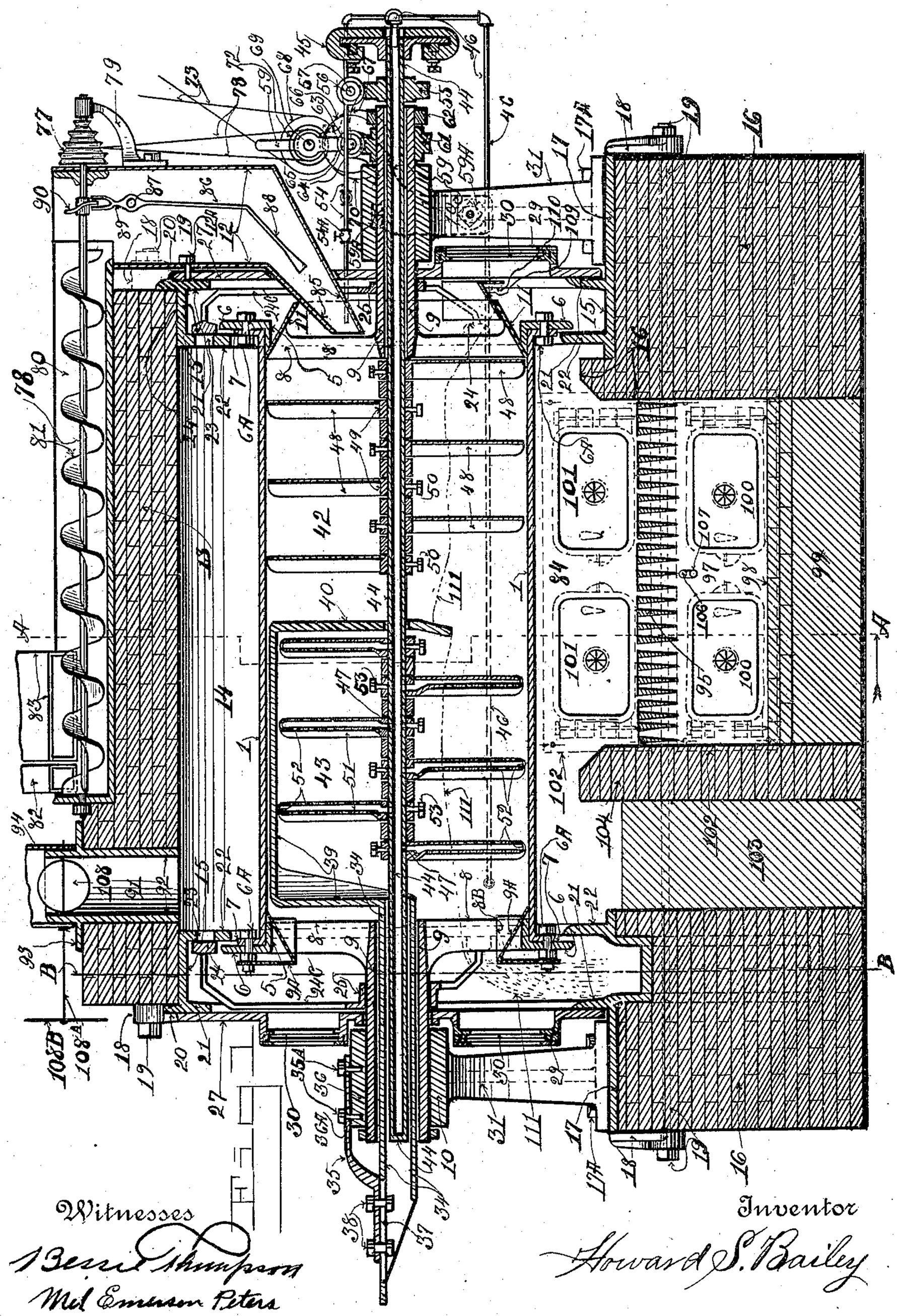
No. 687,713. Patented Dec. 3, 1901.

# H. S. BAILEY.

## ORE TREATING FURNACE.

(Application filed Dec. 1, 1899.)

(No Model.) 4 Sheets—Sheet 1.



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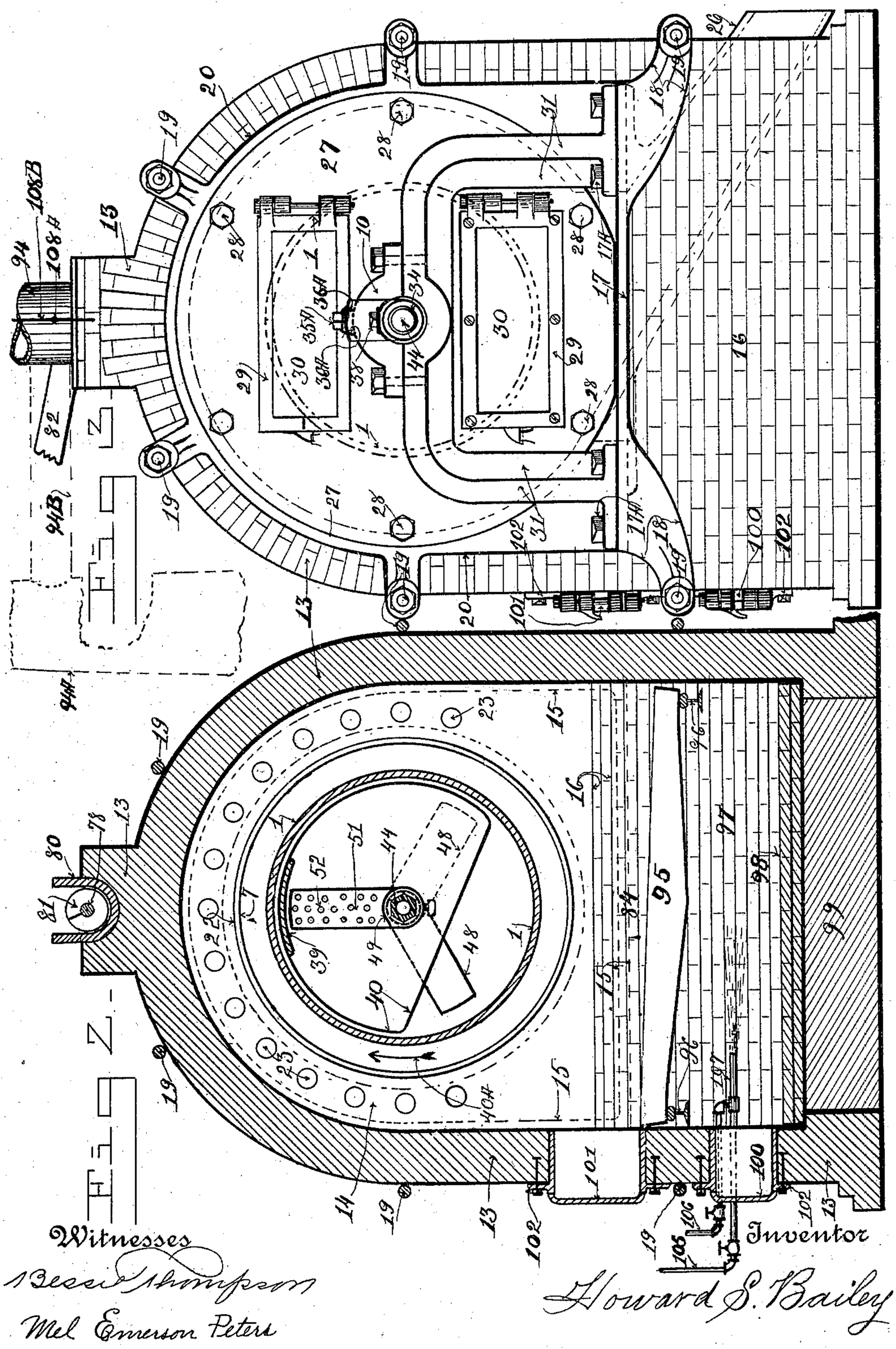
(No Model.) 4 Sheets—Sheet 2.



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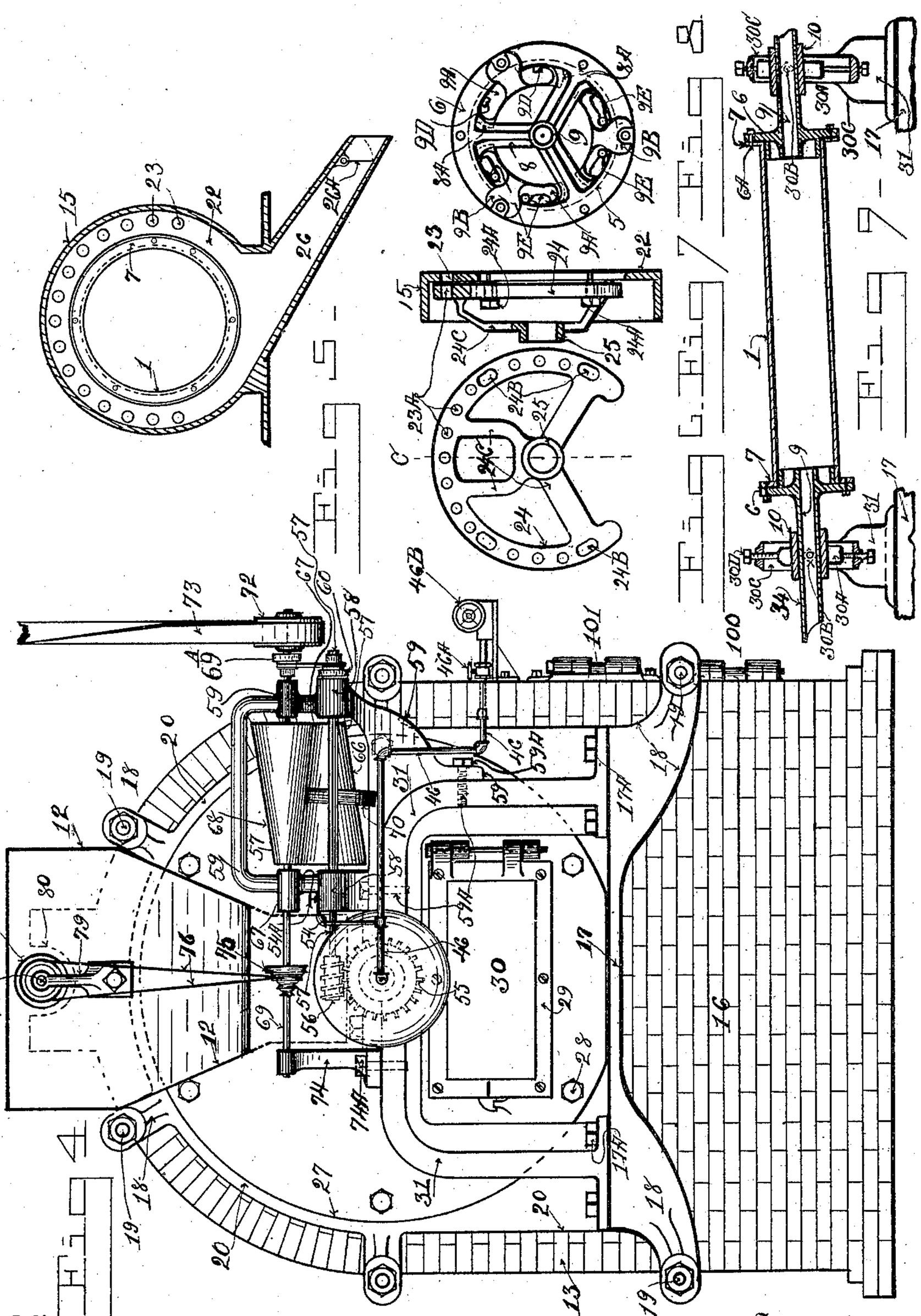
(Application filed Dec. 1, 1899.)

(No Model.) 4 Sheets—Sheet 3.



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## ORE TREATING FURNACE.

(Application filed Dec. 1, 1899.)

(No Model.) 4 Sheets—Sheet 4.

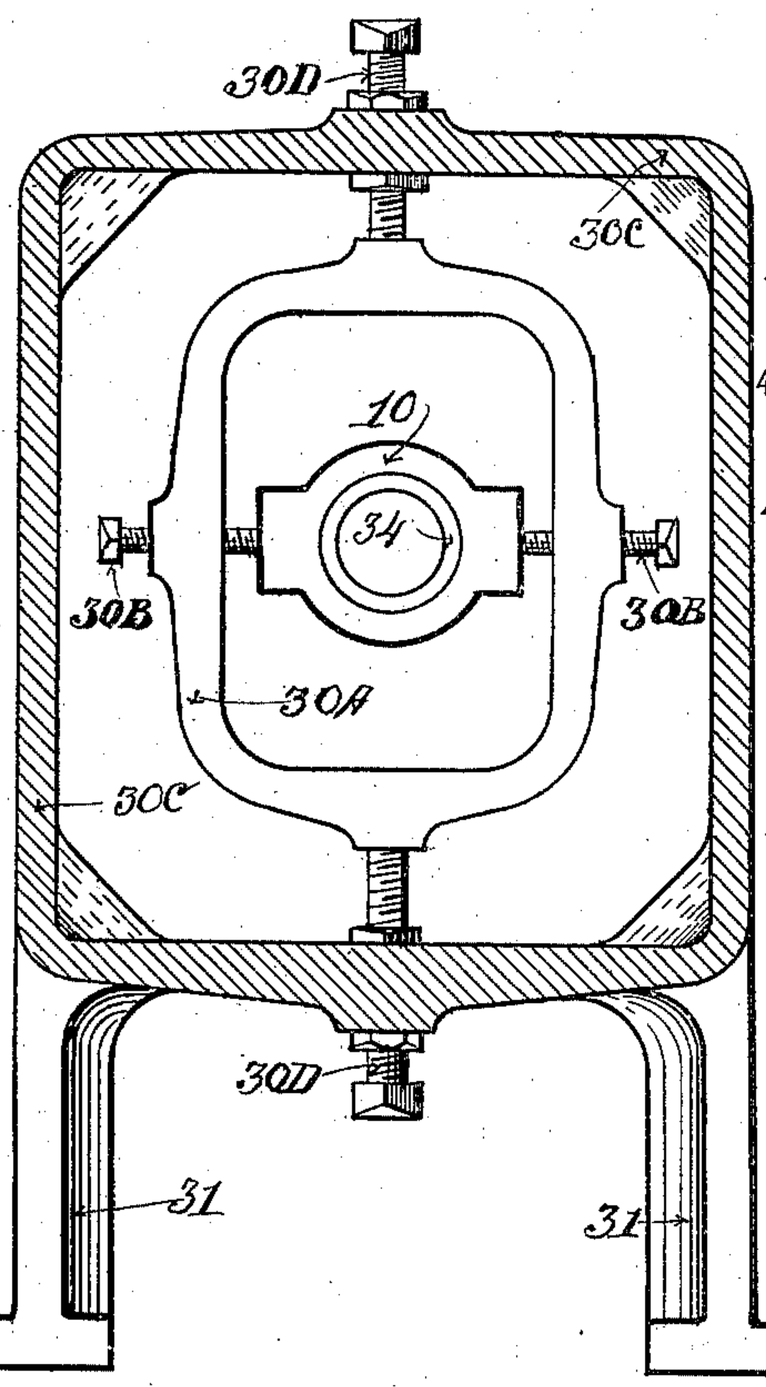
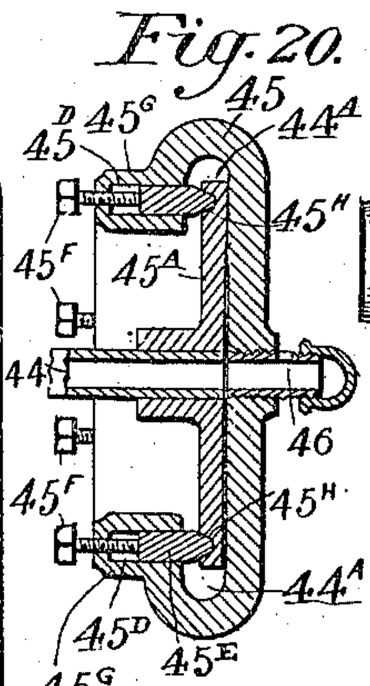



Fig. 20.



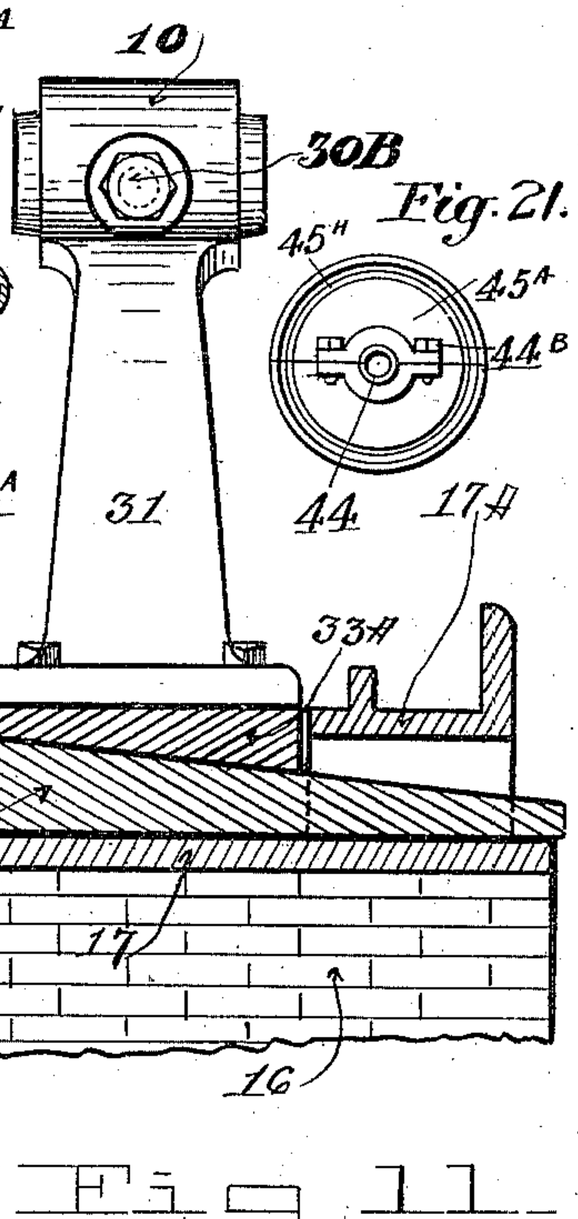




Fig. 21.




Fig. 10.

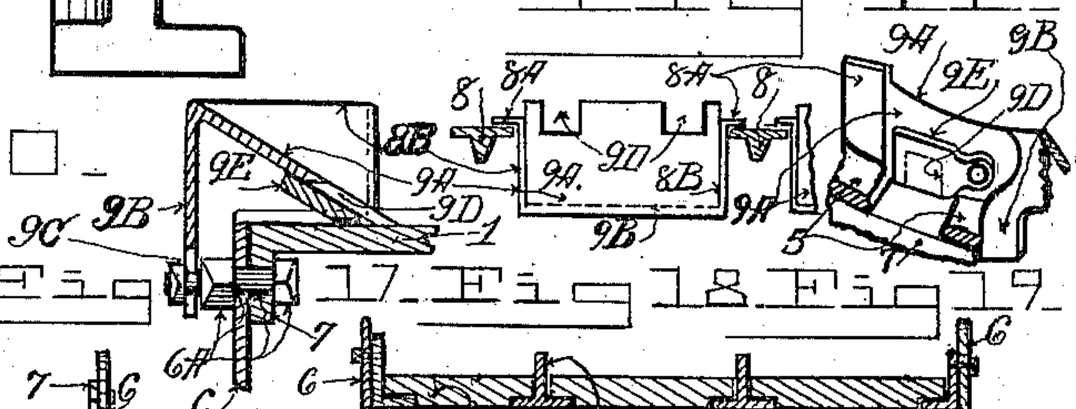



Fig. 11.




Fig. 17.

Fig. 18.

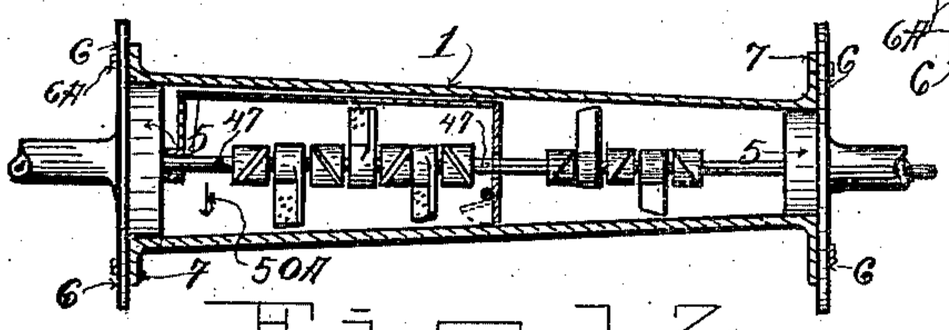



Fig. 12.

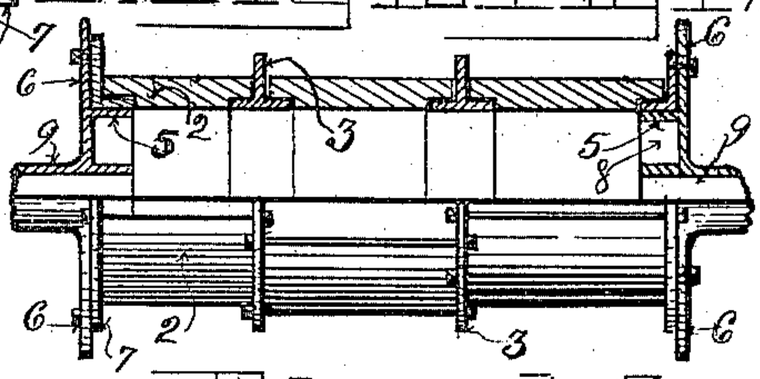



Fig. 13.

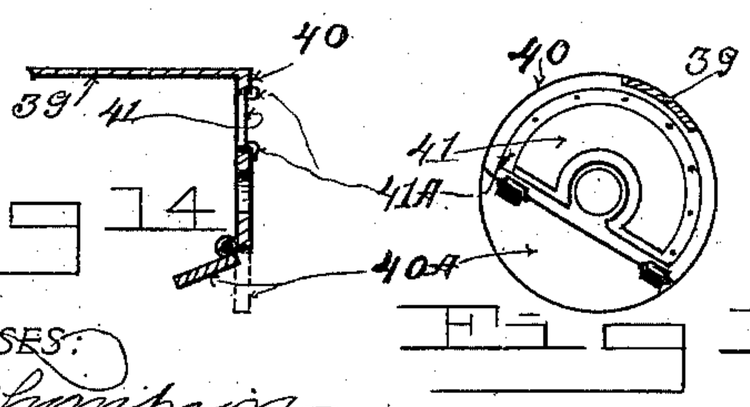



Fig. 14.

Fig. 15.

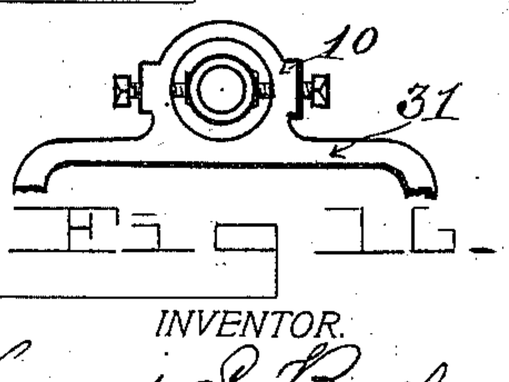



Fig. 16.

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# UNITED STATES PATENT OFFICE.

HOWARD S. BAILEY, OF DENVER, COLORADO.

## ORE-TREATING FURNACE.

SPECIFICATION forming part of Letters Patent No. 687,713, dated December 3, 1901.

Application filed December 1, 1899. Serial No. 738,827. (No model.)

*To all whom it may concern:*

Be it known that I, HOWARD S. BAILEY, a citizen of the United States of America, residing at Denver, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Ore-Treating Furnaces; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in automatic cylindrical ore-treating muffle-furnaces; and the objects of my invention are, first, to provide a furnace that will either roast or convert an ore; second, to provide a furnace in which ores can be given treatment; third, to provide a furnace that will give either a desulfurizing treatment by burning and volatilizing the sulfur or a sulfur-converting treatment by converting the sulfur to a sulfate, and, fourth, to provide a furnace in which the ore-treating cylinder can be taken out of and inserted in the furnace without destroying the brickwork or casing of the furnace. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a central longitudinal vertical section of my improved furnace. Fig. 2 is a cross-section on line A of Fig. 1. Fig. 3 is an elevation of the discharge end of the furnace. Fig. 4 is an end elevation of the feed end of the furnace. Fig. 5 is a cross-section through the discharge-chute on line B of Fig. 1, showing the discharge-ring and the end of the ore-treating cylinder in elevation. Fig. 6 is an elevation of the valve that controls the passage of the fumes from the cylinder into the chimney-flue. Fig. 7 is a cross-section on line C of Fig. 6 and of the adjacent valve-seat ring. Fig. 8 is an end view of the cylinder-ring at the discharge end of the cylinder. Fig. 9 is a fragmentary view of an inclined cylinder, showing a method of raising or lowering one end to incline the discharge end to set it at any desired incline above or below a horizontal plane, so as to retard the feed of the ore through the cylinder or to hasten it. Fig. 10 is an enlarged end view of Fig. 9. Fig. 11 is a fragment of one end of the cylinder, showing the box-stands mounted on adjustable wedges, which allow them to be raised or lowered. The boxes themselves should be pivoted on screws, as shown in the inner frame of Fig. 10, which is a common method of mounting boxes in stands and hangers so that they will tip in alinement with the axis of the cylinder as either end is raised or lowered. Fig. 12 is a longitudinal view of a taper cylinder which may be substituted for the straight cylinders shown in Figs. 1 and 9. Fig. 13 illustrates a cylinder, half in section and half in elevation, built of fire-clay rings and cast-iron, supporting two rings bolted together. Fig. 14 shows a fragmentary sectional view of Fig. 15 on line C of the adjustable partition of the cylinder, showing a window of isinglass in it. Fig. 15 is a plan view of Fig. 14. Fig. 16 is an end elevation of the top of the stand shown in Fig. 11, drawn to a smaller scale. Fig. 17 is a cross-section of one of the converging conical sections of the discharge end of the cylinder, showing a fragment of one of the cylinder and trunnion rings. Fig. 18 is a plan view of one of the conical sections and a fragment of another, showing sections of the arms of the trunnions and the manner in which they lap around them. Fig. 19 is a perspective section fragment of one of the conical sections, showing the trunnion-ring cut away below the valve. Fig. 20 is an enlarged sectional view of the air-pipe and tubular shaft-coupling, and Fig. 21 is an end elevation of the disk of the coupling shown in Fig. 20.

Similar numerals of reference refer to similar parts throughout the several views.

Referring to the drawings, the numeral 1 designates a cylinder, preferably made of cast-iron; but fire-clay cylindrical sections 2 and cast-iron flanged rings 3, clamped together by bolts 4, may be used, if desired, as shown in Fig. 13. The cylinder may be either straight or tapered. This cylinder may be made of any desired length from a few feet up to as many feet in length as it is practical to make it. Each end of the cylinder is supported by a trunnion provided with arms, a ring portion 5 fitting inside of the cylinder, and a flange portion 6 extends beyond the ring and

bolts by bolts $6^A$ to a flange 7, cast on the cylinder. Both rings have spokes 8 and a hub or trunnion 9, that extends away from the cylinder and forms trunnion-bearings for the cylinder and are journaled in adjustable boxes 10. The ring at the feed end of the cylinder is provided with a thin taper flange portion 11, that diverges from the inner edge of the ring toward the trunnion and forms a conical ring that decreases the diameter of the opening into the cylinder at this end and forms a downward-inclined surface at the bottom of the cylinder and keeps the ore from moving out of this end as well as facilitating its feeding into the cylinder as it discharges into the cylinder from the hopper 12 and feed-chute 85. At the discharge end, whenever it is desired to hold an ore back in the cylinder and run it much deeper than it would be naturally run if the discharge end was left of the full diameter of the cylinder, I place converging conical sections $9^A$, which are fitted between the spokes 8 and lap by laterally-extending plates $8^A$ around their inside edges, as shown in Figs. 8 and 18. These converging sections extend to the floor of the cylinder and diverge upward away from the cylinder toward the trunnion. Each section has straight sides $8^B$ at its end, and at their upper ends a depending lug $9^B$, which fits over the ends of the bolts $6^A$ and is secured there by nuts $9^C$, the bolts $6^A$ at this end of the cylinder being made long enough to extend through their nuts that clamp the flange 6 of the trunnion to the flange 7 of the cylinder 1. In order to allow the floor strata of ore to escape slowly without its having to move up over the inclined section and also to keep the converted ore at the floor moving out of the cylinder and to prevent its being held and lodged at the edge of the sections, I make one or more passages $9^D$ through them at their lower edges, which may also cut through the ring 5, as shown in the fragmentary view in Fig. 19. While these passages may be left open at all times, I preferably place a valve $9^E$ over each opening, as shown in two of the sections in Figs. 8, 17, and 19. The valves are placed on the under side of each section and consist of a plate which is pivoted to the sections loosely and swings away from the openings. The valves can be operated while the cylinder is running by opening the door and tapping them with a rod. The cylinder is surrounded, preferably, by a brick coping 13 only; but, if desired, an iron casing may be used instead, or an iron casing may be used and a brick wall may be laid against and around it, or, if preferred, a thick coat of fire-clay or asbestos or any other heat-non-conductive material, as mineral wool, may be laid on and around the iron casing.

Concentrically around the feed end of the cylinder a ring 15 is placed, which rests on the brick or stone foundation-pier 16. A flat table portion 17 extends over the top of the end pier and also extends in the form of arms 18 to and over the side edges of the foundation, as shown in Figs. 3 and 4, far enough to allow bolts 19 to be passed through them to the opposite end of the furnace, where a similar casting 15 is mounted in the same manner. Several other arms 18 radiate from these castings at suitable distances apart. Each end of each arm contains a bolt-hole and a bolt 19. The arms are made long enough to allow a brick wall to be built inside of the bolts and leave several inches clearance for a flue all around the ore-cylinder. The rings 15 are provided with a flange 20, that extends beyond the periphery of their ring portion and forms shoulders between and against which the brick is laid. The bolts bind and tie the brick and end castings together. The rings have two introverted flanges 21 and 22, one on each side of the ring. The flange 22 overlaps the flange of the cylinder-rings and forms a partition that prevents any of the gases or flames from the products of combustion from passing around the end of the cylinder and entering it. This flange is provided with a plurality of holes 23, placed at equidistances apart, and it also forms a valve-seat for the valve. A ring 24, (shown in Figs. 6 and 7,) having a similar number of holes $23^A$, forms a valve. It is bolted loosely to the flange valve-seat by bolts $24^A$, which project through the slots $24^B$ and screw into the flange and registers over the holes, and is provided with spokes $24^C$ and a hub 25, that surrounds loosely the trunnion of the end ring of the cylinder. This valve-ring is adapted by being moved slightly by hand to turn it on the trunnion and on its bolts to partially or wholly open or close the holes in the flange valve-seat, and thus regulate the area of openings for the passage of fumes from the cylinder through these valved openings to the flue 14, that surrounds the sides and top of the cylinder, and into the chimney of the furnace. The flange 22 of the end ring 15 at the discharge end of the cylinder is also provided with a similar valve-seat and a valve 24, except that it is provided with a discharge-chute 26, as shown in Fig. 5, that extends from it at a downward angle through the brickwork to one side of the furnace. To the top of the inside of this chute, close to its end, I pivot a door $26^A$, which is adapted to close the entrance of the chute and keep all but a little air from flowing up into the space in front of the cylinder. It is swung open by the ore as it slides down the chute only enough to allow the ore to pass under it. The flanges 21 of these rings form a bearing for disk plates 27, which are bolted to them by the bolts 28. In this disk plate, at the discharge end, I place two doors 29, and in the disk at the feed end a door, and in each door I place a window 30, of glass or of isinglass. The lower windows are in line with each other. They let light into the cylinder and enable an operator to see the condition of the

ore without opening the doors, which need not be opened only when it is necessary to secure a sample of ore.

The boxes 10 are illustrated in Figs. 9 and 10 adjustable vertically and horizontally by the inner frame $30^A$, to which the box is attached by screws $30^B$, and the outer frame $30^C$, to which the inner frame is attached by screws $30^D$. The frame $30^C$ is formed integral with the stand 31, which may be substantially the same as in Figs. 1 and 3; but, if preferred, they may be formed integral with the stands 31, which would be preferable where very heavy long cylinders are used, and, if desired, a vertical adjustment of the discharge and feed ends may be effected by means of the wedge screws 32 and wedge blocks 33 and $33^A$, as shown in Fig. 11. A bracket $33^B$ extends from the bed-plate to support the screw and an upward-projecting arm $33^C$, which is also cast integral with the plate, confines the stand between the raised portions $17^A$ and $33^C$, under which the wedge 33 slides. Adjustable boxes are preferable for furnaces used for custom-work when a great variety of ores of different character are treated; but it is preferable to have the boxes stationary when treating one particular kind of ore right along, in which case they are cast integral with the stands and the stands rest on and are bolted to the bed-plates of the end rings of the furnace by bolts $17^A$, as shown in Figs. 1, 3, and 4.

The hubs of the trunnions of the end rings of the cylinder are bored out, and at the discharge end a sleeve 34 extends loosely through the trunnion of that ring. This sleeve extends through and beyond the box on each side of it and at the outside of the box is bolted to an arm 35, that extends over and is bolted to the top of the cap 36 of the box by bolts $35^A$ and is provided with oblong holes $36^A$ so that the arm and sleeve may be turned a little way in either direction. In the top of the sleeve there is a long slot 37, through which the bolts 38 extend from the arm 35, which enables the sleeve to be pushed through the trunnion into the cylinder or withdrawn from it, as desired. From the inner end of this sleeve, which extends beyond the inner end of the trunnion, an arm 39, which forms an integral portion of it, extends vertically upward to close to the top of the inside of the cylinder and then turns and extends along the top of the cylinder to near its central portion, where it turns downward and forms a semi diaphragm or partition 40, that fits loosely in the cylinder and extends across it and fills all of the upper half and a portion of the lower half of the cylinder, leaving a space below it along the bottom of the cylinder, which is filled with ore that extends above the lower edge of the partition. The lower edge of this movable partition is preferably arranged to stand at about the angle the ore will assume when the cylinder is rotating in the direction of the arrow $40^A$. It can be turned around its axis a little, however, in either direction on the bolts $35^A$, which pass through slots $36^A$ in the arm 35, to bring it in line with the angle the ore assumes, which of course will depend upon the rotative speed of the cylinder. While I preferably make this partition solid, I may find it of advantage, when treating some ores, to have a window 41 of isinglass, as shown in Figs. 14 and 15, which may be secured to the partition by cleats $41^A$. This partition is used to divide the cylinder into two compartments, one of which, 42, is a converting-compartment, and the other, 43, is a reducing-compartment, these two compartments being necessary when converting ores; but when desulfurizing ores the partition and the compartments are not needed and if using the furnace for desulfurizing ores by burning and volatilization may be dispensed with. In order to make the partition automatically adjustable to divide the cylinder positively into two compartments when different depths of ore are fed through it, I hinge or pivot it into two parts, as shown in Figs. 12, 14, and 15. In these views the lower part $40^A$ is fitted to fill the curvature of the cylinder and is preferably pivotally hinged loosely to the upper portions, so that it will hang vertically, as shown by the dotted lines in Fig. 14, when there is no ore in the cylinder, and will be raised by the pressure of the ore as it is fed through the cylinder. It should be constructed of thin cast-iron. The operator can see the ore and partition at all times through the windows. He can quickly turn the partition from the journal-box by loosening the bolts $35^A$ and move it so that the swinging part will stand at the same angle as the ore. The sleeve 34 is also bored out, and in it is loosely and rotatably seated one end of a tubular air-shaft 44. This end of this shaft is closed. The shaft passes loosely through the partition. The opposite end of this shaft is also loosely journaled in the trunnion of the opposite end of the cylinder and extends beyond it. At the extreme end, preferably the feed end, a coupling 45 is attached to the tubular shaft and a pipe 46 is attached to the coupling. One part of this coupling rotates with the tubular shaft and the other part is held stationary by the pipe. This coupling comprises the disk $45^A$ and the hood $45^B$. The disk is preferably made in two halves and clamped together by the bolts $44^B$, as shown in Fig. 21, on the end of the tubular air-shaft 44, or the two halves of the disk may be clamped together and its bore threaded and screwed on the end of the tubular shaft, if desired. The hood $45^B$ is a circular disk having a hood portion that surrounds the edge of the disk. This hood portion contains a chamber $44^A$, in which the disk fits. In the overhanging edge $45^C$ of the hood an annular recess $45^D$ is formed, in which fits loosely a packing $45^E$, that is cut into overlapping sections, which is pressed against the side of the disk by the set-screws $45^F$, which are threaded

to the annular portion 45$^{C}$, formed on the hood which is adapted to support them. The packing-receiving recess is deep enough to allow the packing to be pushed back out of the way of the halves of the disk when it is inserted in the hood, which is very easily done, as the halves of the disk are only a trifle larger in diameter than the diameter of the overhanging edge of the hood portion, and the chamber in the hood portion is made enough larger in diameter and enough wider to allow the halves to be inserted in the hood, which can be done at the shop, and the coupling can be attached to the tubular shaft after the furnace is set up. The packing may be the hard-rubber packing commonly used for piston-rings and preferably extends into a groove 45$^{H}$, formed in the side of the disk. The hood is supported partially by the pipe to which it is secured and partially by the hard-packing ring extending into the groove of the disk. The coupling is not expected to be perfectly air-tight. The pipe 46 extends back into the brickwork or casing of the furnace, from which it is carried outside. A valve 46$^{A}$ is placed in it just outside of the wall, from which a pipe extends to and is connected to a blower 46$^{B}$. By this means air is forced through the pipes and is heated in passing through the brickwork of the furnace and hot air is delivered to the tubular shaft. The air flows along the tubular shaft through the feed end of the cylinder into that portion of the tubular shaft that lies between the partition and the discharge end. Perforations 47 are made in the shaft to allow the air to escape into this compartment, which is the oxidizing-compartment of the furnace, while the portion between the partition and the feed end of the cylinder is the converting-compartment. This tubular shaft may be either round or square or of any polygonal form of cross-section, and upon it are mounted arms. The arms 48, that are placed in the shaft in the converting-compartment, are preferably thin blades that are formed to stand at a slight oblique angle to the axis of the shaft and are arranged to feed the ore through the cylinder from the feed to the discharge end, and more particularly to stir and rabble it. Each arm has a hub 49, that slips loosely on the shaft, and a set-screw 50 is threaded through it to set and clamp them to the shaft, if a round shaft is used, at different points in its circumference, they being preferably set at each quarter or third of the circumference. Where a polygonal form of shaft is used, as shown in Fig. 2, only the end arms need be clamped or keyed to the shaft. When a taper cylinder is used, the arms, if all were inclined to feed the ore forward, might feed it too fast, in which case some arms could be used with their arms inclined in the opposite direction, as shown in Fig. 12, where the end and the alternate arms are inclined toward the feed end, and if rotated in the direction of the arrow 50$^{A}$ would hold the ore back and more thoroughly rabble and mix it, while it can be made to feed at the right speed by increasing or diminishing its rotary motion and by lowering the discharge end of a straight cylinder.

The arms 51, that are used in the reducing-compartment, are made hollow, and each arm is placed over a perforation in the pipe. Through each arm a number of small holes 52 are drilled at the sides and extreme end, through which the hot air discharges all through the ore as they travel through it. These arms are also provided with set-screws 53 to secure them to the shaft. There are preferably no holes made in that part of the shaft that passes through the converting-compartment of the cylinder, and when hot air is needed in this compartment it is admitted by the pipe 54, which enters the compartment at the side of the hopper through the end disk. This pipe connects to the air-supply pipe adjacent to the coupling at the end of the hollow shaft. A valve 54$^{A}$ is placed in it to control the amount used and is kept closed when air is not wanted. From the coupling to where the air-pipe enters the brickwork a hose may be used instead of a metal pipe, if desired. A worm-wheel 55 is mounted rigidly on the tubular shaft adjacent to the coupling, and a worm-pinion 56 meshes with the worm-wheel. This pinion is mounted on a shaft 57, that is supported in the bearings 58, which form a part of a yoke-shaped frame 59, that is secured to the stands 31 of the boxes 10 by the bolts 59$^{A}$. This shaft extends beyond the end of the frame, and a small cone-pulley 60 is secured to it. A worm-wheel 61 is also secured to the trunnion at the outside of the box, and a collar 62 is secured at its side on the end of the trunnion. A worm-pinion 63 meshes with the worm-gear. This pinion is supported on a shaft 64, that is journaled in bearings 65 of the frame 59. This shaft extends across this frame, and a cone-pulley 66 is secured to it in the frame. As these bearings are directly back of and in line with the bearings 58 of the arms 67 of this frame, they are not seen in Fig. 2, but are shown in Fig. 1, the shaft 57 passing in front of the cone. Directly above this cone a second cone 68 is secured to a shaft 69, which is journaled in the same frame, the cone 68 being arranged so that it drives the cones 66 and 68 by means of the ring 70. This arrangement of the cones and the rings makes a compact and quickly-changed variable-speed driving mechanism. In place of this arrangement I could place the driving-cone 68 in a counter-shaft and belt direct to the driving-cone 66; but for small machines the ring-driving cones are the cheapest and most convenient and the easiest to manipulate to change speeds and are used for obtaining a number of different speeds. The shaft 69 extends beyond the frame, and a pulley 72 is secured to it, from which a belt 73 leads from it to a power-driven pulley. A cone-pulley 69$^{A}$ is also secured on this end of

this shaft, that belts to the cone 58 by a belt 58[A] on the shaft 57. The cone-pulley 69[A] and 58 drive the shaft 57 and the worm-pinion 56, which rotates the worm-wheel 55 and the hollow air-shaft. The shaft 69 also extends beyond the opposite end of the frame, and its end is journaled in a bracket 74, that is bolted by a bolt 74[A] to the top of the box-stand. Upon this end of this shaft a cone-pulley 75 is secured, from which a belt 76 extends to a cone-pulley 77, that is secured to the end of a shaft 78, the adjacent end of which is supported by a bracket 79. This shaft extends through a trough 80, built of any suitable material, such as sheet or cast iron, and is set in the brickwork, or, if desired, it may be formed in the brick. The shaft is journaled in the opposite end of the trough. This shaft forms the axis of a spiral conveyer 81. At the opposite end from this cone-pulley a flux-feed chute 82 is arranged to deliver any flux it is desired to mix with the ore. At its side an ore-feed chute 83 is arranged to deliver ore into the trough. The ore-chute delivers the pulverized ore from the machinery, which pulverizes and dries it, and the flux-chute delivers the fluxing material from a laboratory or storage-bin, where it is prepared. At the end of the trough adjacent to the cone-pulley a hopper 12 is bolted by a bolt 12[A] to the disk plate 27 and is arranged so that as the ore leaves the trough it falls into the hopper. The hopper at its lower end has a discharge-spout 85, that projects through the end disk into the end of the cylinder. In the hopper a positive feeding-rod 86 is pivoted between its ends on a bolt 87. The lower end 88 of the feed-rod is bent to extend into the spout of the hopper, and the upper end 89 is bifurcated and straddles a disk cam 90, that is secured to the shaft of the spiral conveyer. The cam as it is rotated by the shaft imparts a reciprocative movement to the feed-rod, that prevents packing or scaffolding of the ore in the hopper and its discharge-chute. A vertical flue 91 is formed, preferably, at the discharge end of the cylinder through the casing and brickwork, which preferably is lined by a casting 92, which is provided with a flange 93 just below its outer end, that sets on top of the wall, and a chimney-stack 94 sets over the end of the flue-casting and rests on the flange. If preferred, a chimney 94[A] can be built at the side of the furnace, and a pipe 94[B] can be extended from the flue-casting to it, as shown in dotted lines in Fig. 3. All the space below the cylinder I designate the "combustion-chamber" 84. A grate 95 is placed under the cylinder and is supported, preferably, by the T-rails 96, which are built into the walls. Below the grate an ash-pit 97 is formed, the bottom being defined by the brick floor 98, below which is a filling of earth or other material 99. A pair of doors 100 open into the ash-pit from one side of the furnace through the brickwork, and above the grate a pair of doors 101 open through the brickwork to them. These doors are hung on a frame 102, that is built into and bolted to the side wall of the furnace. 103 designates a filling of earth or other suitable material between the brick wall 104 of the foundation.

The furnace can be heated by any kind of fuel. Oil can be used, if desired. An oil-burner is illustrated in Fig. 2.

105 designates the steam-pipe, and 106 the oil-pipe. The oil and steam unite in the pipe 107. The grate should be removed if oil is burned.

108 designates a damper placed in the chimney-stack to assist in regulating the heat of the combustion-chamber.

108[A] is a rod upon which the damper is pivoted, and 108[B] is a cross-bar on the end of the damper-rod for turning the damper.

109 designates a guard used to keep the ore from feeding out of the cylinder. It extends about a quarter of a circle inside of the conical end of the cylinder and rests stationary on it. It is hooked to the hook 110 or may be otherwise removably secured to the disk plate.

The operation of my improved furnace is as follows: The ore and flux are fed by suitable conveyers through the flux and ore spouts into the trough, where the screw conveyer feeds it and at the same time mixes the ore and flux together into the hopper, from which the ore discharges into the adjacent end of the cylinder. The cylinder may be rotated in either direction, but preferably in the direction of the arrow 40[A], and the hollow shaft and rabblers are rotated, preferably, in the opposite direction, the cones providing a large range of speeds for both the cylinder and the shaft and enabling either one to be driven faster or slower than the other in opposite or in the same direction. As the ore feeds through the cylinder it naturally is carried up in one side of the cylinder and rolls down over and over itself, and as it feeds through the cylinder it banks up a little higher against the partition, as shown by the dotted line 111, which designates the outline of the top of the ore. This prevents air from flowing freely under its edge into the converting-compartment. When converting a sulfid ore to a soluble sulfate condition, only a very limited amount of air should be allowed to reach the ore in the converting-compartment, and enough air flows by the edges of the partition for this purpose. As some ores throw off large quantities of arsenical, antimonial, and other gases, it may be necessary to let a quantity of air from the pipe 54 and open the valve at the end of this compartment and drive them out. Some of these gases will naturally flow by the ends of the partition into the oxidizing-chamber and out of it through the valves at that end into the flue and chimney. The rabblers may be rotated very fast or very slow, as desired, and when the vertically-adjustable boxes are used the discharge end of

the cylinder may be raised to keep the ore back until it is thoroughly roasted or converted, whichever treatment is being given to the ore. The air should be given pressure enough by the blower to prevent the ore from feeding into the holes in the end of the arms, and as they rotate the air permeates all through the ore in the oxidizing-compartment and thoroughly oxidizes it. The ring-valves at each end of the cylinder can be opened as much or as little as desired to carry off the gases and fumes evolved during the roasting or conversion of an ore and can be quickly changed at any time by opening the doors at each end and turning them slightly by a slight rap with a rod at their lower ends, as they are pivotally mounted on the trunnions. As the ore leaves the cylinder it drops into the discharge-chute and runs into a conveyer, which carries it to further treatment.

My furnace is adapted to either roast an ore to desulfurize it or to convert an ore to a free milling condition by changing most of the sulfids, except the silver sulfids, to soluble sulfates. In a desulfurizing roast the sulfur is volatilized and burned out of the ore, and such a treatment requires about from 1,200° to 2,000° Fahrenheit of heat, and air is allowed to circulate freely all through the ore and cylinder at all times during the treatment. In a converting treatment in which a gold and silver sulfid refractory ore is converted to a free milling condition the ore is not heated above the melting-point of the easiest-fused metal in the ore and generally not above and from about 550° to 620° Fahrenheit in this treatment. Only a very small amount of air is allowed to come in contact with the ore while it is traveling through the converting-compartment, and the ore must be kept in this compartment until the sulfur has softened, which takes place when the ore feeds into the oxidizing-compartment when hot air under pressure is flowing into it out of the numerous holes in the arms. The ore takes up quantities of oxygen from the hot air and, with the sulfur, copper, and zinc that is still present in the ore, forms soft friable soluble sulfates and oxids that are soluble in water, while the gold and silver are individualized and left free and can be recovered by the cyanid or chlorinating processes or by amalgamation followed by concentration, which should also follow the other process. The copper and zinc can be recovered by leaching. The sulfid and tellurid ores generally mined in Colorado require from twenty minutes to an hour to convert to a free milling condition, and all ores should be tested in small roasting-dishes in an assay muffle-furnace to determine the time required to convert it. Then any amount can be fed through this furnace by simply setting the driving-cones and rabbling-arms to feed the ore through the cylinder in the time required, which is very readily done, as the cones can be rotated to drive the cylinder and rabbling and feeding arms slow enough to require an ore three hours to feed through the cylinder or quick enough to feed it through in ten minutes. The stationary partition is made slidably movable, so that the converting-compartment can be made longer or shorter by loosening the bolts that clamp its hub portion to the lever that holds it in position and moving it either toward the hopper end of the cylinder, toward or up to the adjacent feeding and rabbling arm in the converting-compartment, or away from it, thus increasing or diminishing the length of either one or the other of these compartments as the ore requires a few minutes' more or less time in one compartment than in the other. Thus an ore might require ten minutes in the converting-compartment and twelve minutes in the oxidizing-compartment or eight minutes in one and eighteen in the other. This would require twenty-two minutes in one case and twenty-six in the other. Now if the cylinder and rabbling and feed arms are set to feed an ore in twenty-two minutes the partition could be easily moved to a position that would make the oxidizing-compartment enough longer than the converting-compartment, and vice versa, to allow the ore ten minutes in the converting-compartment and twelve minutes in the oxidizing-compartment, and likewise with the eight and eighteen minute treatment. The rabbling and feeding arms can be made with but very slight angle, so that they will not move but a trifle of an inch forward as they pass through it, and the discharge end of the cylinder can be raised or lowered to give the desired speed of the travel of the ore through the cylinder. When the feed of the ore is regulated in this manner, the rotative speed of the rabbler may be much higher. The windowed doors allow an operator to see the ore at all times and take a sample of the ore at any time by opening them and inserting a spooning-tool.

Whenever it is necessary to remove the cylinder, it can be done by removing the trunnion box and hanger at the discharge end and the disk plate. Then by loosening and removing the rabbling-arms and the cylinder-ring at the opposite end the cylinder can be drawn out through the end ring.

While I have illustrated and described a preferred construction of my furnace, I do not wish to be limited to the construction shown, as my invention contemplates the use of any arrangement of mechanical elements that practice and experience may dictate without departing from the spirit of my invention as claimed.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. An ore-treating furnace comprising a cylinder rotatably mounted on trunnions, journals for supporting said trunnions, windows for admitting light into said cylinder, a shaft extending through said cylinder, rab-

bling-arms mounted on said shaft some of which are hollow, perforations through said hollow arms and shaft, means including a blower for forcing hot air into said shaft and arms into said cylinder, means including cones for rotating said cylinder and shaft in the same or in opposite directions and at the same or at different speeds, and a suitable casing surrounding said cylinder, substantially as described.

2. An ore-treating muffle-furnace consisting of a cylinder, trunnions connected to the ends of said cylinder and arranged to rotatably support said cylinder, a stationary partition arranged to partially divide the cylinder above the ore-bed into two independent compartments, windows in the ends of said furnace, means including cones for rotating said cylinder, suitable inclosing walls for said cylinder, and a combustion-chamber and chimney for heating said cylinder, substantially as described.

3. An ore-treating, muffle-furnace comprising a cylinder mounted on trunnions, a suitable casing surrounding said cylinder at its sides and ends, a combustion-chamber under and a flue around said cylinder, a chimney connecting with said flue, doors leading into said cylinder, windows in said doors, a partition in said cylinder arranged to be adjusted axially and rotatively, a hollow shaft mounted in said cylinder, arms on said shaft, adapted to rabble and move ore through said cylinder, hollow arms also mounted on said shaft, apertures in the ends and sides of said arms and through said hollow shaft registering with the apertures in the ends of said arms, a pipe leading from said shaft through said furnace, means including a blower for driving air through said pipe, shaft and arms into said cylinder, and means including cone-pulleys for rotating said cylinder and shaft in the same or in opposite directions and at the same or at different speeds, substantially as described.

4. In an ore-treating muffle-furnace, the combination with the brick side walls, of a cylinder rotatably mounted on trunnions at each end and arranged to receive and discharge ore at its ends, boxes supporting said trunnions, a trough in the top of said brickwork, a conveyer in said trough, a hopper at the discharge end of said trough arranged to discharge into said cylinder and a force-feed device in said hopper comprising a reciprocating rod pivoted in said hopper and a cam mounted on said conveyer and arranged to engage one end of said rod, substantially as described.

5. The combination of the brick side walls and the casing at the ends of said brick walls, with the cylinder having trunnion-bearings, a space between the ends of said cylinder and said casing, a flange at each end of said cylinder, introverted flanges overlapping said end flanges of said cylinder and extending from said brickwork, a plurality of holes through said introverted flanges and a valve-ring arranged to register against said introverted flange at each end of said cylinder and having a hub loosely mounted on the trunnions of said cylinder, substantially as described.

6. In an ore-treating muffle-furnace the combination with the inclosing side and roof walls, of a pier at each end of said walls, a ring at each end of said walls having a bed-plate resting on said piers, introverted flanges at each end of said ring, a flange overlapping the outside of said walls, a disk bolted to the outside of said rings at each end of said walls, an ore-treating cylinder within said walls, a trunnion secured to the ends of said cylinder and extending through said disks and having spokes radiating from them across the ends of and secured to said cylinders, boxes adapted to journal said trunnions and having supporting-arms resting on and secured to the bed-plate of said end rings, and having a valve-seat formed on each inner flange of said rings, a valve pivotally mounted on said trunnion and slidably bolted to register against said valve-seats, and apertures through said valves and seats adapted to be opened and closed by said valves, substantially as described.

7. In an ore-treating muffle-furnace, the combination of an ore-treating, rotatable cylinder supported by trunnion-bearings at its ends, with a surrounding casing of any suitable material, having a combustion-chamber therein arranged to heat said cylinder, a chimney in said casing, a damper in said chimney, a hollow shaft or tube passing through said cylinder and revolubly journaled in said trunnions, a pipe connected to said tube, a blower connected to said pipe, rabbling and feeding arms mounted on said shaft in said cylinder and comprising solid, oblique blades extending radially from said shaft to close to the inner periphery of said cylinder, a plurality of air-distributing rabbling and ore-feeding arms also mounted on said shaft comprising hollow blades, perforations in the sides and ends of said hollow blades, perforations in said hollow shaft registering with said hollow blades whereby air is forced into said cylinder and is forced to permeate the ore passing through said cylinder, and means including cones and gears for imparting different rotative speeds to said cylinder and hollow shaft, substantially as described.

8. In an ore-treating muffle-furnace the combination with the brick side and roof walls, of the end piers, the end rings and bed-plate at the ends of said walls, the journal-boxes and their stands mounted on said bed-plate and piers, an ore-treating cylinder having open ends, means including an axial shaft in said cylinder provided with blades for feeding and discharging ore into and from said cylinder, trunnions secured to the ends of said cylinder by arms and journaled in said boxes, means including a combustion-cham-

ber for heating said cylinder, a hollow shaft journaled in said trunnions and passing through said cylinder, hollow, obliquely-inclined arms mounted on said shaft having perforations in their sides and ends, perforations through said shaft registering with the chamber of said hollow arms, means including a blower for forcing air into said cylinder through said shaft and hollow arms, obliquely-inclined arms comprising blades also mounted on said hollow shaft, a partition supported by one of said trunnions extending into said cylinder at its central portion and arranged to be moved axially and concentrically of said cylinder and arranged to divide it into two independent compartments, and means including cones and gears for imparting different rotative speeds to said cylinder and hollow arms in the same or in different directions, substantially as described.

9. In an ore-treating muffle-furnace the combination with a suitable casing, of a cylinder rotatably supported and divided at its central portion by a non-rotatable semipartition adapted and arranged to be adjusted axially and angularly a short distance in said cylinder, substantially as described.

10. In an ore-treating muffle-furnace, the combination with a suitable casing, of an ore-treating muffle-cylinder rotatably mounted, a non-rotative partition arranged to divide more than the upper half of said cylinder into two independent compartments and adapted to be moved axially and angularly in said cylinder, a hollow shaft in said cylinder, oblique arms comprising blades mounted on said shaft in the compartment at the end of said cylinder into which ore is fed, a hopper arranged to feed ore through said casing into said cylinder, and oblique hollow arms containing perforations and mounted on said shaft in the compartment at the ore-discharging end of said cylinder, a valved pipe connected to said hollow shaft, a blower connected to said pipe whereby air is forced into the compartment of said cylinder at its discharge end, and means including cones for rotating said cylinder and hollow shaft at different speeds and in the same or in opposite directions, substantially as described.

11. In an ore-treating muffle-furnace the combination of the end piers and the side and roof and end walls, with a cylinder, a partition in said cylinder arranged to divide it into two independent compartments, and means within said cylinder including revoluble hollow arms containing perforations for admitting hot air under pressure into one of said compartments, substantially as described.

12. In an ore-treating muffle-furnace, the combination of the casing, a cylinder mounted to rotate within said cylinder, a combustion-chamber within said casing under said cylinder, a flue above said cylinder, a space at each end of said cylinder separated from said combustion-chamber by a partition formed partially by an introverted flange extending from said casing, and a flange formed on the ends of said cylinder and overlapping said introverted flange, and valved openings through said introverted flange, substantially as described.

13. In an ore-treating muffle-furnace, the combination of the casing, with the cylinder, the combustion-chamber below said cylinder, the flue above and around said cylinder, the chimney in said casing, the damper in said chimney, the flues or spaces at the ends of said cylinder separated therefrom by an introverted flange, the valve-seat formed by said introverted flange, the openings through said introverted flange, the trunnions supporting said cylinder and the valve-ring having openings and pivotally mounted on said trunnions and arranged to open or close said openings in said introverted flange, substantially as described.

14. In an ore-treating muffle-furnace, the combination with the side and end and roof walls, of a cylinder having trunnion-bearings at its ends, annular flanges at each end of said cylinder, an introverted flange extending from said casing and overlapping the annular flanges of said cylinder, a flue or fume-space at each end of said cylinder between said flanges and the end casing of said cylinder, doors in said end casings, windows in said doors, a combustion-chamber below said cylinder, a flue above and around said cylinder, and valve-controlled openings in said introverted flange opening into the flue surrounding said cylinder from said flue or fume-space at the ends of said cylinder, substantially as described.

15. In an ore-treating muffle-furnace the combination of the end piers, the side and end and roof walls and the removable end rings and bed-plate, the tie-bolts and disk plates, having doors therein and windows in said doors, with the journal-boxes and their stands, a cylinder in said walls having trunnions at its ends journaled in said boxes, a combustion-chamber under said cylinder, a flue surrounding said cylinder, fume-spaces between the ends of said cylinder and said end disk plates and separated from said combustion-chamber by flange-shaped portions surrounding the ends of said cylinder; valve-controlled openings in said flanged portions, a partition in said cylinder comprising a hub portion loosely mounted in and extending through the trunnions of said cylinder, an arm that extends upward and along the top of the inside of said cylinder and a blade portion that depends from the top of the cylinder to below its center, means for moving the partition axially and concentrically of said cylinder, a hollow shaft journaled in the hub of said partition at one end and in the trunnion of the cylinder at the opposite end and means including a blower for forcing air through said shaft into said cylinder, substantially as described.

16. In an ore-treating muffle-furnace the

combination with the inclosing casing, of a cylinder having its upper portion divided into compartments by a partition, trunnions secured at the ends of said cylinder and journaled in boxes positioned outside of said casing, a hollow shaft extending through said cylinder and partition and trunnions, perforations through said shaft into one of said compartments, hollow arms mounted on said hollow shaft over said perforations, perforations through said hollow arms, a coupling on one end of said hollow shaft, one-half of which is adapted to rotate with said hollow shaft, a pipe extending from said coupling into said casing and from said casing to a blower, a hopper arranged to feed ore into said cylinder, a trough in the roof of said casing, a conveyer in said trough arranged to feed ore from said trough into said hopper and means including worm-gears and cones for rotating said cylinder and hollow shaft, and for operating said conveyer, substantially as described.

17. In an ore-treating muffle-furnace the combination with the casing, the cylinder revolubly mounted in said casing, the hollow shaft axially mounted in said cylinder and the rabbling and feeding arms mounted on said hollow shaft, a trough in the roof of said casing, a spiral conveyer in said trough, a hopper at the discharge end of said trough arranged to feed ore into said cylinder and a rod pivoted in said hopper, a cam on said conveyer arranged to reciprocate said rod, means for rotating said cylinder, hollow shaft and spiral conveyer, and means for forcing air through said hollow shaft into said cylinder, substantially as described.

18. In an ore-treating furnace, the combination with the brick and iron casing, of an open-ended cylinder, trunnions secured to said cylinder, a movable partition in the central portion of said cylinder, a conically-contracted end at the feed end of said cylinder, a discharge-chute at the discharge end of said cylinder extending through said casing, a spiral conveyer and trough in the roof of said casing, a hopper arranged to receive ore from said spiral conveyer and trough and discharge it into said cylinder, and means including pipes and a blower for delivering hot air into said cylinder, means including arms for rabbling and feeding ore through said cylinder, and means including gears for rotating said cylinder, substantially as described.

19. In an ore-treating muffle-furnace, the combination of the brick casing, the cylinder mounted on trunnions, the partition in said cylinder, the combustion-chamber under said cylinder, the ash-pit, the flue around said cylinder, the chimney-stack in said casing, and the damper in said chimney, with the removable disk plates in the ends of said furnace, the doors therein, the windows in said doors, means including cones for rotating said cylinder, and means including pipes and hollow blades for delivering air into said cylinder on each side of said partition, substantially as described.

20. In an ore-treating muffle-furnace the combination with the surrounding casing having removable end plates, doors in said plates, windows in said doors, a cylinder mounted on trunnions in said casing and divided into two compartments, an adjustable partition in said cylinder forming the said two compartments, means including a hollow shaft and hollow arms for feeding hot air constantly into ore-compartment and means for forcing hot air when desired into said converting-compartment, a fume flue at each end of said cylinder communicating with said compartments, a combustion-chamber under said cylinder, a flue around said cylinder, a partition between said combustion-chamber and said fume-flue, valve-controlled passages between said combustion-chamber and flue and said fume-flue, a hopper arranged to feed ore into said cylinder, a trough in said casing, a screw conveyer arranged to feed ore from said trough into said hopper and means including cones for rotating said cylinder at different speeds, substantially as described.

21. In an ore-treating muffle-furnace, the combination with the casing, of a cylinder inclosed by said casing and mounted on trunnions, journal-bearings for said trunnions, a converging, conical ring at the feed end of said cylinder and a relatively-fixed curved plate removably secured to bear on the inside of the lower side of said conical ring, substantially as described.

22. In an ore-treating muffle-furnace the combination with the casing, of a rotatable cylinder within said casing having a converging frusto-conical portion at its feed end and converging frusto-conical, removable portions at its discharge end and openings in said conical sections, substantially as described.

23. In an ore-treating muffle-furnace the combination with the casing, of a cylinder rotatively mounted in said casing, a converging frusto-conical portion at its feed end and converging removable frusto-conical portions at its discharge end having valved discharge-openings, substantially as described.

24. In an ore-treating furnace, the combination with the casing, of a cylinder rotatably mounted in said casing on axial supports, projecting through and beyond said casing, suitable supporting-boxes for the axial supports of said cylinder at each end of said cylinder, means for adjusting one of said boxes to raise and lower one end of said cylinder above or below a horizontal plane, and a partition in said cylinder arranged to divide said cylinder into two compartments and slidably supported on one of said cylinder's axial supports, substantially as described.

25. In an ore-treating muffle-furnace the combination with the casing of a cylinder mounted to rotate in said casing and partially divided at its central portion by a partition into two ore-treating compartments, and having

said partition slidably supported at the axis of said cylinder, an air-pipe extending through said cylinder, means for delivering hot air under pressure into the ore from said air-pipe and means for rotating said cylinder and air-pipe, substantially as described.

26. In an ore-treating furnace, the combination with a suitable casing, of a rotatable cylinder in said casing divided into two compartments by a partition, means including pipes for delivering hot air to said cylinder and means for rotating said cylinder at different speeds, substantially as described.

27. In an ore-treating furnace the combination with a suitable casing, of a cylinder rotatably mounted in said casing, an axially and angularly adjustable partition in said cylinder arranged to divide said cylinder into two ore-treating compartmenis and having the said partition divided into two parts and said parts pivotally connected together, the lower part being movable, means for heating said cylinder, means for delivering air into said cylinder and means for rotating said cylinder at different speeds, substantially as described.

28. In an ore-treating furnace, a suitable casing, a cylinder in said casing, a partition in said cylinder the lower portion of which is arranged to be raised by the ore as it feeds through said cylinder to allow said ore to pass said partition, a contracted end at the feed end of said cylinder, a contracted end at the discharge end of said cylinder, valved discharge-openings in said discharge end of said cylinder, means for feeding ore to said cylinder, means for supplying air to said cylinder, and means for heating said cylinder, substantially as described.

29. In an ore-treating furnace a suitable casing, a cylinder within said casing, a partition in said cylinder having a lower portion arranged and adapted to be moved by the movement of ore feeding through said cylinder to allow said ore to pass under said partition, means for feeding ore to said cylinder, means for feeding ore through said cylinder in different periods of time, means for delivering air to said cylinder, and means for heating said cylinder, in combination with doors in said casing having windows adapted to admit light to both ends of said cylinder whereby an operator can see the condition of said ore at all times without opening said doors and without opening any aperture by which cold air can flow into said cylinder, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

HOWARD S. BAILEY.

Witnesses:
BESSIE THOMPSON,
MEL EMERSON PETERS.