No. 821,190. PATENTED MAY 22, 1906.

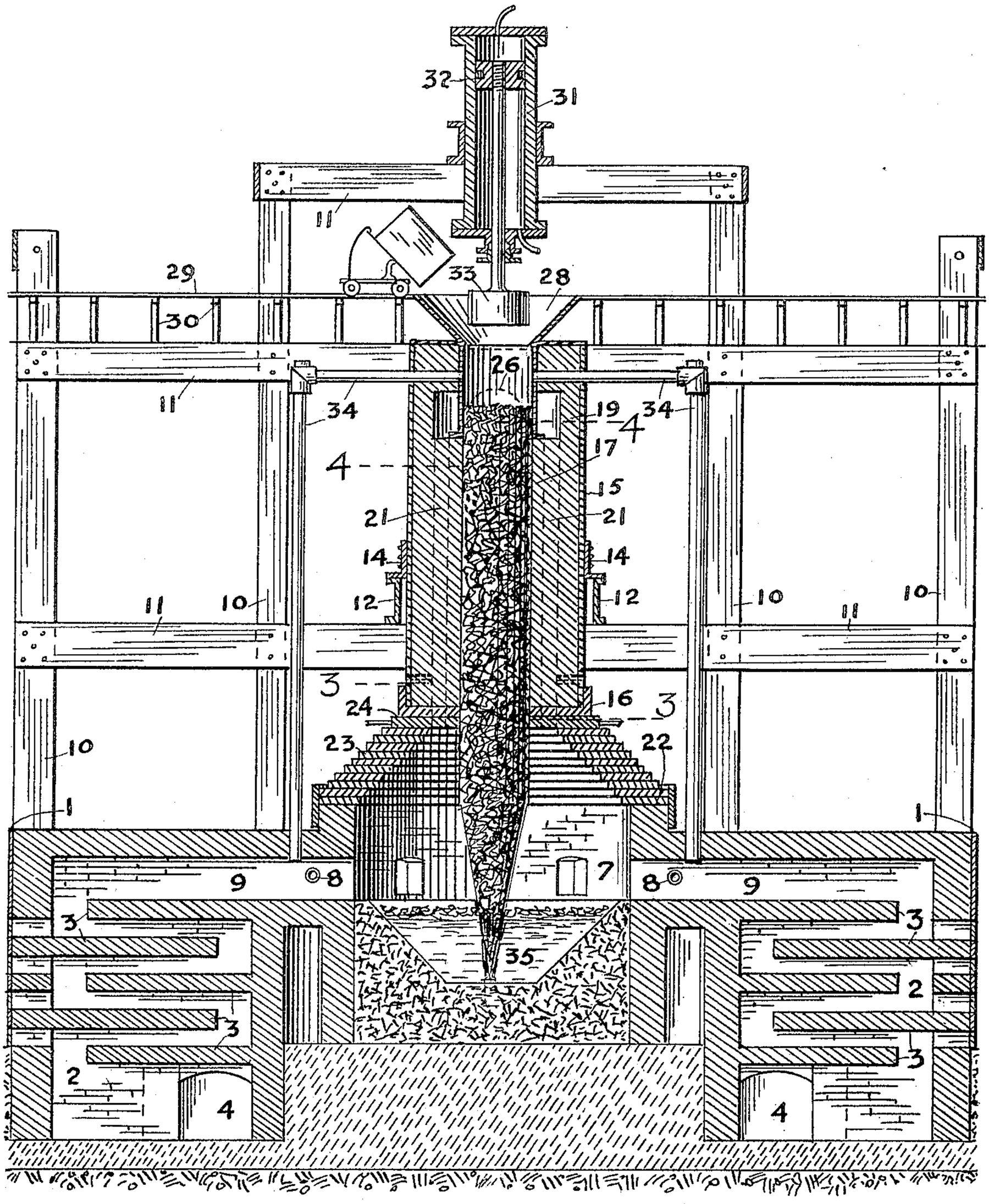
J. A. POTTER.

APPARATUS FOR SMELTING ORES.

APPLICATION FILED JUNE 27, 1905.

4 SHEETS—SHEET 1.

FIG. 1

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4 SHEETS—SHEET 2.

FIG. 3

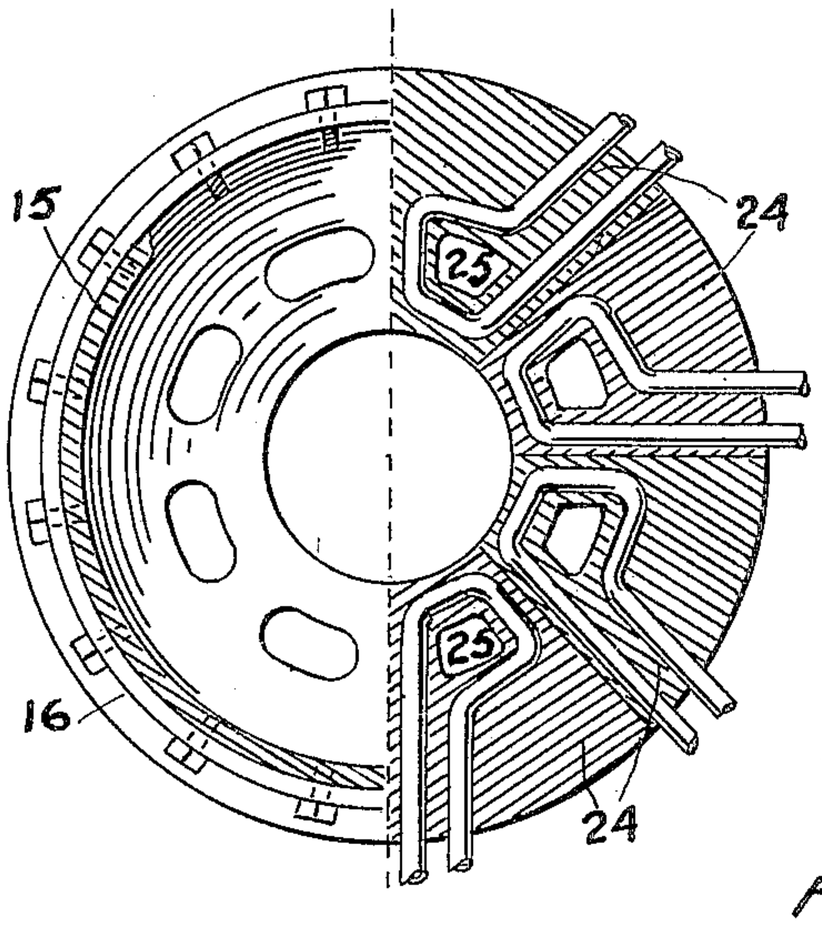



FIG. 4

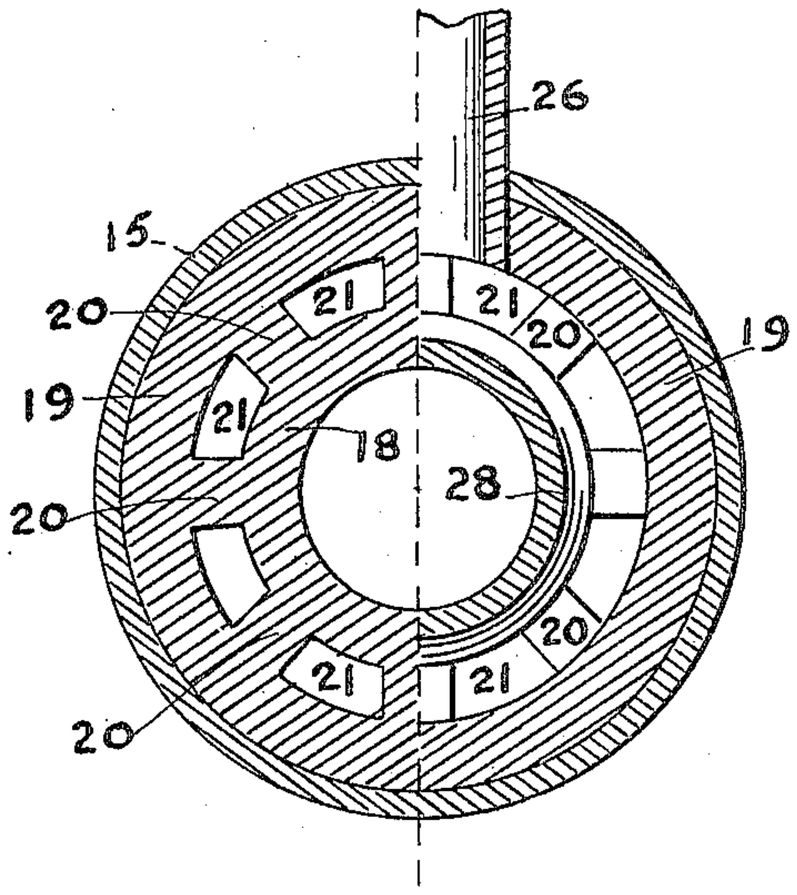
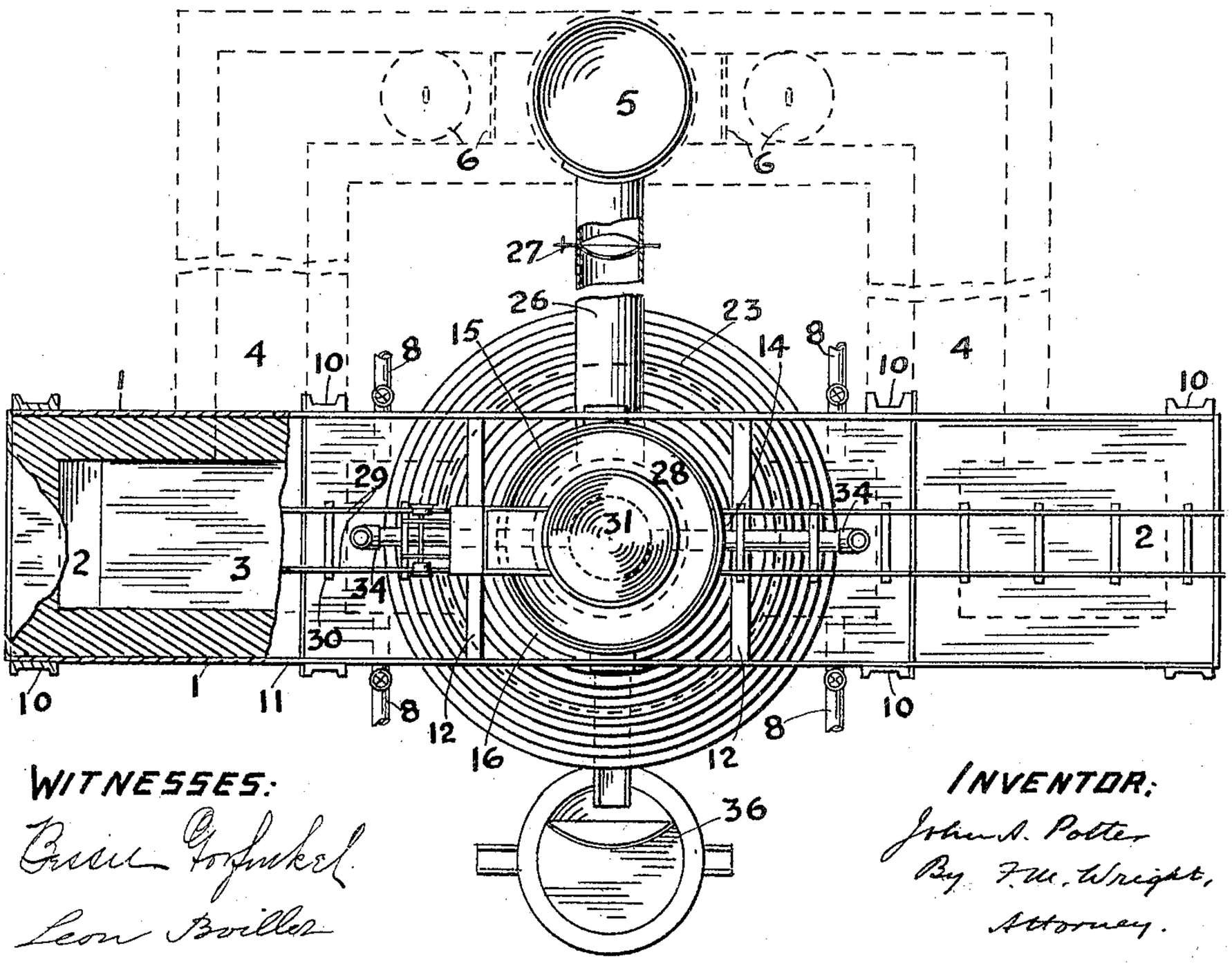



FIG. 2

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4 SHEETS—SHEET 3.

FIG. 5

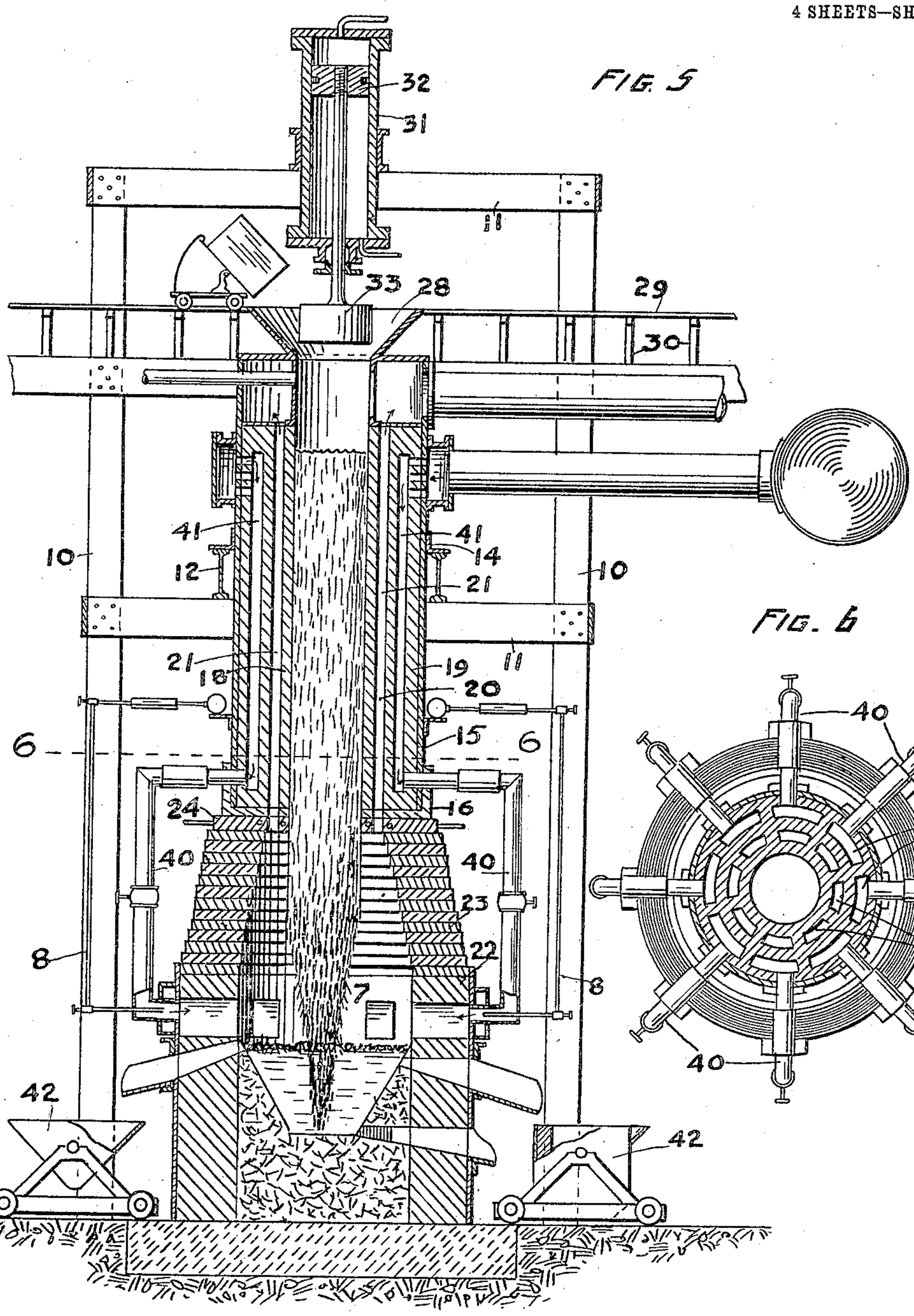


FIG. 6




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4 SHEETS—SHEET 4.

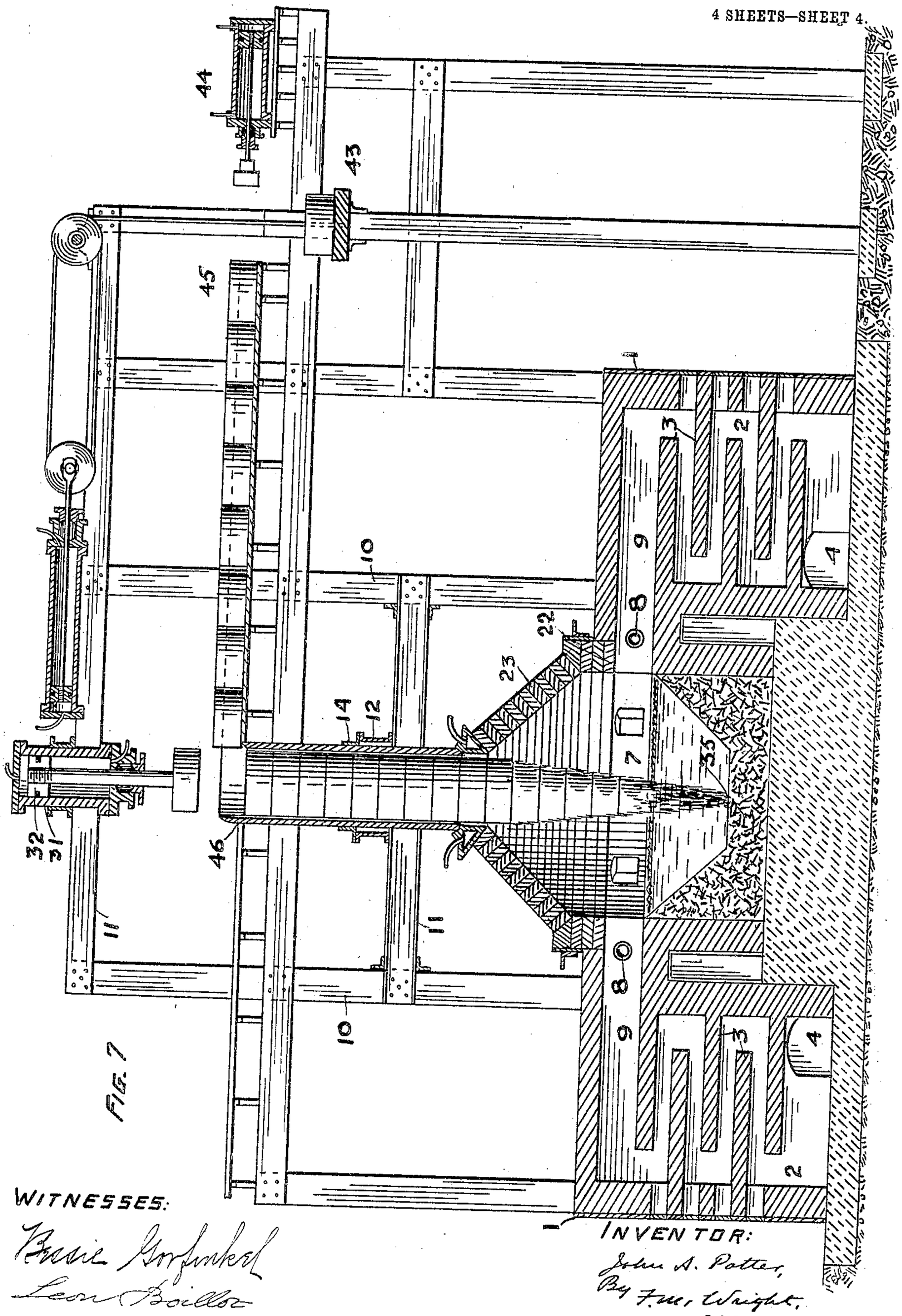


FIG. 7

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# UNITED STATES PATENT OFFICE.

JOHN A. POTTER, OF SAN FRANCISCO, CALIFORNIA.

## APPARATUS FOR SMELTING ORES.

No. 821,190. Specification of Letters Patent. Patented May 22, 1906.

Application filed June 27, 1905. Serial No. 267,303.

*To all whom it may concern:*

Be it known that I, JOHN A. POTTER, a citizen of the United States, residing at San Francisco, in the county of San Francisco and State of California, have invented certain new and useful Improvements in Apparatus for Smelting Ores, of which the following is a specification.

This invention relates to an improved apparatus for smelting ores, particularly ferriferous ores, the object being to provide an apparatus by which, first, the smelting may be conveniently accomplished on a large scale with the use of fluid fuels, such as petroleum-oils or fuel-gas; secondly, with which a compact and economical apparatus may be used; thirdly, in which the operation may be substantially continuous, and, fourthly, in which the cost of smelting shall be reduced to a minimum, principally from the economical proportioning and application of the amounts of fuel used, respectively, for reducing the oxids and for the application of the heat of fusion.

In the accompanying drawings, Figure 1 is a vertical section of the apparatus. Fig. 2 is a plan view of the furnace, partly in section. Fig. 3 is a horizontal section on the line 3 3 of Fig. 1. Fig. 4 is a horizontal section on the line 4 4 of Fig. 1. Fig. 5 is a vertical section of a modified form of the invention. Fig. 6 is a horizontal section on the line 6 6 of Fig. 5. Fig. 7 is a vertical section of a further modification.

Referring to the drawings, 1 represents a rectangular iron casing inclosing two regenerative chambers 2, provided with shelves 3 of fire-brick. Said chambers communicate at the bottom with flues 4, leading to a stack 5, suitable reversing-dampers and air-inlet valves 6, such as is common in the art, being provided for changing the direction of the ingoing air and outflowing gases. Between said regenerative chambers 2 is located a circular smelting-chamber 7, of fire-brick, the bottom of which is preferably formed of magnesite, over which pass the products of combustion. For said combustion fluid fuel, such as petroleum-oil or fuel-gas, is admitted through pipes 8, discharging into the air or gas conduits 9, leading from the tops of said regenerative chambers 2 to said open-hearth combustion or smelting chamber 7. At the sides of said casing 1 are secured channel-posts 10, which are connected by channel-beams 11, across the mediate portions of which are secured transverse channel-beams 12, to which are secured angle-iron brackets 14, which in turn are secured to the metallic casing 15 of a retort. To the lower end of said retort-casing 15 is secured a metal ring 16, which serves the purpose of supporting the brickwork 17 of said retort, said brickwork consisting of an inner cylindrical wall 18, an outer cylindrical wall 19, and ribs 20, connecting said walls for strengthening purposes and extending to a point near the top of the retort. The spaces 21 between these walls 18 19 and the ribs 20 serve as flues, through which the necessary hot gases from the combustion-chamber 7 pass, thereby highly heating said retort. Between the circular top 22 of the open-hearth or smelting chamber 7 and the ring-casting 16 is built a roof or dome 23 of refractory material, as fire-brick, the top of said dome being separated from said ring-casting only by means of a water-cooled metallic top made in sections, as boxes 24, which can be separately withdrawn when necessary for the purpose of inspection or repairs. This withdrawal is permissible by the fact that the retort does not rest upon said boxes 24, but is supported by the ring-casting 16 and the metal casing 15, which is in turn supported upon the channel-beams 13. Thus the necessary portion of the hot gases proceeding from the combustion-chamber 7, especially those from the extreme top thereof, are allowed to escape through holes 25 through said water-cooled boxes and ring-casting and thence to pass into the flues 21 of the retort to the top thereof, from any portion of which they can pass by the flue 26 to the main stack, the damper 27 being used to regulate the desired amount of gases to pass through the retort-flues 21.

Upon the top of the retort is supported a hopper and dependent ring 28, into which the material can be discharged by any suitable means, as by cars moving upon rails 29, suitably supported upon a frame 30. In the middle of this frame is also mounted, immediately over the hopper, a vertical hydraulic cylinder 31, the piston 32 of which is connected with a plunger 33, which can pass through the mouth of the hopper and fit with sufficient closeness therein to substantially prevent gases escaping from the retort-chamber. When it is desired to charge the retort, the plunger 33 is raised, and the material which has been fed into the hopper falls into the dependent ring in the retort-cham-

ber on the top of the previous charge. From the top of the retort-chamber pipes 34 convey the gases distilled therefrom to the conduits 9, where they are burned with the fuel supplied through the pipes 8.

35 is a tap-hole for drawing off the molten metal and slag at suitable intervals, discharging the same into a separator 36, from which slag and metal are withdrawn at different levels and disposed of.

When manufacturing cast-iron as pig-iron, the process is as follows: The ores to be reduced, also suitable quantities of limestone and tarry carbonaceous material, are all brought to a pulverulent or granular condition and are thoroughly commingled. On first commencing the process, which when once started can be continued indefinitely, a shell, preferably of sheet metal, of the same outside diameter as the interior of the retort is inserted in the lower end of said retort, from which it extends to the bottom of the furnace-hearth, thus connecting the lower end of the retort and furnace-bottom. The above mixture is discharged into the retort to fill said shell, and then heat is applied to the outside of said shell by the combustion of liquid fuel admitted through the pipes 8, said shell being slowly subjected to the increasing heat of the liquid fuel, causing its contained mixture to become bound together and hardened by the oozing and charring of the tar and coking of the combined carbon, after which it is melted at its lower end, at which time the heat in the furnace has been raised to such degree that the continuous smelting process has commenced independent of any such extraneous means as that of the shell.

The heat to which the mixture discharged into the retort is subjected increases gradually as the material descends, and the effect of this heat applied on the outside of the column of the mixture is to first char the tar and coke the combined carbon which forms a constituent of the outer layer or surface of the column, thus forming a hard binding crust or shell of carbon, lime, and ores bound together, which crust or shell gradually increases in thickness as the material descends into the lower and hotter zones of the retort, where the tarring and coking operation extends into the interior of the column. The effect of this earlier charring process is to drive off the light hydrocarbon gases from the column of commingled pulverized ores, limestone, and carbonaceous material, said gases passing to the top of the retort, whence they are conveyed through the pipes 34 to the conduits 9 and are added to the fluid fuel used for smelting and heating purposes.

During the intermediate and later process of charring, binding, and coking the hydrocarbon gases distilled from the carbonaceous material act as reducing agents on the ores commingled with said material, this reduction increasing as the heat becomes greater, since hotter gases are distilled from the charred tar, coke of the column. Said gases oozing from the interior pass through the porous hard charred column and escape up to the top of the retort; but as the material in its descent approaches the bottom portion of the retort the gases so distilled following the path of least resistance tend to escape downward into the furnace and combustion-chamber proper and are there burned, the products of combustion passing up through the flues of the retort, highly heating the same, and finally out to the stack. Such hot reducing-gases constantly passing from the interior to the exterior of the column maintain a protection of the semimetallic particles that have formed on the exterior of the column from oxygen and oxidation during their exposure while traveling from the bottom of the retort through the furnace-chamber to the hottest part of the furnace, which is greatest just above the surface of the bath, at which point the heat completes the reduction of the ores, compelling the remaining oxygen thereof to unite with the solid carbon contained in the column, while at the same time the lime has combined with the silicious and other earths of the column, forming a slag which gathers and floats on top of the metallic bath contained in the furnace-hearth. While this action is going on continually the metallic particles formed in the earlier stages of the process are constantly being attracted and fused together and formed into a fibrous contracted metallic column intermingled with entrapped combined carbon, as coke from the carbonaceous materials, which gradually descends with the metallic column into and under the liquid-bath of dissolving carbonaceous molten iron that is always maintained in the furnace-hearth, where they are constantly being dissolved and amalgamated in said bath. The accumulating molten iron and slag are tapped off at suitable intervals into a metal and slag separator located on the outside of the furnace-hearth, from where the metals and slags are drawn from different levels for final distribution. If the column should not gradually descend in the retort by its own gravity, it may be assisted from time to time by means of the plunger 33.

In the apparatus shown in Figs. 1 to 4 after the combustion has been continued for a sufficient length of time in one direction the direction is reversed, and the air is passed through the regenerative chamber which has been highly heated in the previous step, thereby utilizing the waste heat of combustion and rendering the process more effective and economical. In Figs. 5 and 6 is shown a simpler form of apparatus in which this reversal is dispensed with. In this apparatus the air for combustion is brought in simultaneously at opposite sides of the furnace by

pipes 40 and is heated by the radiated heats by being previously passed around the retort through passages or flues 41, which are exterior to the ascending flues 21, which conduct the hot gases of combustion. Cars 42 are used to carry off the molten iron and slag.

While the retort is a convenient means of binding together the mass of iron ore, limestone, and carbon to form a self-supporting column, yet it may be dispensed with, as is shown in the apparatus illustrated in Fig. 7. In using this apparatus the ores, limestone, and carbonaceous material are formed into briquets, which are preferably of a cylindrical form and are raised by an elevator 43 into suitable position to be pushed by a hydraulic cylinder 44 onto a guideway 45, by which the briquets are advanced in succession over the chute 46, through which they descend into the furnace. As the briquets descend slowly through the chute into said furnace they are gradually heated and fused together, forming a self-supporting column, that is finally reduced and smelted similar to that in the apparatus previously described.

The carbonaceous material to be used as a binding and reducing and recarbonizing agent to be mixed with the ores and lime comprises, among others, such materials as coke, coal, charcoal, graphite, &c., or it may be advantageous to mix any of the dry carbons with residuum, asphaltum, or oils or the like. The object of using a tarry carbonaceous material is for two purposes: First, the tarry substances which ooze throughout the heated column of material and become charred and form, together with the coke resulting from the coking of the fixed carbon, a strong carbonaceous binder that binds the mass together, thus forming a column strong enough to withstand the downward and outward pressure of the superimpending portion thereof during the smelting process; secondly, the hot carbonaceous gases generated from the charring and coking carbonaceous materials at the different temperatures act as an oxygen-consumer, ore-reducer, metallic protector, and metal-recarbonizer throughout the whole process of heating, binding, charring, smelting, and dissolving.

The result of the commingling of the combined carbon entrapped in the iron column as it is descending and being immersed in the liquid-bath is that a continual replenishment takes place of carbon in the liquid-bath, this being necessary to keep the liquid-bath of the same constituency the same as that of pig-iron—that is, a carbonaceous iron containing sufficient carbon to furnish a solvent for the iron continually added thereto, increasing the fluidity of the iron and maintaining its solvent effect. No mention has heretofore been made of any ferriferous ore, except the ordinary iron ore; but the same process is applicable to a mixture of ores necessary to produce any grade of metal desired. Thus any kind of ferreous combination can be made by this process by adding the necessary ingredients, as ores, metals, or metaloids—for instance, as ferric manganese or spiegeleisen or chromic metals.

It is understood that my invention includes the application of this process as applied to other metals than iron so far as it may be found applicable thereto.

I claim—

1. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, a retort-chamber over said hearth, open at the bottom, whereby the material discharged from said retort-chamber descends into said hearth, and means for feeding the material into said retort-chamber, substantially as described.

2. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, regenerative chambers connected with said conduit, means for reversing the direction of the flow of the air and gas through said conduit and chambers, a retort-chamber over said hearth, open at the bottom, whereby the material discharged from said retort-chamber descends into said hearth, and means for feeding the material into said retort-chamber, substantially as described.

3. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, a tubular retort-chamber, the lower end of the tube being open and discharging over the open hearth, and means for feeding material into the upper end of the tube, substantially as described.

4. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, a tubular retort-chamber, the lower end of the tube being open and discharging over the open hearth, means for passing hot gases from the smelting-chamber around the retort to heat the material therein, and means for feeding material into the upper end of the tube, substantially as described.

5. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, means for passing fluid fuel into said conduit along with the air, a retort-chamber over said hearth, open at the bottom, whereby the material discharged

from said retort-chamber descends into said hearth, and means for feeding the material into said retort-chamber, substantially as described.

6. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth, a conduit arranged to conduct products of combustion over said hearth, regenerative chambers connected with said conduit, means for reversing the direction of the flow of the air through said conduit and chambers, means for passing fluid-fuel in either direction along said conduit with the air, a retort-chamber over said hearth, open at the bottom, whereby the material discharged from said retort-chamber descends into said hearth, and means for feeding the material into said retort-chamber, substantially as described.

7. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, means for feeding the material into the upper end of said retort, and means for heating said retort, substantially as described.

8. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, means for feeding the material into the upper end of said retort, and means for passing the hot gases from the smelting-chamber around the retort to heat the same, substantially as described.

9. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, a plunger for depressing the material in said retort, and means for heating said retort, substantially as described.

10. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, means for feeding the material into the upper end of said retort, an apertured water-cooled top for said dome, and means for passing the hot gases from the smelting-chamber around the retort to heat the same, substantially as described.

11. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, means for feeding the material into the upper end of said retort, a sectional apertured water-cooled top for said dome, and means for passing the hot gases from the smelting-chamber around the retort to heat the same, substantially as described.

12. In an apparatus of the character described, the combination of a smelting-chamber having an open hearth at the bottom thereof, and a dome of refractory material, an air-conduit leading over said open hearth substantially at the level thereof, means for passing fluid fuel into the conduit with the air, a tubular retort above said dome, open at the bottom to discharge the material into the open hearth, a hopper in the top of said retort having a depending ring extending into the retort, a plunger descending into said ring, and means for heating said retort, substantially as described.

13. In an apparatus of the character described, an open-bottomed tubular retort, means for heating the same, means for discharging material into the top of the retort, means for closing said top, means for drawing off the gases distilled from the material in the retort, and means for applying heat to the material descending from the lower end of the retort, substantially as described.

14. In an apparatus of the character described, the combination of an open-bottomed tubular retort, means for heating said retort, means for feeding material into one end thereof, means for drawing off the gases distilled from the material in said retort, and means for applying smelting heat to the material emerging at the other end of the retort to smelt the ore therein, substantially as described.

15. In an apparatus of the character described, the combination of an open-bottomed tubular retort, means for heating said retort, means for feeding material into one end thereof, means for drawing off the gases distilled from the material in said retort, and means for burning fluid fuel in proximity to

the material emerging from the other end of the retort, substantially as described.

16. In an apparatus of the character described, the combination of an open-bottomed tubular retort, means for heating said retort, means for feeding material into one end thereof, means for drawing off the gases distilled from the material in said retort, means for burning fluid fuel in proximity to the material emerging from the other end of the retort, means for storing up the heat of combustion, and means for utilizing said stored heat to heat the air in a succeeding step of the operation, substantially as described.

17. In an apparatus of the character described, the combination of an open-bottomed tubular retort, means for feeding material into one end thereof, means for drawing off the gases distilled from the material in said retort, means for burning fluid fuel in proximity to the material emerging from the other end of the retort, and means for passing part of the products of combustion around the retort to heat the same, substantially as described.

In witness whereof I have hereunto set my hand in the presence of two subscribing witnesses.

JOHN A. POTTER.

Witnesses:
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BESSIE GOFINKEL.