Aug. 20, 1935. A. A. ANDERSON 2,012,092

ORE REDUCTION FURNACE AND CONDENSING CHAMBER

Filed Nov. 13, 1933 2 Sheets-Sheet 1

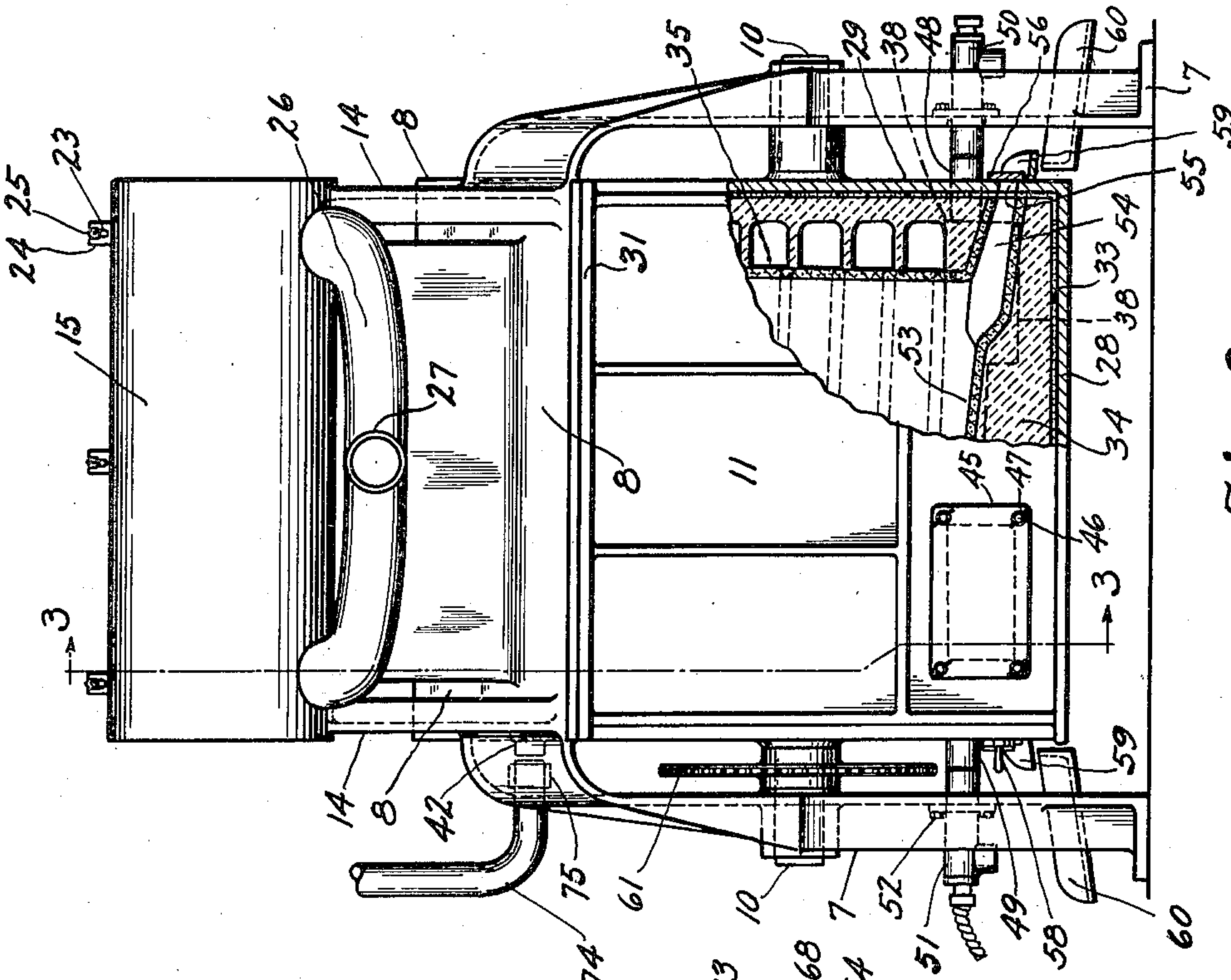

Fig. 2

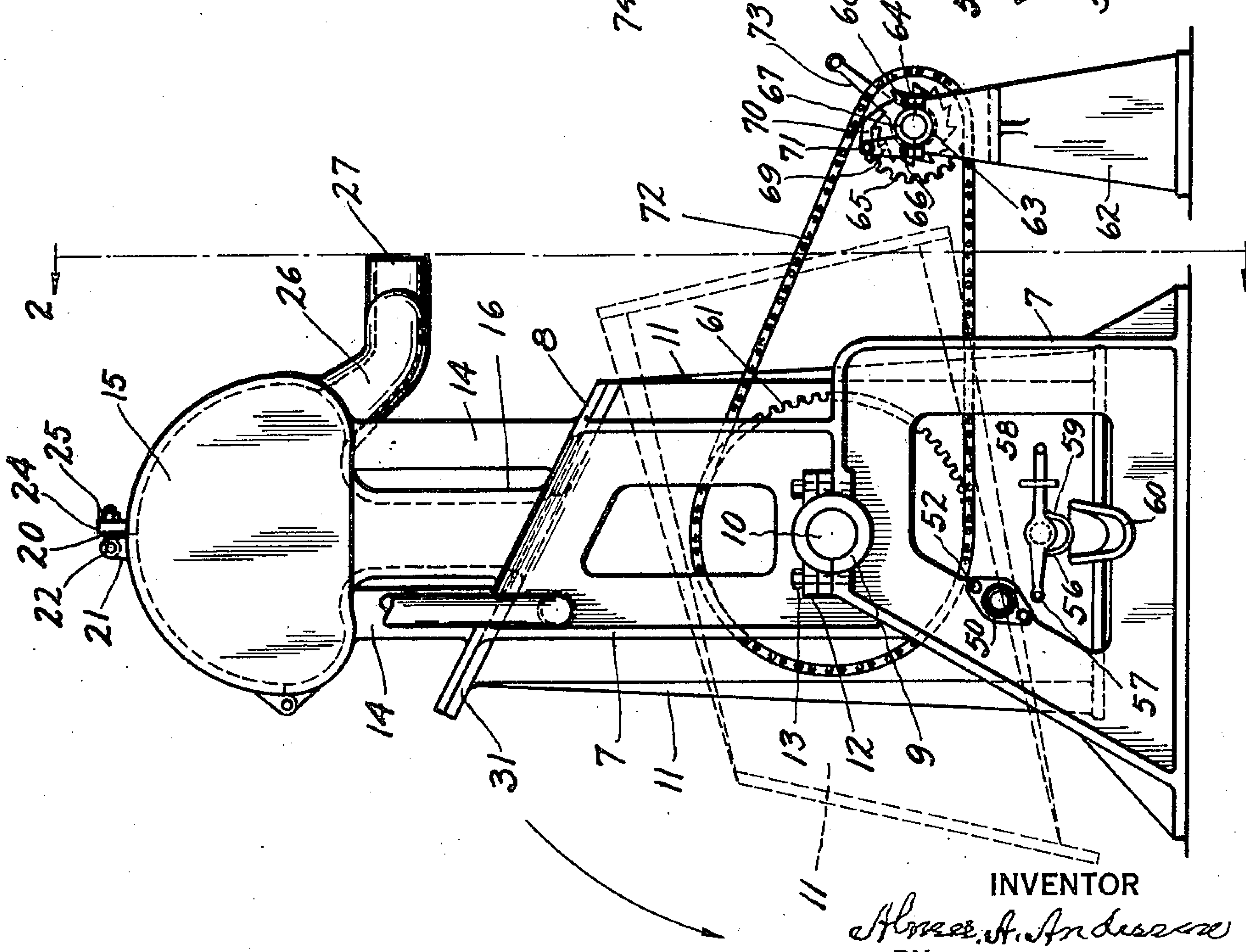

Fig. 1

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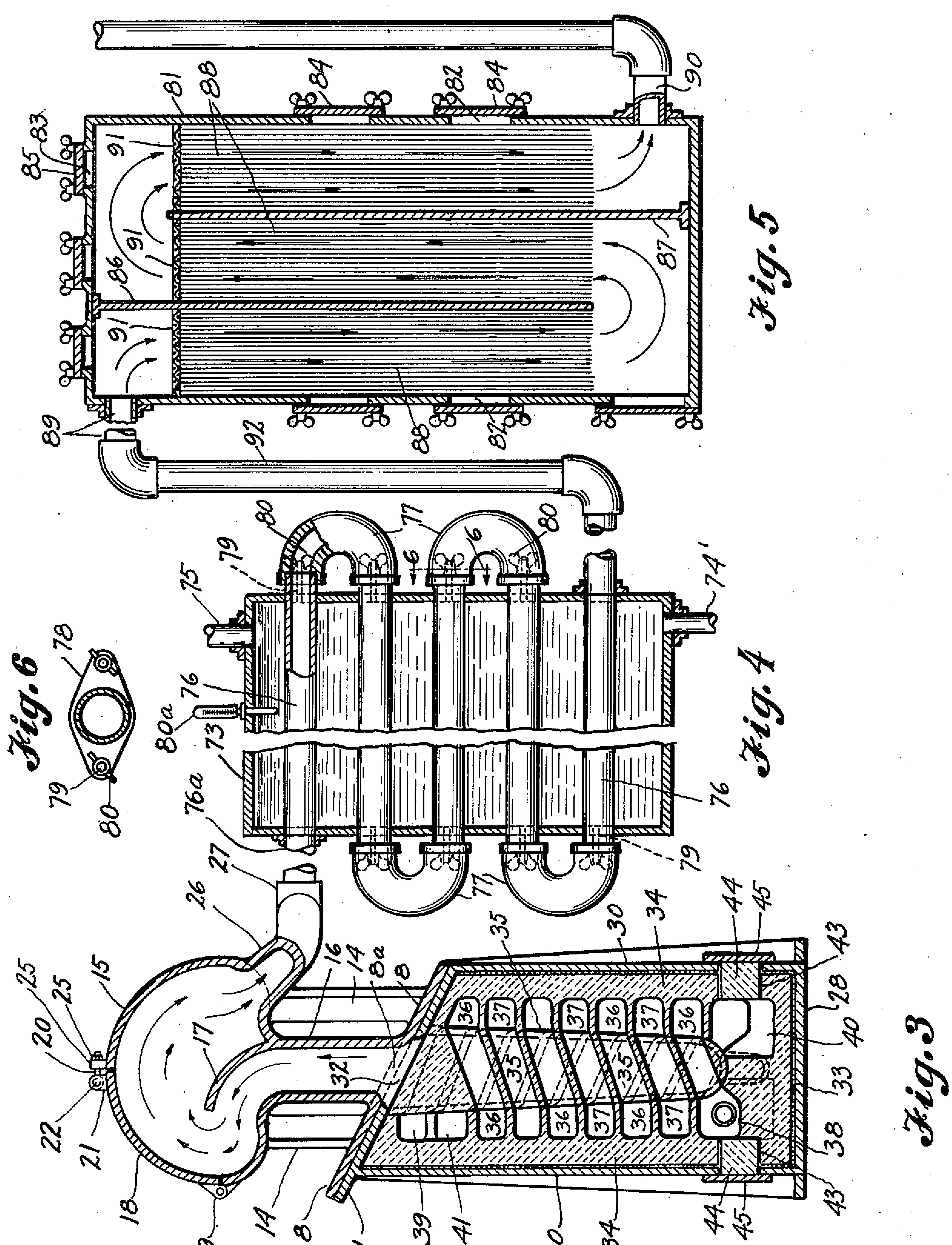

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ORE REDUCTION FURNACE AND CONDENSING CHAMBER

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Application November 13, 1933, Serial No. 697,803

16 Claims. (Cl. 266—18)

My invention relates to an ore reduction and vaporizing furnace means combined with an integrally constructed condensing means, whereby most metals and values may be extracted from most ores by volatilization thereof in an enclosed crucible furnace and reduced by selective condensation in connected and co-ordinating condensing apparatus. The means provides separate control and elimination of combustion gases and ore vapors. Combustion chambers consist of rectangular helical ascending passages through special firebrick which confine combustion flames against the crucible exterior, fortify the crucible with spiral partitions and assist in insulating the crucible from the furnace shell; each of two or more such described heat lanes leading combustion flames from separate pressure burner nozzles, within the base of the furnace, in multiple circuitous inclined courses about the crucible and exhausting separately to stacks. Ore vapors are provided with a sealed perpendicular passage from crucible through a throat, corresponding in size and shape to the rim of the crucible, into an overhead reservoir or hood which is built stationary upon the main frame casting or horse. The crucible is suspended in and as a part of a tilting cradle. The crucible is designed in elongated, narrow V or flat trough shape to facilitate rapid and thorough penetration of heat to contents when upright, rapid dumping of gangue when fully tilted and rapid charging when partially tilted. The furnace shell of steel, containing the crucible, firebrick, combustion apparatus and other devices shown, constitutes a cradle and is suspended upon suitable trunnions extending from each end thereof and mounted in bearings in the end standards of the stationary main frame casting at points measured to make the cradle balance its sloping top surface flush against, and also permit tilting same fully away from, the apertured under surfaces of the stationary base of an overhead vapor reservoir. The cradle may, by power applied to an attached wheel gear, operated from a removed source by chain or belt, be tilted through an arc sufficient for gravity dumping of gangue from crucible and charging crucible with ores. When upright, the furnace, crucible top, combustion exhaust and other operating features are by virtue of reciprocally inclined planes of contact sealed as a unit to co-incident surfaces, parts and apertures in the overhead hood and stationary frame respectively; the cradle is closed when upright and in such closed position the crucible chamber is firmly sealed to the condensing units and ready for the vaporizing operation.

The general object includes special objects in the condensing means wherein ore vapors are carried automatically by heat and vapor expansion pressure generated in the crucible into reservoirs, passages and chambers designed consecutively to facilitate prompt and full reduction of the metal and value content to commercial or solid form; particularly by a combination of construction and preparation as hereinafter shown designed to reduce internal pressure by release of the vapors into expanded areas, to disrupt the column or internal structure of the vapors by sudden interruption and reversal of direction of flow, to cool vapor passageways through water filled tanks in which temperatures may be regulated and sharply reduced, to induce in particular metals such as gold a molecular attraction and adhesion to surfaces washed or treated with a preparation of silica or other corrosion resisting material and to filter vapors in perpendicular passages through napped wool or asbestos strands hung between vertical baffle plates. The object contemplates integral construction and cooperation of all the foregoing, but permits optional selection of portions to meet special requirements. The object includes permissible auxiliary or alternative use of the furnace for reduction and recovery of metals and values in molten or residuary form. The invention contemplates adequate access to every part of the condensing means for full and easy removal of reduced metals and values.

Other objects of the invention, more specific than those referred to above, will be in part obvious and in part pointed out in the following description of the elements, combinations, arrangements of parts and application of principles constituting the invention, and the scope of protection will be indicated in the appended claims. The accompanying drawings are by reference made a part of this specification and show a preferred ideal and illustrative operating form of the invention, wherein:

Figure 1 is the end elevation of the evaporating furnace and condensing dome unit.

Figure 2 is a view upon line 2—2 of Figure 1 with sprocket chain removed.

Figure 3 is a section upon the line 3—3 of Figure 2 with the supporting framework removed.

Figure 4 is a longitudinal section of the second stage or return tube condensed.

Figure 5 is a cross-section of the vertical filter or collecting tank.

Figures 3, 4 and 5 show the whole assembly of the ore reduction furnace and condensing chamber.

Figure 6 is the section upon the line 6—6 of Figure 4.

Referring more particularly to the drawings reference numeral 7 represents the main end frames of the general shape shown in Figure 1 which are connected at their upper ends by a member or shelf 8 provided with a rectangular opening 8*a* (Figure 3) and may be cast integral with the frames as shown. The end frames 7 are provided with bearings 9 in which are supported the trunnions 10 of the cradle represented in its entirety by reference numeral 11 which will be described later. 12 are the bearing caps and are secured in place by bolts 13. Extending upwardly from the shelf 8 are stanchions 14 supporting the condensing dome represented in its entirety by 15. 16 is a rectangular neck or passage connecting opening 8*a* with dome 15. 17 (Figure 3) is a deflector extending the full length of the dome. The condensing dome 15 is provided with an opening which may be tightly closed by cover 18 hinged at 19 and latched by means of eye bolts 20 pivoted to brackets 21 by means of pin 22 and adapted to swing into slots 23 in lugs 24 (Figure 2) cast in the main body of the dome. 25 are nuts by means of which the latching arrangement may be tightly drawn up. 26 is a manifold consisting of two branches as shown in Figure 2 and connecting to a common outlet 27. The entire interior of dome 15 with neck 16 is coated with a thin layer of silica or fireclay.

The cradle 11 is in general a rectangular metal box, preferably steel consisting of bottom 28, ends 29 and sides 30 and a sloping cover 31 machined at its upper face so as to make a close fit with the machined surface on the under side of shelf 8 when the cradle is in its normal or upright position. Cover 31 is provided with a rectangular opening 32 (Figure 3) which registers with opening 8*a* in shelf 8 when the cradle is in its normal position. The joint between top 31 of the cradle and the undersurface of shelf 8 may be sealed by any approved form of gasket or fire resisting material.

The interior of cradle 11 is first lined with an approved insulating material 33 such as asbestos or the like. The cradle is next lined with a fireproof brick 34 so as to form a pocket to receive the crucible 35. The inner face or surface of this pocket is provided with two passages or grooves 36 and 37. Passage 36 commences at the lower right hand end (Figure 2) of cradle 11 as at 38 (Figures 2 and 3) and winds upwardly in the form of a rectangular helix and terminates at the upper left hand end of the cradle as shown at 39. Passage 37 commences in the lower corner opposite 38 as at 40 and winds helically upward in a like manner and terminates at 41 where it joins with passage 39, the junction terminating in a single tube 42 (Figure 2). The beginning 38 and 40 of passages 36 and 37 respectively are enlarged as shown (Fig. 2 and Fig. 3) and are provided with passages 43 extending through the firebrick and also through the side walls of the cradle. These passages may be stopped up by removable firebrick plugs 44 secured to covers 45 which are secured to the sides of the cradle by means of bolts and wing nuts 46 and 47 respectively. The end 38 of passage 37 is provided with a tube 48 which extends through the end of the cradle. The end 40 of passage 37 is provided with a similar tube 49. 50 and 51 are oil burners provided with flanges by means of which they are secured to the end frame 7 by screws 52 (Fig. 1 and Fig. 2). The mouths or outlets of these oil burners are located so as to register with tubes 48 and 49 when the cradle is in its normal upright position. 35 is a crucible with sides tapered downwards and rounded at the bottom so as to fit snugly into the pocket formed by the fire brick lining. The bottom of the crucible slopes towards each end as shown at 53 (Fig. 2) and terminates in spout 54 which registers with opening 55 in the cradle. Openings 55 are closed by shutters 56 pivoted as at 57 (Fig. 1) and provided with a handle 58 (Figures 1 and 2). 59 are small spouts or troughs immediately below openings 55 in the cradle 11 and 60 are other troughs which may be cast integral with the frame and located directly below spouts 59.

To one trunnion of the cradle is rigidly secured a sprocket wheel 61. 62 is a pedestal forked at its upper end and provided with bearings 63 in which rests a shaft 64 to which is keyed a sprocket 65 and ratchet wheel 66. 67 is a bearing cap secured in place by means of bolt 68. This bearing cap is provided with a small lug 69 to which is pivoted a pawl 70 by means of pin 71 and adapted to engage the ratchet wheel 66. To the opposite side of sprocket wheel 65 may be secured another ratchet wheel (not shown) and pawl arrangement adapted to work in the opposite direction. One pawl of course is disengaged when the other is in operation. Passing over sprocket wheel 61 and 66 is a sprocket chain 72. To one end of shaft 64 is secured a crank 73.

Secured to the frame and registering with tube 42 (Figure 2) is an exhaust pipe 74 the inner end of which is provided with a loosely fitted sleeve 75 which may be slipped over the end of tube 42 when cradle is upright and furnace in operation.

The return tube condenser consists of a main body or shell 73 constructed of any suitable material such as wood or metal and fitted with intake pipe 74′ and outlet pipe 75 to permit circulation of a cooling medium such as water. 76 are tubes passing through the condenser making tight joints where they penetrate the shell. The protruding ends are connected by return bends 77 so as to form a continuous passage for the gases. The interior diameter of the tubes and the interior diameter of the return ends are the same so as to prevent any shoulders. The exterior ends of the condenser tubes 76 and the interior ends of the return bends are machined so as to form gas tight joints. The ends of the return bends 77 are provided with flanges 78 (Figure 6) which are drilled to receive studs 79 (Figure 4) which are secured to the condenser shell 73. The studs are provided with wing nuts 80 so the returned ends may be drawn up tight on the ends of the tubes and also facilitate easy removing. The tubes may pass through the shell in any desired manner such as vertically or horizontally. The interior surface of tube 76 and return bends 77 are coated with a thin layer of silica or fireclay.

80*a* is a thermometer by which the temperature of the cooling medium can be determined.

The vertical filter consists of a casing 81 provided with suitable openings 82 and 83 to facilitate easy cleaning and removing of inner parts. These openings are closed by easily removable covers 84 and 85 respectively. The covers may be held in place by studs and wing nuts as in-

dicated. 86 and 87 are vertical baffles considerably shorter than the height of the casing 81 and secured and joined alternately with the top and the bottom of the casing as shown (Figure 5) and extending from side to side making tight joints therewith forming a number of vertical ducts 88, the lower ends of the first and second duct communicating with each other as shown, and the tops of the second and third communicating with each other so as to form a continuous passage for the gases from an inlet pipe 89 to an outlet pipe 90 of the casing 81. The number of baffles and ducts may be increased to any desired number to suit conditions.

Suspended in each duct 88 from racks 91 are banks of linted asbestos or wool strands of length shown and of sufficient number to fill the entire duct and packed closely enough to cause the desired filtering of the gases to recover the remaining values before the gases are exhausted to the atmosphere through pipe 90. The outlet 27 of condensing dome 15 (Figure 3) connects with the first or inlet 76*a* of the first condenser tube 76 of the return tube condenser (Figure 4). The outlet of the return tube condenser tubes are connected with the inlet 89 of the filter by means of a pipe 92, the inner surface of which is also coated with a thin layer of silica. The above connections causing a continuous passage for the gases from the crucible through the dome condenser through the return tube condenser and finally through the filter (Figure 5) to the atmosphere.

The method of operation is as follows: Pawl 70 is lifted and crank 73 turned causing the sprocket 65 to turn which in turn rotates sprocket 61 by means of chain 72 so as to tilt the cradle containing the crucible in the direction indicated by arrow. The cradle is tilted sufficiently far to give access to loading the crucible with the ores to be reduced and the cradle returned to its upright position. In starting the fire the covers 45 of the cradle (Fig. 2 and Fig. 3) are first removed and the fires started directing the flames into the spiral passages 36 and 37. The object for removing the covers 45 is to eliminate the danger from explosions which may be caused by an accumulation of oil or gases before sufficient draft or proper fire is attained. After fire is started the covers are secured in place.

When sufficient temperature has been reached the ores in the crucible will melt and finally vaporize, the hot ore vapors passing up through neck 16 into dome condenser 15 where the first condensation takes place or, where the metal vapors which will condense at the highest temperature will be condensed depositing the metal on the baffle 17 or the interior lining in dome 15. The vapors which are not condensed will pass through passage 27 (Figure 3) into return tube condenser (Figure 4) where more metals will be condensed out, the greatest amount being deposited in the returned bends 77 where the direction of flow is interrupted or changed. The condensing temperature in the tubes 76 may be varied by changing the temperature of the cooling medium passed through the condenser or by changing the time for it to flow through, the temperature being read by thermometer 80*a*. The metals or values requiring a lower temperature to condense will pass on through pipe 92 into the filter (Figure 5) where the remaining values will be deposited on the stranded asbestos or wool banks in ducts 88. After the heat is finished the values or deposits are removed; those in the dome condenser by opening cover 18. The values in the return tube condenser are removed by loosening wing nuts 80 and removing the return bends 77 from which the values can be easily removed and given full access for removing the values deposited in the straight tubes 76. The final values are removed from filter (Figure 5) through the openings 82 or 83 or by removing the stranded asbestos or wool banks in ducts 88 which may be removed in sections.

Ores whose contents will not volatilize under normal heats in the crucible, but sink to the bottom of the crucible, may be drawn off thru spouts 54 at the bottom.

Residue and gangue are dumped by tilting the cradle to position shown by dotted lines (Figure 1).

Inasmuch as many changes may be made in the dimensions and construction of any and all parts without departing from the spirit and scope of the invention as defined in the following claims, it is intended that all matter contained in this specification as well as in the accompanying drawings shall be interpreted as illustrative, and not in a limiting sense. Various changes in material, size, shape, relation, construction and arrangement of parts may be resorted to by those skilled in the art without departing from the spirit of my invention or any subjoined claims.

Reference is hereby made to my previous application for Letters Patent, under Serial No. 624,986, filed in the United States Patent Office on July 27th, 1932, for an Ore evaporating furnace.

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

1. An apparatus of the type described comprising an externally heated trough crucible very narrow in proportion to length and depth imbedded in fire-resisting material fixed in a metal box cradle, the cradle having a flat, slanting-plane top provided with an opening which corresponds and communicates with the crucible rim, the cradle tiltably suspended on trunnions between standards bearing a connecting top frame having a flat under surface slanting coincidentally as the top of the cradle when upright and having an opening communicating exclusively with the entrance to condensing and filter apparatus combined with the top frame; the point of trunnions and bearings thereof in the standards, and the slanting angle of said coincident surfaces of cradle and frame being such that the cradle will balance itself in upright position and the upright position thereof causes said surfaces to register crucible rim and condenser entrance in airtight union to complete a passage for ore fumes, and so also that the cradle may be tilted and inverted to disunite said surfaces and fume passageway to permit charging, discharging and recharging of the crucible with ore, and means for heating said crucible.

2. In apparatus of the type described, an elongated trough crucible substantially of V shape in cross section and very narrow in proportion to length and depth, and means for applying heat externally to all sides of the crucible except the top for distilling the values of ores.

3. In apparatus of the type described, an elongated trough crucible substantially of V shape in cross section and very narrow in proportion to length and depth and having a sloping bottom, optionally to one or both ends, descending into

channels and spouts at either end, the spouts having shutter stops to close the drainage and to permit drainage of the crucible in upright position.

4. An apparatus of the type described comprising an elongated trough crucible substantially of V shape in cross section, very narrow in proportion to its length and depth and means for heating same exteriorly, imbedded in a cradle of fire-resisting material, the cradle having a slanting flat top provided with an opening communicating with the mouth of the crucible and being tiltably suspended within a frame which is provided with a flat surface having an opening communicating with the entrance to a condensing system, said tiltable suspension and relation of surfaces being such that the flat surface of the frame coincides with the flat top of the cradle when in upright position, bringing the mouth of the crucible into registry with the entrance to the condensing system to complete an exclusive passageway for gases from crucible to condensing system and being also such that the tilting of the cradle will separate the flat surfaces and disunite the passageway from crucible to condensing system.

5. An apparatus of the type described comprising a crucible, means for heating same externally, a condenser, means supporting said crucible for pivotal movement to permit said crucible to be swung downwardly for charging, said crucible and said condenser having connections meeting at an angle whereby they may be separated and brought into registry by movement of said crucible.

6. An apparatus of the type described, an elongated trough crucible substantially of V shape in cross section, very narrow in proportion to length and height with combustion means and rectangularly moulded helical combustion cells surrounding same and all imbedded in fire-resisting materials fixed in a cradle characterized by a slanting plane top, said top having an opening equal to the crucible rim and communicating therewith; means supporting said cradle for tilting movement but normally maintaining the cradle in operative position; the cradle suspension being in combination with a stationary fume condenser and filter system having an opening leading thereto; said crucible being movable from chargeable position to a normally operative position with its outlet in registry with said opening.

7. An apparatus of the type described consisting of an externally heated crucible very narrow in proportion to length and depth having an open top normally lying in an inclined plane and provided with a closable drain spout at the bottom, said crucible imbedded in a cradle of fire-resisting material with means supporting same for tilting movement downwardly to charging position, and a fixed condensing and filter system having an opening leading thereto, said crucible being movable into a normal operative position with its top in registry with said opening, the crucible further characterized by sloping bottom, drain-off channels and closable drain-off spouts.

8. An apparatus of the type described, an ore vapor condensing and filter system in combination with and for attachment to, the ore vapor exhaust passageway from an ore furnace; the system comprising a continuous passageway for said vapors exclusively through adjacent, connected cells, separately described as follows; a dome drum of adequate reservoir capacity for reception and immediate expansion of all said vapors, with entrance and interior designed with curvatures for agitating the vapor column and inducing temporary relaxation of flow therein and constructed of material permitting slight cooling of contents by radiation to the atmosphere and with an easily removable cover, said cell collecting the quickly condensible values from the vapor; further, varying temperatured cells in a multiple return tube series, tubes carried through a liquid type cooling case with ends protruding and connected in continuous vapor passageway by easily removable slip-on returned bends, the case provided with means to circulate a cooling medium and to regulate the temperature therein, with a device for indicating temperatures therein, said cells collecting values selectively according to known volatility and condensation temperatures; further, a filter case with longitudinal cells therein alternately connected at opposite ends and separated only partially by baffles alternately extending from opposite ends in such manner as to cause ore vapors to pass alternately back and forth through the case, each such cell packed with dry, loosely-banked, strands of such materials as asbestos and wool, said packs removably installed, the case provided with easily removable covers to give access therein for removing filters and values.

9. An apparatus of the type described comprising a crucible, means for heating same exteriorly in combination with a condensing system composed of a dome drum with a removable cover for condensing and collecting the least volatile values from ore, and a varying temperature continuous passage return-tube condenser in a case adapted to contain a medium for cooling same, terminal portions of said condenser extending exteriorly of said case, and slip-on bends for connecting terminal portions for access to the interior and means for cooling said condenser to different degrees of temperature at different points whereby ore values are condensed selectively according to volatility points.

10. An apparatus of the type described comprising a crucible and means for heating same exteriorly in combination with a condensing system consisting of a dome drum, a curving throatway lip in said drum for turning the vapor flow to induce precipitation and to serve as a receptacle to receive precipitated values; and a continuous passage condenser comprising parallel tubes passing through a cooling case, ends protruding from said case and joined in series by removable slip-on returned bends which are machined interiorly to fit over the tube ends, means for circulating a cooling medium in said case whereby the temperature of the tubes may be controlled, and means for temperature indication in the medium; the reverse passageways being operative to break the column of vapor flow therethrough to induce disruption and uniform cooling.

11. In apparatus of the type described, an elongated trough crucible substantially of a V shape in cross section and very narrow in proportion to length and depth, means for heating same exteriorly, a cradle mounted for tilting movement and containing said crucible in combination with an ore vapor condensing and filter system, the crucible having a slanting-planed top sloping towards one side to facilitate gas-tight junction of said top with the entrance to the condensing and filter system and disjunction by tilting the cradle.

12. In apparatus of the type described, an elongated trough crucible substantially of V

shape in cross section and very narrow in proportion to length and depth, and means for heating the same exteriorly in said cradle, in combination with an ore vapor condensing and filter system, the crucible having a slanting-planed top sloping towards one side, a flat member having a sealed connection with the top of the crucible throughout the entire periphery thereof and extending in all directions from the crucible rim substantially upon said slanting plane of said crucible top to said edge of the cradle top.

13. In apparatus of the type described, a vapor trap and condensing means consisting of a cell contained in an elongated dome drum the upper surface of which is semi-circular in cross section in connection and communication with the ore vapor exhaust passageway from an ore furnace, an entrance thereinto under a curved deflector dividing the drum into a reversely directed continuous passage, and an exit therefrom for ore vapors; the drum being thin so as to permit partial cooling of vapors by radiation through the material to the atmosphere, and with a removable cover provided to give access for removal of values condensed therein; said cell of sufficient dimensions to adequately receive and permit expansion of ore vapors from the furnace, said dimensions and reverse passageway being operative to interrupt the column of said vapors and partially impound same for cooling.

14. In apparatus of the type described, a series of parallel ore vapor condensing tubes in connection and communication with the ore vapor exhaust passageway from an ore furnace, the tubes extending through a liquid type cooling case with tube ends protruding therefrom and connected in series to complete the continuous passageway for ore vapors therethrough, slip-on return bends connecting tube ends and removable to permit recovery of values which condense in the tubes; means for circulating a cooling medium through said case and a temperature indicating device in said case to facilitate temperature regulation and condensation of values from ore vapors in the tubes.

15. In apparatus of the type described, an ore vapor filter system comprising a filter case connected to and in communication with the ore vapor exhaust passageway from an ore furnace, the filter case containing parallel cells formed between alternate parallel baffles, and alternately connected at opposite walls of the case, the baffles alternately extending from opposite walls of the case in such a manner as to cause ore vapors to pass continuously through the filter case in reverse alternate passage through adjoining cells; each such cell being uniformly packed with dry, loosely-banked, strands of such materials as asbestos and wool; said packs removably installed and the case being provided with removable covers to give access therein for removing filters and values.

16. An apparatus of the type described, a complete ore smelting and distilling furnace having a fluid-fuel combustion means, a box cradle tiltably suspended in balance on trunnions in such a manner that the furnace may be inverted for charging and dumping without substantial interruption of the smelting and distilling operation, said combustion means and furnace being wholly contained in said cradle, a crucible in said furnace having a sloping bottom for drainage and recovery of value, a frame supporting a complete ore vapor condensing and filter system whose entrance forms a severable, airtight junction with the mouth of the crucible when the cradle is upright on its trunnions, said crucible being located within said frame, the mouth of the crucible and the condenser entrance meeting at reciprocal planes with reference to trunnion bearings and being so machined that registered junction may be readily made and broken by tilting the cradle on its trunnions.

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