No. 653,202. Patented July 10, 1900.

P. ARGALL.

ORE ROASTING FURNACE.

(Application filed Sept. 28, 1899.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.

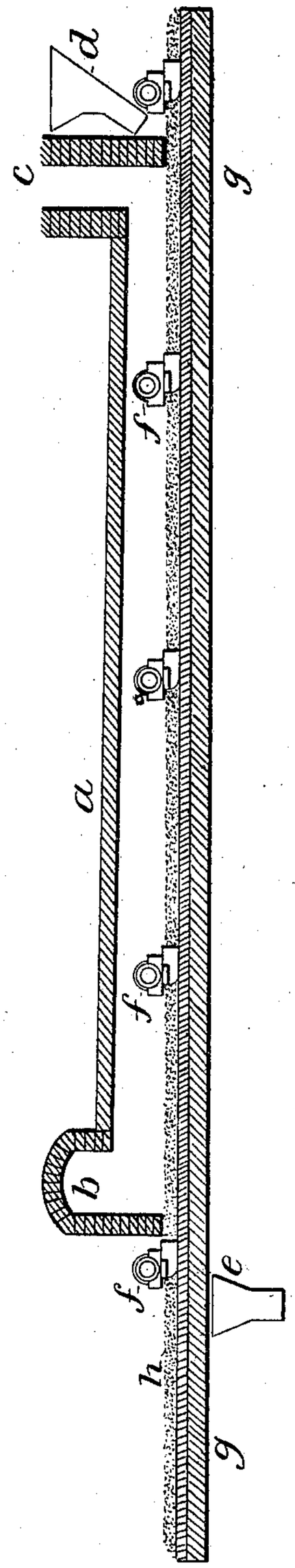
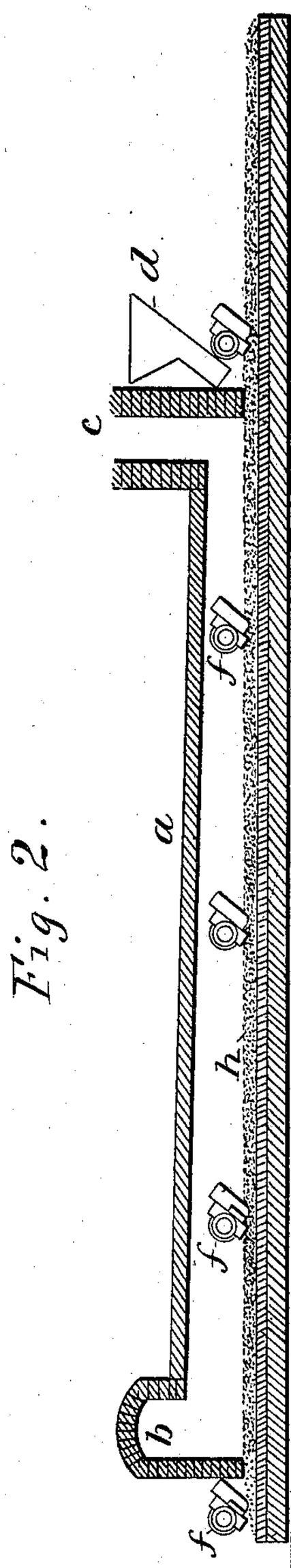


Fig. 2.



Witnesses:
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Inventor:
Philip Argall;
By Henry H. Bates, Atty.

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(No Model.) 4 Sheets—Sheet 2.

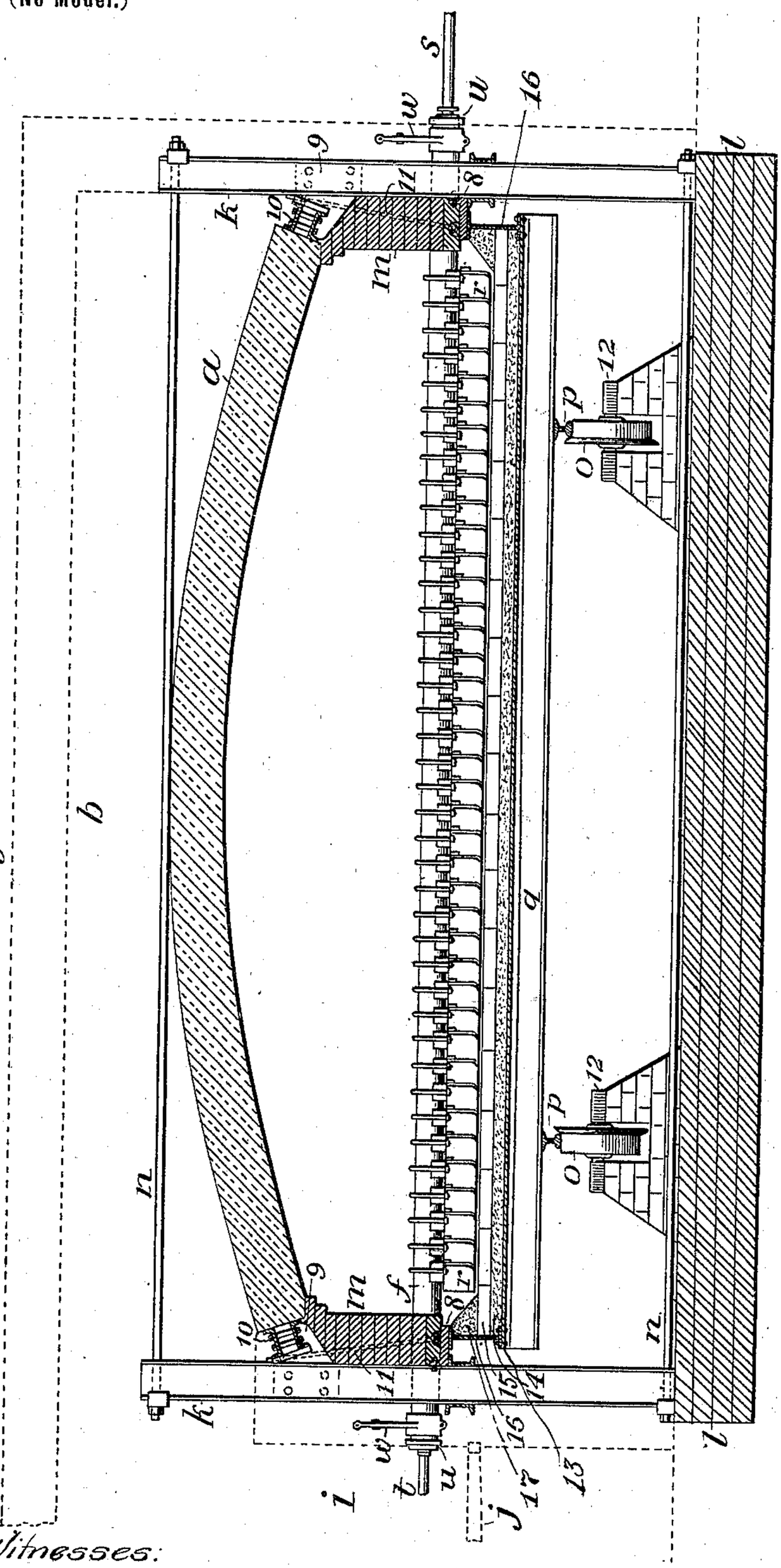

Fig. 3.

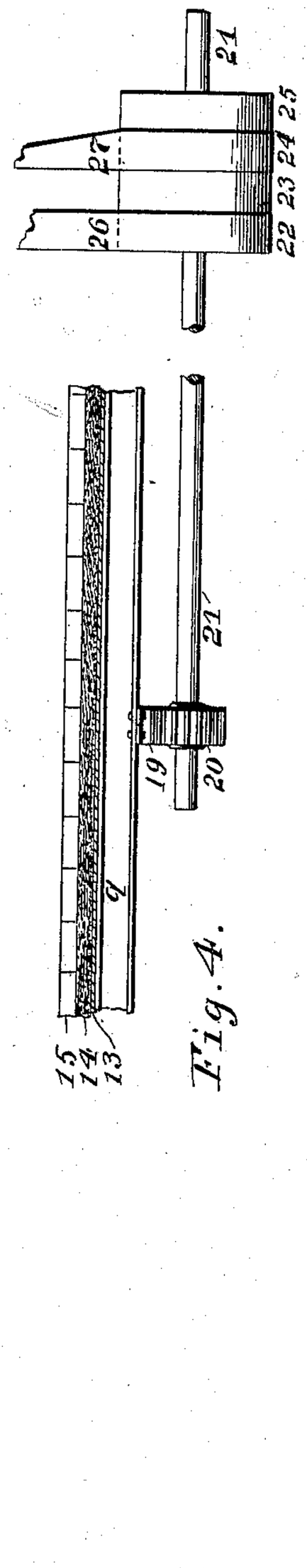

Fig. 4.

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4 Sheets—Sheet 3.

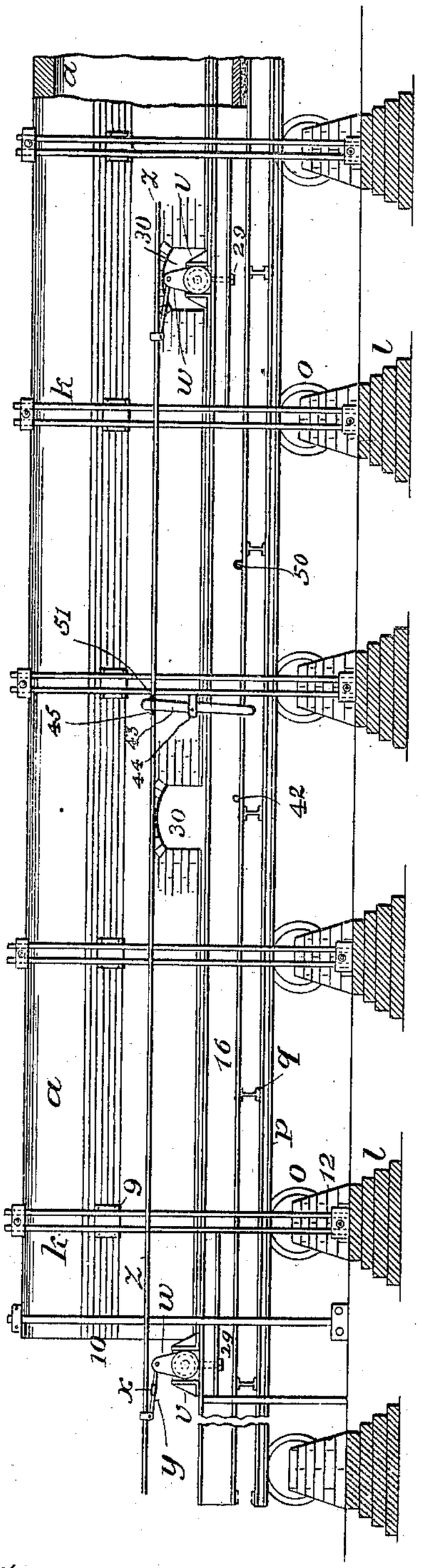

Fig. 5.

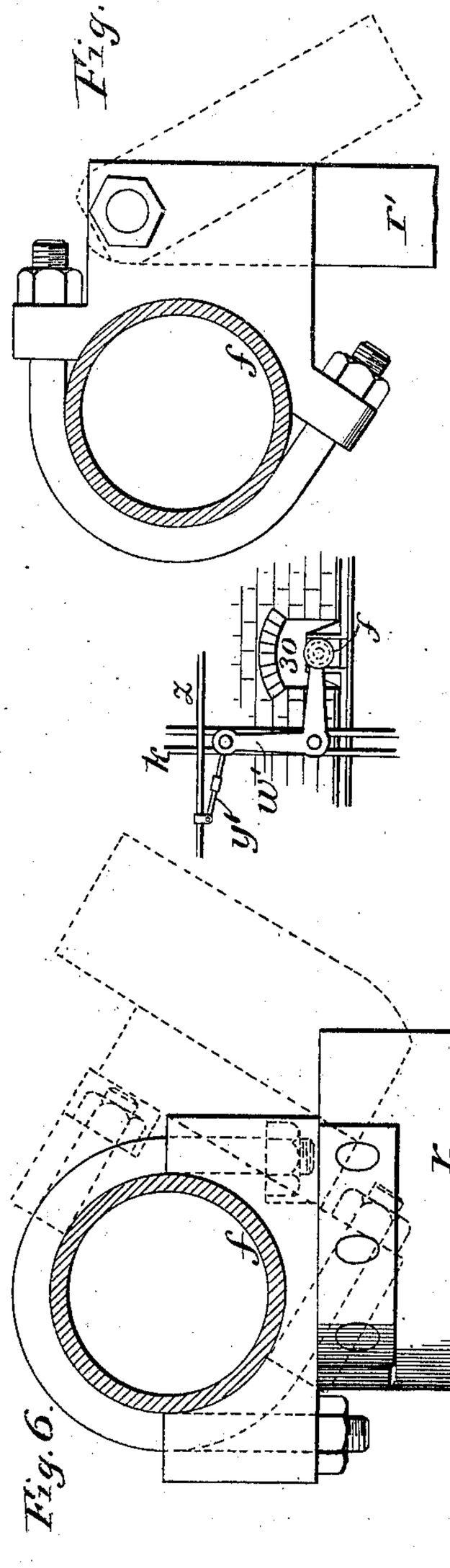

Fig. 8.

Fig. 6.

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(No Model.) 4 Sheets—Sheet 4.

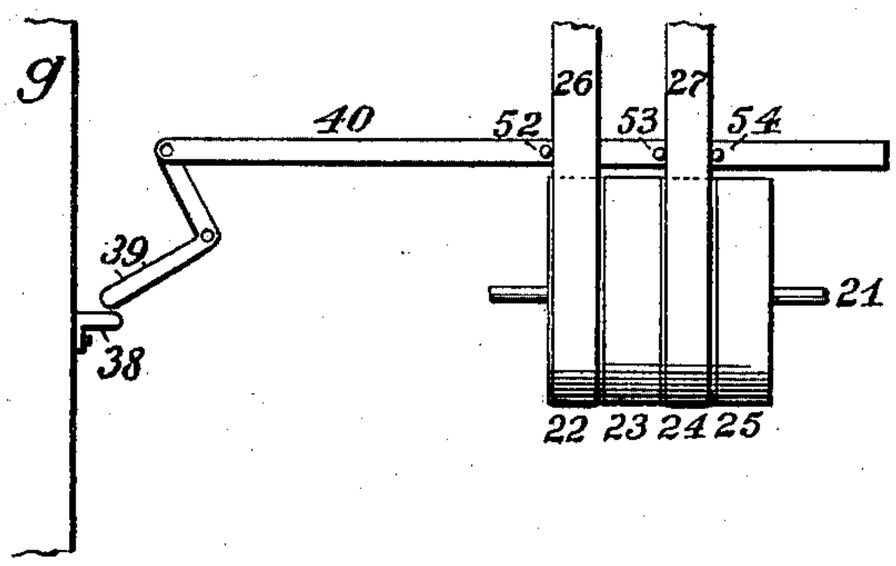


Fig. 9.

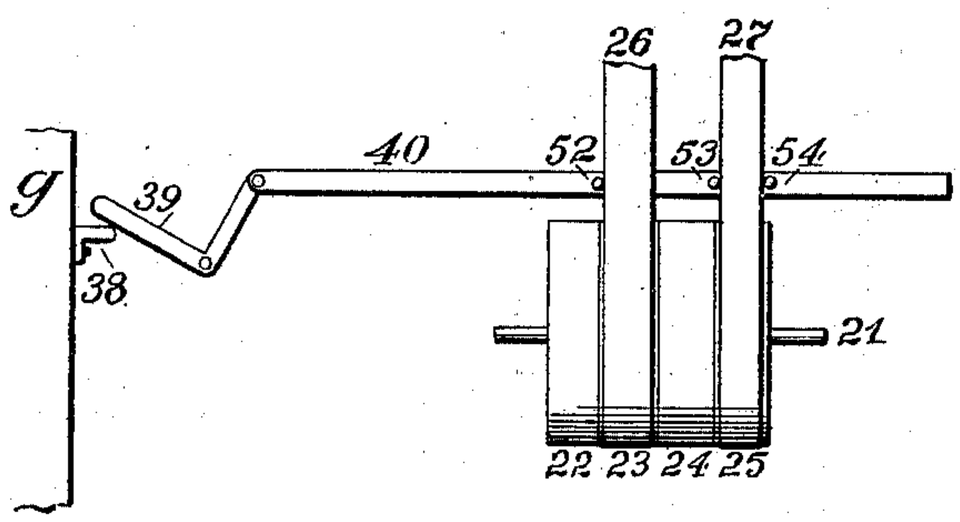
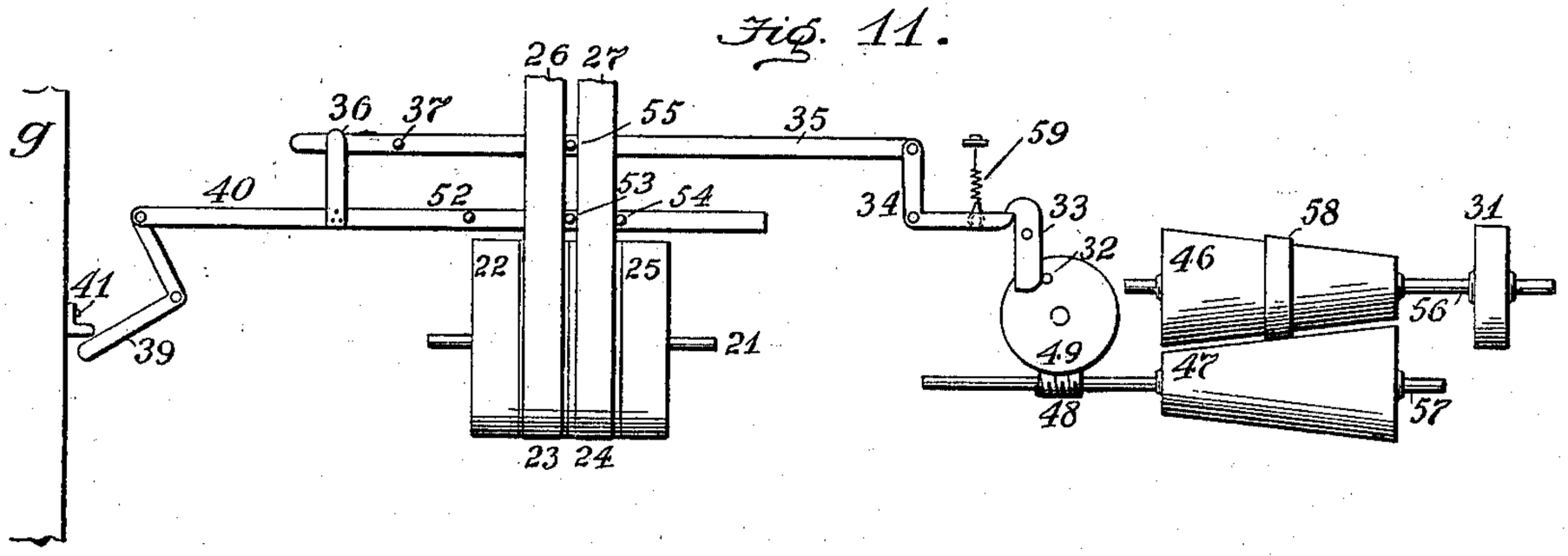


Fig. 10.

Fig. 11.



Witnesses:
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UNITED STATES PATENT OFFICE.

PHILIP ARGALL, OF DENVER, COLORADO.

ORE-ROASTING FURNACE.

SPECIFICATION forming part of Letters Patent No. 653,202, dated July 10, 1900.

Application filed September 28, 1899. Serial No. 731,971. (No model.)

To all whom it may concern:

Be it known that I, PHILIP ARGALL, a citizen of the United States, residing at Denver, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Ore-Roasting Furnaces; and I do hereby 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.

My invention relates to improvements in ore-roasting furnaces operated mechanically. Mechanical ore-roasting furnaces have been largely introduced on account of their economy over the costly and exhaustive hand-labor required to roast ores on the primitive plan and may be roughly divided into two classes—namely, first, the rotary, in which the furnace is tubular or multitubular and revolubly mounted on an axis slightly inclined from the horizontal, the rotation thereof being relied on to stir up and advance the ore from the feed end to the discharge end under the influence of gravity during the period of roasting, and, second, the fixed reverberatory furnace, in which rabbles are reverted to for stirring and advancing the ore, as in the hand process; but the rabbles are worked mechanically, the rabble-arm passing into the furnace through a slot in the sides and traversed back and forth by suitable mechanism from the outside. In certain species the mechanical reverberatory furnace is annular, the rabbles traveling in a circular path worked from a central rotary shaft, or the rabbles may be fixed while the furnace-bottom rotates.

The mechanism for operating the mechanically-operated rabbles is difficult to adequately protect from heat, and consequently the wear and tear and the expense are very great in proportion to the complexity and exposure of the moving parts. Some of these furnaces are also inconvenient of access at all points for repairs or for removing obstructions or accretions on the hearths of the furnaces. In seeking to improve the mechanically-operated furnace I have gone back to the ordinary type of reverberatory hand roasting-furnace still largely in use, which is excellent in design, easily accessible from both sides, and only objectionable on account of the cost of the hand-labor required to operate it. This furnace is commonly about seventy feet long, the hearth about fifteen feet wide, the fire at one end and the stack at the other, and has working doors on each side through which the charge is stirred and advanced by hand-rabbles operated through the side doors. I have retained these features of excellence so far as possible in a mechanical furnace.

My improvement consists, primarily, in making the extended reverberatory furnace above described with a reciprocating bed, hearth, or bottom and with fixed rabbles extending across the hearth from side to side, with means for lifting the rabbles out of the ore mechanically to enable the traversing bottom to return without disturbing the advance of the ore, and, secondarily, in the means hereinafter described by which the said mechanical furnace is reduced to practical and operative form.

In the drawings forming a part of this specification, Figure 1 is a vertical longitudinal section of my improved furnace in roasting position, showing the bottom ready for movement to the right to stir up and advance the ore toward the discharge end by means of the stationary rabbles. The rabbles are in the ore. Fig. 2 is a vertical longitudinal section of the same furnace, showing the furnace-bottom after it has been moved to the right, having discharged the ore lying on the exposed section on the left and received a corresponding charge of ore on the right. The rabbles are lifted out of the ore to permit the return motion to the left. Fig. 3 is a transverse sectional view showing in dotted lines a portion of the fire-box and combustion-chamber, grate-bars, &c. Fig. 4 is a transverse sectional view of a portion of the movable bottom and means for operating the same. Fig. 5 is a side elevation, partly in section, of a portion of the furnace, showing the mode of supporting the movable bottom, the side channel-posts and supports, the inspection-openings, the rabble-arms, and means for operating, &c. Fig. 6 is a detail view showing the hollow rabble-arm in section and the position of the rabble when in the ore and when lifted by rotation, the latter in dotted lines. Fig. 7 is a similar detail view of an alternative form of the rabble which does not require the lifting or rotation

of the rabble-arm. Fig. 8 is a detail view in elevation of an alternative mode of lifting the rabbles out of the ore. Fig. 9 is a diagrammatic view showing one mode of tripping the belt-shifter by the movements of the reciprocating bottom to automatically reverse the direction of its motion, the parts being in the positions occupied just before the shift for the return movement. Fig. 10 is a diagrammatic view showing the relative positions of the tripper, belt-shifter, and belts just after the shift for the return movement. Fig. 11 is a diagrammatic view showing a simple means for causing the automatic pause between the pairs of reciprocating movements while the charge of ore is roasting.

Referring the drawings, *a* is the arched top of the furnace.

b is the arch of the opening from the combustion-chamber into the furnace.

c is the flue or stack for exit of products of combustion.

d is the feed inlet or hopper for ore to be roasted.

e is the discharge-hopper for the roasted ore.

f f are the hollow rabble-arms, extending across the hearth and through the apertures in the walls from side to side.

g is the movable or reciprocating hearth.

h is the ore, spread out on the movable hearth in a layer of suitable depth for the rabbles to operate upon.

i is the combustion-chamber, situated at the discharge end of the furnace at the side, (shown in dotted lines in Fig. 3,) communicating with the furnace by the arch *b*.

j is the grate.

k k are upright channel-posts supported on suitable foundations *l l*, said channel-posts sustaining the side walls and arch of the structure.

m m are the side walls, and *n n* are tie-rods, extending across the structure above and below the furnace to secure the upright supports against displacement by the thrust of the arch. I do not confine myself to this mode of sustaining the furnace to afford space for the movable bottom, but describe and show it as a practical and efficient style of construction for the purpose. The combustion-chamber is located between two channel-posts, the grate extending outward from the side of the furnace. The channel thrust-beams 10 are omitted for the width of the fireplace, and the combustion-chamber arch extends entirely across the furnace, so that the flame rising from the combustion-chamber crosses the full width of the furnace and descending through the opening in the arch of the main furnace passes onward through the furnace to the extremity thereof, where the flue or stack is located. The side walls are supported on angle bracket-plates 8 8, firmly secured to the upright supports *k k*, permitting the movement of the bottom of the furnace beneath said side walls.

9 9 are cast-iron brackets firmly secured to the channel-supports of such shape and in such position as to take the thrust of the arch, a double channel-beam 10 10, with separators between, being seated on the bracket to form the immediate abutment of the arch.

11 11 are tie-bolts secured to the horizontal bracket-plates 8 8 and to the brackets 9 9 for the purpose of stiffening the said bracket-plates and aiding in the transfer of the entire weight of the side walls and arch to the upright channel-posts *k k*, leaving a free open space beneath for the reciprocating hearth and the operating mechanism. The end walls come down to within a short distance of the traveling bottom, leaving just space enough for the bed of ore to clear the walls as it is projected forward and backward by the movement of the traveling bottom.

The reciprocating bottom is made longer than the entire length of the furnace by the amount of travel conferred upon it, which may be from ten to thirty feet. It thus alternately projects at one end or the other of the furnace by this amount. The said bottom is carried on ordinary car-wheels *o o* by means of railway-rails *p p*, which run on the wheels. Said wheels are journaled in suitable supports 12 12. On these rails are the transverse **I**-beams *q q*, covered with sheet metal 13, over which is laid a layer 14 of non-heat-conducting material and above that a layer 15, of fire-brick or analogous refractory material, forming the roasting-hearth of the furnace. Deep **I**-beams 16 form the sides of the hearth-bottom to retain the ore, the insides of the beam next the hot ore being protected by a banking of fire-clay 17 or analogous refractory material.

Upon the hollow rabble-arms *f* are fixed the rabbles *r* in the manner shown in detail in Fig. 5 or in any other suitable and workmanlike manner. These rabbles, formed of steel or equally-refractory metal, are set on the rabble-arm diagonally with respect to the axis thereof at an angle of about thirty degrees, so as to shift the ore sidewise as well as longitudinally, leaving it furrowed like a plowed field. The hollow rabble-arms are supplied with means for maintaining a cooling water circulation through them, of which *s* is the inlet-pipe, and *t* is the outlet-pipe, for the cooling fluid. These are provided with suitable caps and stuffing-boxes *u* to form a water-tight joint and allow the rabble-arms to rotate. Said rabble-arms, although fixed in the sense that they do not travel relatively to the fixed furnace, are arranged so that the rabbles can be lifted out of the ore just before the reciprocating bed is returned and also so that they may be adjusted vertically to compensate for the wear of the rabbles and for perfect adjustment to the position of the movable bed. *v v* are the adjustment-boxes for this purpose, and 29 is the adjustment-screw, Fig. 5.

To lift the rabbles from the ore, a convenient provision is that shown in Figs. 5 and 6, in which the rabble-arm is rotated through a

small arc sufficient to clear the rabbles from the ore. To this end a crank-arm *w* is provided, secured on the end of the rabble-arm, which is attached by an adjustable link connection *y* (*x* being an adjustment-coupling) to a rod *z*, running longitudinally the whole length of the furnace on both sides, by means of which all the rabble-arms may be turned and lifted simultaneously either at will or by automatic mechanism coördinated with the movement of the hearth-bottom, as hereinafter described. If preferred, the rabble-arms may be lifted bodily from their seats on each side of the furnace a sufficient distance to clear the rabble from the ore by a modification of the mechanism shown in Fig. 8, where *w'* is a bell-crank lever, one arm of which is connected to the rabble-arm and the other arm by means of the adjustable link connection *y'* to the operative rod *z*. In Fig. 7 I have shown a third alternative form, in which the rabble *r'* is jointed to the rabble-support, so as to lift itself out of the ore on the return movement of the same, thus avoiding the necessity for the bodily lifting of the rabble-arm. In this figure, 18 is a section of the rabble, showing the form thereof as presented to the moving body of ore in both directions, the convex side being toward the ore as it advances to be stirred and shifted.

In Fig. 4 I have shown in detail the means preferably employed for reciprocating the movable bottom back and forth. A section of said bottom is shown, to the under side of which, preferably in the center, is secured a rack 19, with which meshes a pinion 20, secured on a shaft 21, journaled in suitable bearings and extending to the outside of the furnace, where on said shaft are mounted four pulleys 22 23 24 25, two being tight on the shaft and two loose. A straight belt 26 runs on one of the tight pulleys—say 22—extending to a drum moved by a source of power, said belt being capable of being shifted by an ordinary belt-shifter to the adjacent loose pulley 23. A crossed belt 27 runs on loose pulley 24, extending to the power-drum and capable of being shifted by similar means to the tight pulley 25, thus in a simple well-known manner effecting the reciprocation of the movable bottom in accordance with the needs of the operation of roasting the ore under treatment. This operation is intermittent in this apparatus, as hereinafter explained, and is automatically conducted by simple well-known mechanical means. Any other well-known form of gearing for conducting the reciprocation of the bed and its intermittent action properly timed would of course be within the scope of this invention.

The furnace may be of a length of one hundred feet and upward, as the work may demand, and the extent of travel of the reciprocating bed may be, as before said, any where from ten to thirty feet. In the illustrations herewith appended I have shown a bed of twenty-five feet travel. This furnace has doors 30 in its sides similar to those of the hand-operated furnaces, located twelve feet apart, or about one-half the distance of the travel of the bed. In every alternate door I locate a rabble-arm, making the arms twenty-four feet apart, thus covering a range of travel of the ore for each charge. The doors are opposite to each other on each side of the furnace. The rabble-arms may be located elsewhere than in the doors, but for convenience I locate them as above stated. In this furnace the movement is intermittent, as above stated. The movement of the ore-bed forward, (or in the direction of the stack,) with the rabbles in the ore, stirs the ore and at the same time advances it a short distance toward the exit at the combustion-chamber end of the furnace. The rabbles are then automatically lifted from the ore, a new charge is supplied, and the return move is made. The rabbles are then automatically lowered into the ore, when the moving mechanism is at rest, for from ten to thirty minutes (depending on the nature of the ore,) to allow time for the ore to become properly roasted before another stirring and advance. Thus the action of the furnace is made dependent on the time necessary to roast the ore and not on the speed of a continuously-moving rabble, as in most mechanical furnaces. The pause while the ore is becoming roasted also permits time for the layer of ore which has been roasted and projected on the extension of the bottom beyond the discharge-hopper to cool to a degree before being finally discharged into the hopper *e*.

The automatic reversal of the reciprocating bed may be effected by a combination of any well-known mechanical means adapted for the purpose. In Figs. 9, 10, and 11 I have shown such a device for purposes of illustration. The power-shaft 21, which operates the moving bed, is shown in Fig. 4, and on it are the four pulleys 22 23 24 25, the two outer ones 22 25 being fast on the shaft, and the two inner ones 23 24 being loose on the shaft. The belts 26 27 give motion to this shaft from a prime source of motion, 27 being a crossed belt, so as to run on the pulley in a direction opposite to that of belt 26. In Fig. 9 the shaft 21 is receiving motion from belt 26 and the movable bed (a portion of which is shown at *g*) is traveling forward or toward the stack and is near the end of its journey. On the bed a tripper 38 is adjustably secured in such a position as to encounter the bell-crank lever 39 just before the time for reversal. The movement of the crank-lever by the tripper moves the belt-shifter 40 toward the right to the position shown in Fig. 10, and by means of the pins 52 and 53, which press against the belts, the latter are shifted onto the adjacent pulleys 23 and 25, 23 being loose and 25 tight on the shaft. The shaft 21 now loses its forward motion and takes a reverse motion from crossed belt 27 through

tight pulley 25, when the movable bed commences its return journey. At the end of this journey a similar tripper 41, Fig. 11, adjustably fixed on the bed in a suitable position, strikes the bell-crank lever 39 on the other side, and thereby by means of pin 54 replaces belt 27 on the loose pulley 24, and thus arrests the motion of the shaft and bed, the belt 26 being left running on the loose pulley 23.

To effect the pause between each double reciprocating movement of the bed while the ore is roasting, an auxiliary device may be employed similar to that illustrated in Fig. 11, where 31 is a pulley on shaft 56, receiving rotary motion from the same prime source of motion as pulleys 22 25. On the parallel rotary shafts 56 57 are fixed two cone-wheels 46 47, forming a well-known variable-speed gear, which gives motion at such speed as may be desired, according to the length of pause required, to the worm 48 on the shaft 57. Said pause may be from ten to thirty minutes, according to the nature of the ore under treatment. The zone of contact between the cone-wheels is formed by the adjustable elastic belt 58. The worm 48 meshes with the worm-gear 49, on which is a revolving pin 32, which in its revolution strikes against catch 33, releasing bell-crank lever 34, which under tension of spring 59 shifts the auxiliary belt-shifter 35 and by means of pin 55 moves belt 26 back to its original position on tight pulley 22, when the shaft 21 and connected bed *g* resume their forward travel, as shown in Fig. 9. The pin 37 is at the same time moved up into proximity with stop 36 on shifter 40, so as to be ready to replace shifter 35 to its position shown in Fig. 11, with bell-crank 34 in engagement with the catch 33, when the belt-shifter 40 shall have been moved from the position shown in Fig. 9 to the position shown in Fig. 10.

The lifting and depression of the rabbles out of and into the ore may be automatically accomplished by similar stop and lever mechanism. Such a means is shown in Fig. 5, where 43 is a lever pivoted at 41, so as to be encountered by stops 42 and 50, fixed in suitable positions on the movable bed or some part that moves synchronously therewith. The opposite end of said lever 43 reaches into engagement with stop-pins 45 51 on rod *z*. By this means when the movable bed is nearing the end of its forward stroke the stop 42 encounters the lever 43 just in time to move the rod *z* and revolve or lift the rabbles out of the ore as the bed comes to rest ready for the return stroke. The return stroke is made with the rabbles lifted, as shown in Fig. 2; but just before the end of said stroke the stop 50 encounters the lever 43 on the other side and replaces the rabbles in the ore as the bed comes to rest, to remain there during the roasting process and during the forward travel of the bed to stir and advance the ore. These elementary devices are shown here simply for illustration to exhibit in operative form the automatic action of the mechanism. In practice other and more intricate specific means may be adopted, and the invention herein set out is not limited in this respect.

As the furnace may be of any length adapted to the work to be done, it is sometimes necessary to have one or more intermediate fire-chambers in addition to the one at the end, depending on the length of the reverberatory arch and the nature of the ore to be roasted, some ores requiring a higher degree of heat than others to bring them to the required condition.

Among the advantages of the form of mechanical furnace herein described are the doing away with the longitudinal slots in the sides of the reverberatory arch found necessary in those furnaces where a moving or traversing rabble-arm is employed, which slots are wasteful of heat, and also the doing away with the swinging doors employed in such furnaces to admit of the entrance and exit of the rabble-carriages at either end of the furnace, which admit an excess of air and greatly interfere with the regular action requisite to the best results in the roasting of the ores. These doors, furthermore, are rapidly destroyed by the heat, causing great expense for repairs, and do not confine the heat at the ends economically, as in the forms of reverberatory furnace having fixed end walls.

I claim and desire to secure by Letters Patent—

1. An ore-roasting furnace provided with a reciprocating bottom, longer than the said furnace, and means for moving said bottom back and forth a specific distance equal to said excess of length, whereby the furnace always remains closed at the bottom, substantially as specified.

2. In an ore-roasting furnace, a reciprocating bottom, and means for moving the same, in combination with a series of rabbles, fixed relatively to the said moving bottom, and arranged across the furnace and bed, substantially as specified.

3. In an ore-roasting furnace, in combination, a reciprocating bottom, means for moving said bottom, a series of rabbles arranged across the furnace and bed, and means for adjusting said rabbles vertically with reference to said bottom, substantially as specified.

4. In an ore-roasting furnace, in combination, a reciprocating bottom, means for moving the said bottom, a series of rabbles arranged transversely to the line of motion of said bottom, means for delivering a charge of ore on said bottom, means for simultaneously depressing said rabbles into the ore, and means for lifting said rabbles out of the ore to clear the same on the return movement of the bottom, substantially as specified.

5. In an ore-roasting furnace, in combination, a reciprocating bottom, a hollow rabble-arm, one or more, mounted transversely to the line of motion of said bottom, a series of rabbles

mounted on said rabble-arm, means for adjusting the height of said rabble-arm relatively to the said bottom, means for lifting and depressing the rabbles independently of said adjustment, and means for passing a cooling fluid through said hollow rabble-arm, substantially as specified.

6. In an ore-roasting furnace, a reciprocating bottom supported on a movable trackway, said bottom being longer than the furnace, and means for moving said bottom back and forth a distance equal to the excess of length of the bottom over that of the furnace, whereby a portion of said bottom is alternately exposed outside the furnace at each end, affording space for spreading the fresh ore, and for cooling the roasted ore, at the respective delivery and discharge ends of the furnace, substantially as specified.

7. In an ore-roasting furnace, a reciprocating bottom, means for moving said bottom, means for feeding ore upon said bottom, means for discharging ore from said bottom, means for mechanically stirring the ore during its movement by rabbles inserted therein, and means for periodically arresting the movement of the said bottom, during the operation of roasting, substantially as specified.

8. In an ore-roasting furnace, having a fire-chamber at one end, a chimney-flue at the other end, and a reverberatory arch between, a movable hearth or bottom extending the entire length of the furnace, and a given distance beyond, means for supporting the said bottom on rotary supports, means for moving the said bottom back and forth, a feed-hopper for ore at the chimney end, a discharge-hopper for ore at the fire-chamber end, and rabbles, fixed against horizontal movement but adjustable vertically, substantially as specified.

9. In an ore-roasting furnace, in combination, a reciprocating hearth or bottom, means for reciprocating the same, a series of hollow rabble-arms extending transversely across said movable hearth or bottom at definite intervals, rabbles fixed upon said rabble-arms, crank-arms on the ends of said rabble-arms, horizontal rods extending the whole length of the furnace on each side, adjustable link connections between the said rods and the said crank-arms, and means for moving the said rods, whereby all the rabble-arms are simultaneously moved and the rabbles thereby lifted from the ore, substantially as specified.

10. In an ore-roasting furnace, a reverberatory arch, having openings in the sides thereof, a reciprocating bottom, means for reciprocating said bottom, rabble-arms arranged transversely to said bottom, with rabbles thereon, means for raising and lowering said rabbles, means for feeding the ore, means for discharging the ore, a combustion chamber or chambers for heating the ore, and a flue or flues for carrying away the products of combustion, substantially as specified.

11. In an ore-roasting furnace, in combination, a reciprocating bottom, means for moving the same, and means in connection with said bottom for automatically reversing the motion thereof at the end of each forward movement, substantially as specified.

12. In an ore-roasting furnace, in combination, a reciprocating bottom, means for moving the same, means in connection with said bottom for automatically reversing the motion thereof at the end of each reciprocating movement in either direction, and means for automatically effecting a pause for a predetermined period between each return movement and the succeeding forward movement, substantially as specified.

13. In an ore-roasting furnace, in combination, a reciprocating bottom, means for moving the same, a series of rabbles arranged across the said furnace and bottom, said rabbles being vertically adjustable and also movable relatively to said bottom toward and from the same, and means coördinated with said moving bottom for automatically lifting and depressing said rabbles, substantially as specified.

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

PHILIP ARGALL.

Witnesses:

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HUGH M. STERLING.