No. 817,414. PATENTED APR. 10, 1906.

H. F. BROWN.

PROCESS OF REDUCING ORES.

APPLICATION FILED OCT. 24, 1905.

2 SHEETS—SHEET 1.

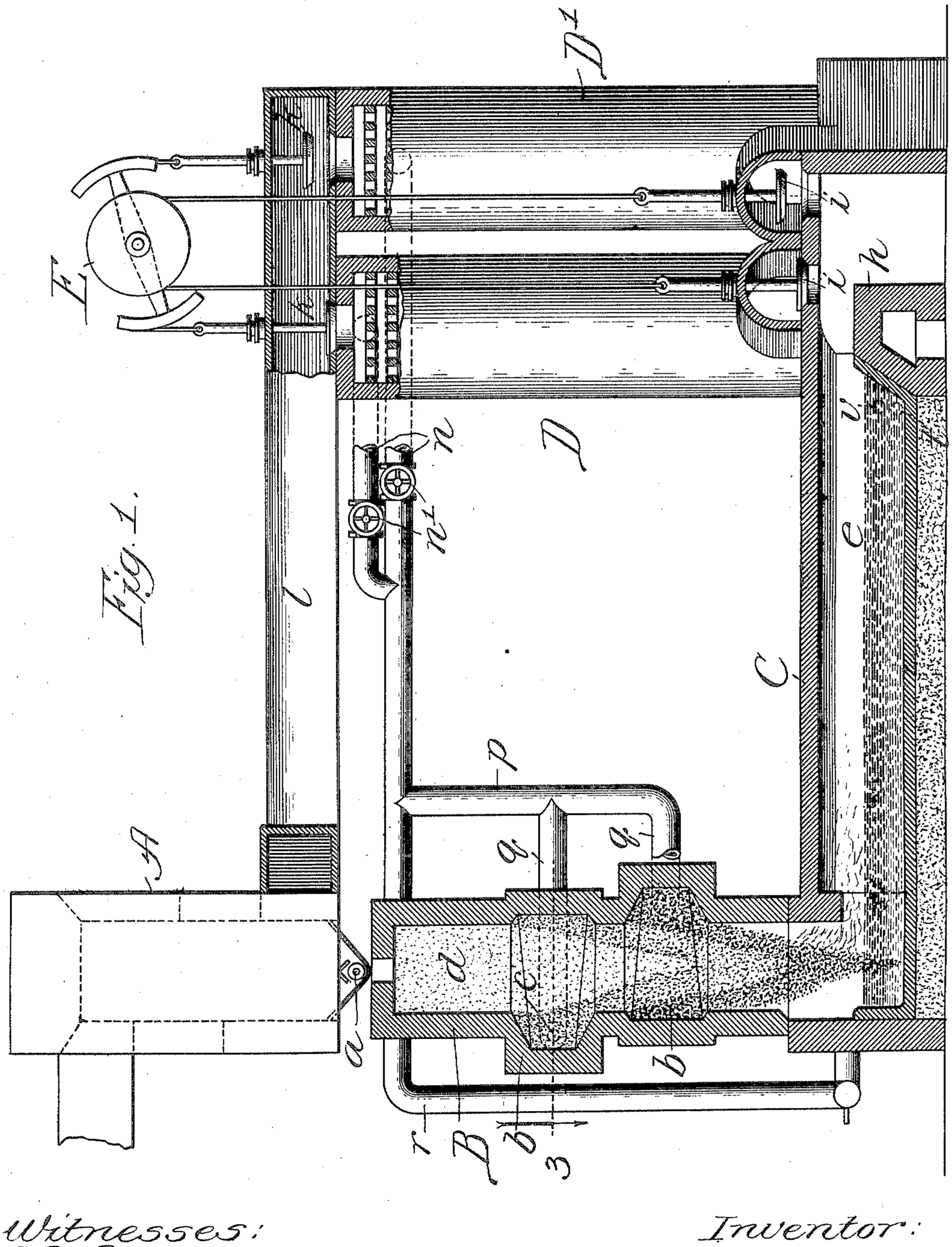

Fig. 1.

Witnesses:
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John Enders.

Inventor:
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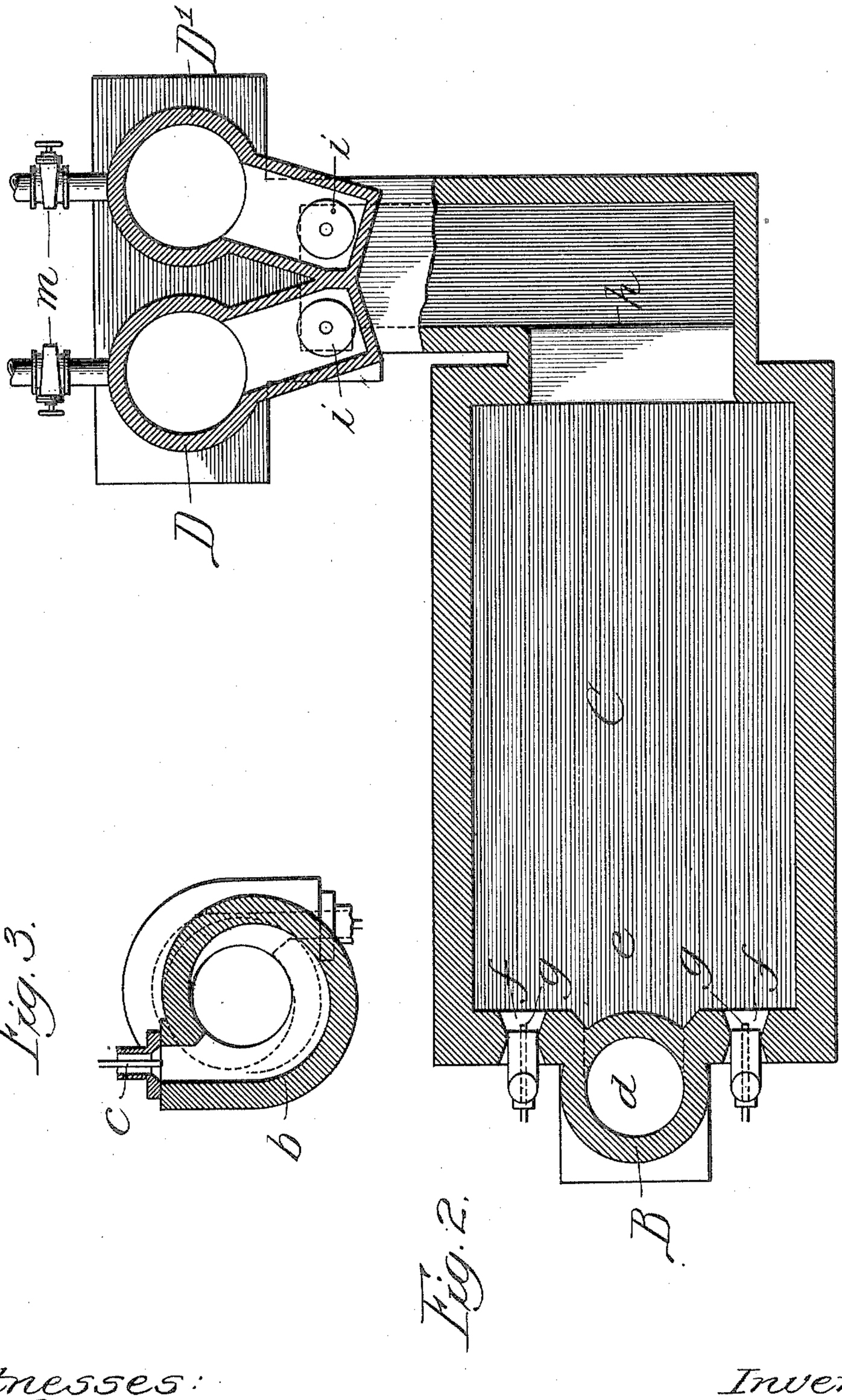

Fig. 2.

Fig. 3.

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UNITED STATES PATENT OFFICE.

HORACE F. BROWN, OF CHICAGO, ILLINOIS.

PROCESS OF REDUCING ORES.

No. 817,414. Specification of Letters Patent. Patented April 10, 1906.

Application filed October 24, 1905. Serial No. 284,238.

To all whom it may concern:

Be it known that I, HORACE F. BROWN, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Processes of Reducing Ores, of which the following is a specification.

My invention relates to the treatment of granular or pulverulent metallic oxids, as well as finely-divided ores, in which the values readily oxidize or are in the form of or are closely associated with metallic oxids, my object being to provide an improved method of reducing and saving such values in the large way, which method for its practical operation on a commercial scale requires but a comparatively simple and inexpensive equipment and can be carried on with peculiar economy in the matter of fuel consumption, losses by volatilization, mechanical dust losses, and operating expenses, while producing eminently satisfactory results.

My invention has reference more especially to the treatment by smelting of finely-divided ores of iron, copper, lead, and zinc, such as flue-dust, mill-dust, fine concentrates, oxid of iron sands, and the like.

In carrying out my invention I feed the ore into the upper part of a vertical stack, there subjecting the particles while in suspension and in a more or less segregated state to the action of a reducing atmoshpere moving in the same direction as the ore, which renders the latter fluid or semifluid. I then cause the deoxidized ore to enter beneath a protecting-covering of molten slag in a reverberatory furnace or forehearth, where the deoxidized values are subjected to further heating to complete their fusion, if necessary, and where final separation takes place out of contact with the oxidizing atmosphere necessarily present in the reverberatory furnace. In practicing my invention carbonating and slag-producing ingredients may be fed with the ore to the stack, if desired.

In the accompanying drawings I show apparatus of one approved form suitable for carrying out my improved method.

Referring to the drawings, Figure 1 is a broken partly sectional elevation showing a stack with means for feeding the ore and supplying the heat thereto, a reverbatory furnace or forehearth, and regenerating means through which air to support combustion in the stack and reverberatory furnace is preparatorily passed; Fig. 2, a broken section through the lower part of the stack, the reverberatory chamber, and regenerating apparatus or stoves; and Fig. 3, a broken plan section taken on line 3 in Fig. 1.

A represents an ore-feeding hopper of any suitable form, means being provided, such as the worm-feed *a* indicated, for discharging the finely-divided ore from the hopper A into the top of the furnace-stack B at a predetermined rate. The stack B is constructed, to all intents and purposes, like the stack shown and described in Letters Patent of the United States No. 774,930, granted to me November 15, 1904, though in the present drawings I show two combustion-chambers *b b*, one below the other and each provided with a single hydrocarbon-burner *c*. The burners enter the chambers tangentially to produce a whirl of the hot products of combustion. Between the upper combustion-chamber and top of the stack is a chamber *d*, through which the ore drops to the upper combustion-chamber through a substantially quiescent or non-whirling atmosphere in order that during the first subjection of the ore particles to heat they may remain in a more or less segregated state. Thus, as explained in my aforesaid patent, the fine particles of ore pass first through a non-whirling atmosphere and are then subjected to the action of a whirling heated atmosphere moving in the downward direction. In the chamber *d* the particles of ore are therefore subjected to a preliminary highly-heating atmosphere, so that on reaching the first combustion-chamber *b* they may be in condition to be quickly deoxidized by the action of the reducing-gases produced by the combustion of the carbonaceous fuel. The action of the whirling reducing atmosphere upon the ore is to produce a vortex, which tends to cause the ore particles to come into physical contact with each other, so that chemical reactions take place, producing the necessary slags for separating the waste material from the metal. This action is enhanced and continued in the present construction by the second or lower combustion-chamber *b* and its hydrocarbon-burner. The stack B is provided of a height and the ore-feeding mechanism and hydrocarbon-burners are so arranged with relation to each other that approximately complete reduction of the ore particles will take place before they reach the lower end of the stack.

C is a forehearth or reverberatory furnace,

into one end or side portion of which in the present embodiment of my invention the stack discharges. At opposite sides of the lower end of the stack in the chamber *e* of the reverberatory furnace are hot-air inlets *f*, which may be supplemented by hydrocarbon-burners *g*, as indicated. At the opposite end of the chamber *e* is a bridge-wall *h*, forming with the front and side walls of the chamber a basin or hearth. Gases from the chamber *e* pass over the bridge-wall *h* and through stoves or regenerators D D′ alternately in a common manner, valves *i* being provided at the lower ends of the stoves and valves *k* at the upper ends thereof, all suspended from a rocking pulley-and-arm device E. In the turning of the device the valves *k i* of one stove are closed, while the same valves of the other stove are opened. Both of the stoves discharge the gases passing through them into a common conduit *l*, leading in a suitable manner through the hopper A to preliminarily dry the ore stored therein. The stoves are provided at their lower ends with valved air-inlets *m*, and at the upper ends of the stoves are air-outlet pipes *n*, provided with valves *n′*, the said pipes leading to a common pipe *p*, communicating through branch pipes *q q* with the hydrocarbon-burners *c*. A pipe *r* extends from the pipe *p* to the air-inlets *f f*.

It is a fact that the oxids of all metals when in a finely-divided state are deoxidized very quickly when subjected to a reducing atmosphere at a high temperature. It is also a fact that deoxidized metal particles become instantly oxidized when subjected under a high temperature to an oxidizing atmosphere in any form. For this reason it is vitally necessary for the purpose of carrying out my method that during the period between reduction and final separation of the metal constituent from the gangue or matrix the metal shall be protected from contact or association with an oxidizing-atmosphere or agent. In carrying out my invention with the apparatus shown a bath of molten slag is maintained in the hearth of chamber *e*, and as the deoxidized ore enters the hearth from the stack it is caused to fall into the said bath. Being of greater specific gravity than pure slag, the deoxidized metal naturally sinks into the bath as it enters the hearth from the lower end of the stack, and the construction is such that a suitable extension of the chamber or forehearth *e* of the full width of the forehearth or narrower, as shown, projects beneath the stack, in which the deoxidized ore falls to become buried beneath the slag before flowing along the forehearth. Entering the forehearth with the ore from the stack is naturally an excess of carbon with the gas, which passes over the slag-level on entering the forehearth and there expands and becomes mingled with the excess of oxygen from the hot-air inlets *f*. This action produces complete combustion and high temperature in the forehearth, which keeps the slag and metal beneath the slag in a highly fluid state while substantially complete separation by gravity of the metal from the slag-making impurities is taking place. In the lower part of the hearth in the position shown is a tap-hole *t*, and at a higher level is a tap-hole *v*. When the separated metal reaches the level of the opening *v*, the taps may be opened to draw off slag and metal, as desired, care being employed, of course, to leave a sufficient protecting layer of slag for the metallic contents of the bath.

It will be seen from the foregoing description and the construction shown that ore may be fed continuously to the stack and that the metal and slag may be withdrawn continuously or as desired from the forehearth, thus causing my invention to operate as a continuous method of ore reduction.

Different ores capable of reduction in accordance with my improved method would naturally require variations in the matter of mixes and handling in the furnace. In the treatment of finely-divided oxid of iron ores, for example, the iron and silicon particles with an added excess of lime particles as they rain in a more or less segregated state downward through the preliminary heating atmosphere are raised to a temperature which causes the oxid of iron particles to be in a condition ready for deoxidation. The deoxidizing or reducing action may commence at the upper combustion-chamber, where the particles first meet the reducing-flame of the upper burner. The space in the stack from the upper combustion-chamber to its lower end is, in fact, a reducing-chamber, care being employed in the practice of this method to prevent any excess of oxygen from entering at the burners. The reduction of the iron oxids should be made as complete as possible in the stack by subjecting them to a strong reducing atmosphere at a suitable high temperature, whereby in the descent of the ore the lime will combine with the silica and alumina of the charge, forming a silicate of lime and alumina, and the iron will reach the lower end of the stack as metal. The excess of lime forms a basic slag, so that when the reduced iron is once beneath the surface of the bath it is protected more or less completely from all oxidizing action. The molten metal and slag impurities mixed therewith rain into the bath, while the carbonaceous reducing gases, as aforesaid, flow from the lower end portion of the stack into the forehearth over the surface of the bath. Here the gases expand and mingle with the highly-heated oxidizing-gases from the inlets to the forehearth, causing further and more or less complete combustion which tends to further heat the bath. The flow of reducing-gases from the stack into the forehearth pre-

vents the deoxidized metal from meeting with any reoxidizing influence before it plunges into the bath, and before flowing outward beyond the air-inlets it will have sunk beneath the protecting-covering formed by the molten slag. Here separation by gravity takes place, and under proper conditions substantially all of the metal may be saved.

In the treatment of finely-divided lead and copper oxids by my improved method a much lower temperature should be maintained in the stack than for the treatment of iron oxids as described. While descending through the stack the impurities would be formed into slag of which iron, silica, and lime would form the main constituents. The reducing gases and heat should be so regulated that the iron would not be deoxidized, but would be caused to unite with the lime and silica, forming a slag consisting of silicate of lime and iron, while the oxids of lead or copper are being reduced to the metallic state. In this operation, as in the case of the treatment of iron oxids, as described, the slag would form a protecting-covering in the forehearth during final separation by gravity of the lead or copper from the impurities.

The presence of two combustion-chambers, one above the other as shown and described, makes it possible, when desired, to carry a very high temperature in the upper combustion-chamber with little or no reducing-atmosphere and to develop an excess of reducing-gas at the lower combustion-chamber.

It will be understood from the foregoing description that the gist of my invention lies in a process of treating finely-divided ore or mixture containing metallic oxids or metal readily oxidizable in the molten state, the process consisting in subjecting the ore or mixture while in atmospheric suspension to a reducing fusing-atmosphere, or first to a highly-heating and then to a reducing-atmosphere, then causing the reduced metal to enter beneath the protecting-surface of a molten bath without subjection to an oxidizing or reoxidizing influence and causing the reducing-gas, which descends through the stack, to expand and mingle over the bath with a highly-heated oxidizing atmosphere to further combustion and heat the bath while separation of the metal from its slag-producing impurities is taking place beneath the said protecting-covering.

What I claim as new, and desire to secure by Letters Patent, is—

1. The process of treating finely-divided ore, containing a metal readily oxidizable in the molten state, which consists in subjecting the ore while in atmospheric suspension to a reducing-atmosphere, then causing the reduced metal to pass, without subjection to an oxidizing influence, beneath the surface of a molten bath which protects the metal against oxidation while separating from the slag-making constituents of the ore.

2. The process of treating finely-divided ore, containing a metal readily oxidizable in the molten state, which consists in subjecting the ore while in atmospheric suspension to a preliminary heating atmosphere and then to a reducing-atmosphere, and at the same time bringing the particles of ore into approximate physical contact, then causing the reduced metal to pass without subjection to an oxidizing influence beneath the surface of a molten bath which protects the metal against oxidation while separating from the slag-making constituents of the ore.

3. The process of treating a finely-divided mixture of metallic oxides and slag-making impurities, which consists in subjecting the material while in atmospheric suspension to the action of a reducing-gas moving in the same direction, and during such subjection bringing the particles of the mixture into approximate physical contact, then causing the reduced material to pass without subjection to an oxidizing influence into a molten slag-covered bath, and at the same time causing the reducing-gas to mix over the surface of the bath with an excess of oxygen to further its combustion and heat the bath, then permitting separation by gravity of the metal from the slag-making impurities while protected by the said slag covering from the oxidizing atmosphere.

HORACE F. BROWN.

In presence of—
A. U. THORIEU,
J. H. LANDES.