloping perforated upper wall 44 having spaced openings 45 through which the cooled reduced ore passes onto the belt conveyer. It will be noted that the openings are situated at progressively greater heights above the belt (in the direction of progress of the belt), so that at each opening a certain restricted amount of material will be taken out; and thus material is removed fairly equally from all parts of the cooling chamber. The cooling chamber has lateral sloping bottom walls, as shown at 46, sloping down to the part 44.

The re-agent employed for reduction may be varied to suit particular requirements; I have preferred to show and describe herein a means for introducing hydro-carbon, coal or water gas or the like to the central parts of the reduction stack 10. I may employ a holder or tank 50 into which the prepared gas is passed and from which the gas is taken by a suitable compressor or blower 51 and forced through the pipe 52 to the distribution pipes 53. Or the gas may be supplied under proper pressure and temperature and in suitable quantity from any convenient source; as, for instance, direct from a gas producer of any kind. I prefer to heat the reducing agent, which may be done by utilizing heat from the furnace (and therefore also from the cooling ores, because, as herein explained, heat from the cooling ores is conducted to the furnace). This is done by passing the gas through a coil 52^a surrounding the furnace chamber 24, embedded in the furnace walls. A branch pipe 52^b leads from pipe 52 to the coil 52^a, and another pipe 52^d leads back to a pipe 52 and is controlled by valve 52^c. A valve 58^e is placed on pipe 52 between its points of connection with pipes 52^b and 52^d. By proper manipulation of these valves the gas may either pass directly from pipe 52 into the distributing pipes 54, or may pass first through coil 52^a, or may be divided and pass both ways. The gaseous reagent thus is heated with heat that would otherwise be lost by conduction and radiation. Heating the reducing agent obviates the necessity of heating the ore to an excessive temperature and enables me to operate the furnace 15 at the temperature required only to give the ore at the top of the stack a temperature approximately, or slightly above, the temperature at which the reduction takes place. Introducing an unheated reagent causes usually cooling of the ore at the point of introduction and necessitates original heating to a higher temperature, with consequent inefficiency. Considering the column of ore and material as a whole from its upper end to its lower end at the bottom of cooling chamber 30, the pipes 53 are preferably arranged somewhat above the center; so that the path of less resistance for the reducing gas is upward. I may arrange a plurality of sets of pipes 53, controlled by suitable valves 54, so that the reducing gas may be admitted to any or all of the sets. The exact point of introduction of the gas is controlled by the proper manipulation of the valves 54, while the amount of gas supplied may be regulated and controlled by controlling the compressor driving motor 56 from the controller 57 on switch board 22. Proper pressure is maintained on the gas to cause its distribution through the ore in the reducing zone at the central portions of the stack and to cause displacement and exclusion of the atmosphere. In actual operation the pressure required on the reducing gas to diffuse it throughout the reducing zone is sufficient to cause some unused gas to pass down, along with the gaseous products of reduction, into the lower part of the stack and the cooling chamber. This mixture of gases is discharged along with the reduced ore at the discharge conveyer 40; and the gases are then caught in a hood 70 (or are separated from the ore by any convenient means) and are conducted through a pipe 71 to the furnace where the unused portions are burnt as fuel. It will be understood that at all points of the column of ore, from top to bottom, there is a gaseous pressure greater than atmospheric pressure; and this pressure effectually prevents entrance of atmospheric air at 40. The casing 43 surrounds the conveyer 40 and is made to form an effective gas-tight hood 43^a to the upper part of which the hood 70 connects. It will be noted that the ore discharge opening 43^b is well below the hood 70, so that no gas may escape; and this not only makes for efficiency but also for preventing the discharge of the gases around the stack where they are dangerous to the workmen. The size of pipe 71 is such as to carry off the gases by the draft of the furnace on pipe 71; and pipe 35 is of sufficient size, with relation to the sizes of the pipes 31 which communicate therewith, to carry off the air from those pipes.

The amount of gas to be supplied must be sufficient to reduce the ore within the time period taken for the ore to pass vertically through the reduction zone. The reduction zone is that zone in which the reduction gas, spreading both upwardly and downwardly from the pipes 53, re-acts upon the ore to cause its reduction. Below the reduction zone there is a constantly downwardly moving stream of reduced ore. As hereinbefore stated, the ore delivered from the roasting drum is in suitably heated condi-

tion; and the operator keeps the temperature of the ore at the most efficient point, that is, at that temperature at which reduction will most efficiently take place. To enable an accurate control of the temperature I may provide pyrometers having indicators 62 and 63 on switch board 22. The operator can accurately control the temperature so as to obtain the proper temperature at and in the reduction zone; whether the total reduction action, including the breaking up of the oxids and the combination of their oxygen with the reducing agent, is exothermic or endothermic in its nature. In the one case the ore above the reduction zone is further heated by the surplus of heat arising from an exothermic action; while in the other a surplus of heat must be supplied from the furnace 13. The outward spread of the reducing gas in the relatively narrow stack drives out and displaces atmospheric air and thus excludes free oxygen entirely from the reducing zone and from the whole stack. When the apparatus is in full operation, the cooling chamber becomes filled with gases from the reduction zone, and the metal is thus cooled in the presence of a non-oxidizing gas.

In my process there is a continuous treatment of the ore, embodying a continuous step of heating, roasting or oxidation, followed by a continuous step of reduction in the manner described, followed by continuous cooling. As herein explained, one of the particular features of my method is the reduction step, wherein I form a constant, continuous column of pre-heated ore and form within that column a zone throughout which a reducing agent is distributed under pressure sufficient to permeate the column and to displace and exclude atmospheric air.

It is a feature of operation that this column is not constricted at any point and that it gradually and uniformly expands from top to bottom. My method involves the use of no excessively high temperatures, and of no great variations of temperature. In fact, the temperatures throughout my method are very close to the total average, and the average temperature is fairly low. The ores are initially heated to no higher point than necessary to completely carry on the action of reduction; and, as hereinbefore stated, I preheat the reducing agent for this purpose. Introduction of hot gas, rather than cold, has the effect of keeping up the temperature of the downwardly moving ore and of keeping the ore at the reaction temperature longer than would otherwise be possible. I keep as much heat as possible within the system of operations. The air jacket surrounding the stack carries heat from the cooling reduced ores to the ore column, materially preventing loss of heat from the ores passing downwardly in the column. Heat is also conveyed from the cooling ores to the roasting surface, and thus conveys heat to the ores at the point of preheating.

Having described a preferred form of my invention, I claim:

1. Ore reducing apparatus, embodying a relatively long and narrow vertical stack substantially unobstructed and free from constrictions from end to end so that ore may move therethrough under gravitational action, means for heating ore at the upper end of the stack and for introducing the heated ore to the upper end of the stack, means for withdrawing ore from the lower end of the stack, means to introduce a fluid reducing agent to the stack and ore column near its central portion, means at the lower end of the stack to cool the ore, and means for transferring heat from the cooling ore to the ore being heated.

2. Ore reducing apparatus, embodying a relatively long and narrow vertical stack substantially unobstructed and free from constrictions from end to end so that ore may move therethrough under gravitational action, means for heating ore at the upper end of the stack and for introducing the heated ore to the upper end of the stack, means for withdrawing ore from the lower end of the stack, means to introduce a fluid reducing agent to the stack and ore column near its central portion, said stack having at its lower end a cooling chamber of larger size than the stack and the stack discharging into the cooling chamber without constriction.

3. Ore reducing apparatus, embodying a relatively long and narrow vertical stack through which ore may gravitate, fuel burning furnace means for heating the ore and delivering it into the upper end of the stack, means for withdrawing ore from the lower end of the stack, means to introduce a fluid reducing agent to the stack and ore column near its central portion, means at the point of withdrawal of the ore to carry off the gases withdrawn with the ore, and means to direct said gases into the ore heating furnace.

4. Ore reducing apparatus, embodying a relatively long and narrow vertical stack through which ore may gravitate, means for heating the ore and delivering it into the upper end of the stack, means for withdrawing ore from the lower end of the stack, means to introduce a fluid reducing agent to the stack and ore column therein, cooling means for the ore at the lower end of the stack, and means to direct heat from the cooling ore to the ore column in the stack.

5. The herein described method of reducing ores, embodying first continuously heating the ore, then continuously introducing the heated ore into a vertical column of heat-

ed ore of substantially uniform diameter from top to bottom and free from constrictions, continuously introducing a reducing agent near the central part of the column of ore and continuously withdrawing reduced ore at the bottom of the column, the rate of introduction and withdrawal of the ore being such as to keep the column of ore constant, continuously cooling the ore at the bottom of the column, and transferring heat from the cooling ore to the ore being heated.

6. The herein described method of reducing ores, embodying first continuously heating the ore, then continuously introducing the heated ore into a vertical column of heated ore of substantially uniform diameter from top to bottom and free from constrictions, continuously introducing a reducing agent near the central part of the column of ore and continuously withdrawing reduced ore at the bottom of the column, the rate of introduction and withdrawal of the ore being such as to keep the column of ore constant, continuously cooling the ore at the bottom of the column, and transferring heat from the cooling ore to the ore being heated and keeping up the temperature of the ore in the column by heat transferred from the cooling ore.

7. The herein described method of reducing ores, embodying first roasting the ore and heating it to a temperature approximately that of the reduction of its metal, then subjecting the ore to the action of a reducing agent, then cooling the ore, and insulating the ore being reduced by a jacket of fluid carrying heat from the cooling ore.

8. The herein described method of treating ores, embodying first continuously heating the ore, then continuously introducing the heated ore into a vertical column of heated ore, continuously introducing a reducing agent near the central part of the column, continuously withdrawing reduced ore at the bottom of the column, and withdrawing gases at the bottom of the column and burning those gases to initially heat the ore.

9. The herein described method of reducing ores, embodying first continuously heating the ore to a temperature approximately that of the reduction action of its metal, then continuously gravitating the ore through a vertical column of ore having no constrictions from top to bottom, continuously introducing a fluid reducing agent at ordinary temperatures to the central part of the ore column under pressure to displace and exclude atmosphere, and continuously withdrawing reduced ore from the lower end of the column, the introduction and withdrawal of ore being regulated so as to keep the column constant.

In witness that I claim the foregoing I have hereunto subscribed my name this 21st day of February, 1917.

HARMON N. TRACY.

Witnesses:
ELWOOD H. BARKELEW,
VIRGINIA BERINGER.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."