No. 676,417. Patented June 18, 1901.

H. CARMICHAEL.

APPARATUS FOR ROASTING ORES.

(Application filed Jan. 24, 1901.)

(No Model.)

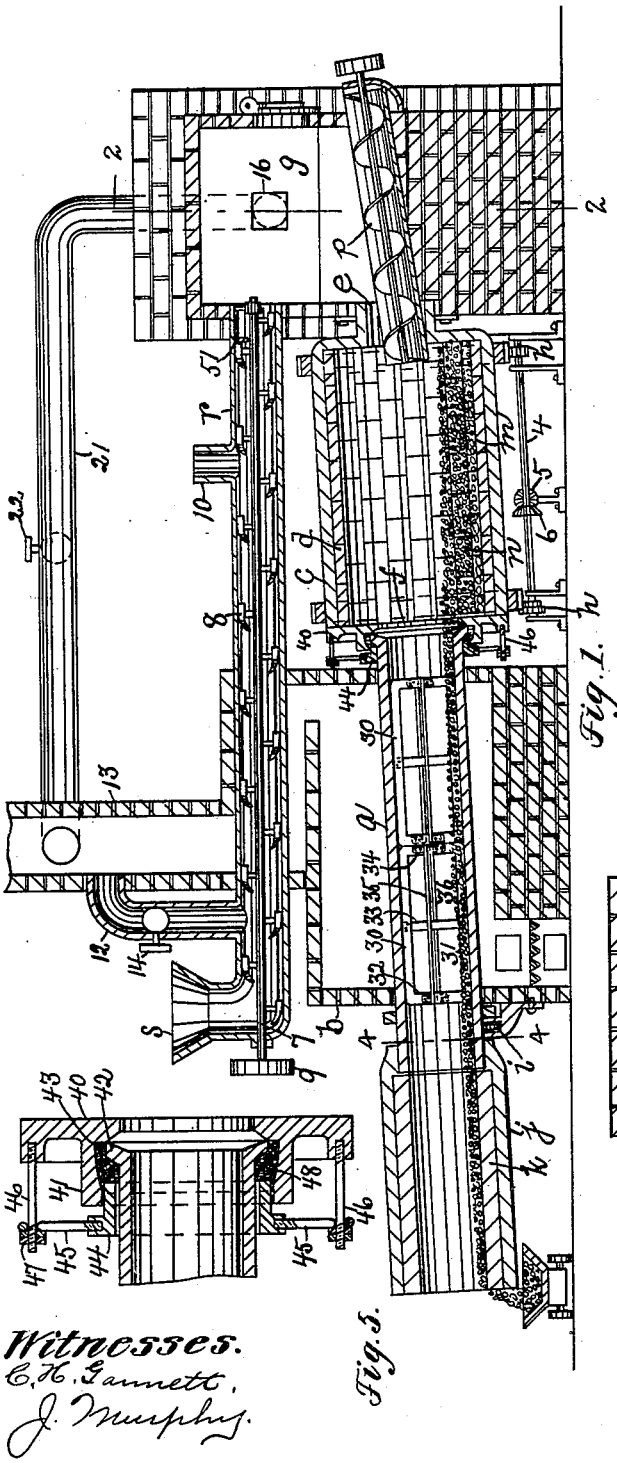

Fig. 1.

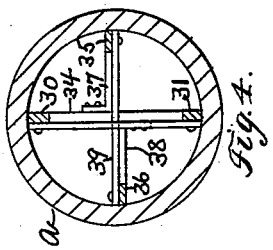

Fig. 4.

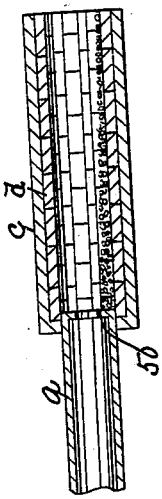

Fig. 3.

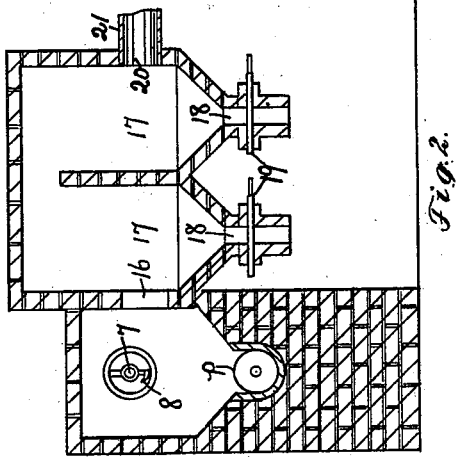

Fig. 2.

Fig. 5.

Witnesses.
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UNITED STATES PATENT OFFICE.

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APPARATUS FOR ROASTING ORES.

SPECIFICATION forming part of Letters Patent No. 676,417, dated June 18, 1901.

Application filed January 24, 1901. Serial No. 44,584. (No model.)

To all whom it may concern:

Be it known that I, HENRY CARMICHAEL, a citizen of the United States, residing in Malden, in the county of Middlesex and State of Massachusetts, have invented an Improvement in Apparatus for Roasting Ores, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention relates to an apparatus with which refractory oxidizable ores containing substantially large amounts of sulfur or arsenic, or both, may be brought to a dead-roast and the ore placed in proper condition for the extraction of the precious metals contained in them by the chlorination or other processes now commonly employed.

In extracting gold from ores by the chlorination process it is essential for commercial success that the ores be as free as possible from sulfur and arsenic, as the presence of even small amounts of either or both of these elements causes a substantially large and excessive quantity or amount of chlorin to be used for the extraction of the gold, and owing to the high cost of chlorin the extraction of gold from low-grade ores is practically prohibited unless the ore is practically freed of its sulfur or arsenic by roasting, and when the ore is thus practically freed from its arsenic and sulfur it has been brought to what is known as a "dead-roast." When ore which has been brought to a dead-roast is subjected to the chlorination process, the chlorin is utilized in combining with the gold or other precious metals in the ore, and consequently low-grade ores which are otherwise of no practical value can be utilized and their precious metals extracted at a profit.

For the purpose of effecting a dead-roast of refractory oxidizable ores the ore after being wholly or partially dried is passed through a combustion-zone the temperature of which is maintained by heat units wholly or partially supplied from the ore itself, and in this zone the greater part of the sulfur and arsenic, or both, is removed from the ore, thereby rendering the latter no longer capable of self-oxidation, and the ore thus treated is passed through a second heated zone, in which it comes in contact with fresh hot air raised to a suitable temperature by heat supplied from an extraneous source, and on its passage through said second zone the partially-oxidized ore is elevated and showered down, and thus in a disseminated condition is thoroughly exposed to the action of the current of hot air, which combines with the sulfur and arsenic in the minute particles of the ore, so that the sulfur and arsenic are practically eliminated or removed to such a degree as to require a minimum amount of chlorin with a maximum extraction of the metals in the ore, and when in this condition the ore has been brought to a dead-roast.

In accordance with this invention I employ for the combustion-zone a rotatable drum provided with a non-heat-conducting wall, which may be a lining of fire-brick, and for the externally-heated zone a rotatable retort or muffle extended through a furnace and secured to said drum, for the best results, by a flexible joint, the said retort having within it lifting devices by which the ore may be disseminated, and thus thoroughly exposed to the action of hot air passing through said retort. The retort may and preferably will be provided with a detachable extension which is open to the atmosphere and affords opportunity for the roasted ore to become partially cooled by contact with the cool fresh air drawn into the extension and which air passes through the retort and drum.

These and other features of this invention will be pointed out in the claims at the end of this specification.

Figure 1 is a vertical longitudinal section of a roasting apparatus embodying this invention; Fig. 2, a section on the line 2 2, Fig. 1; Fig. 3, a modification in section to be referred to; Fig. 4, a sectional detail on the line 4 4, Fig. 1; and Fig. 5, a sectional detail of the flexible joint.

Referring to Fig. 1, *a* represents an iron or steel tube or pipe, which is extended through the walls of a furnace *b* and is externally heated by the products of combustion of said furnace. The retort *a* is inclined and is attached at its upper end to a substantially large cylinder or drum *c*, provided with a non-heat-conducting wall, (shown as a lin-

ing *d* of refractory material, such as fire-brick,) said drum having inlet and outlet openings *e f* in its ends. The inlet-opening *e* communicates with a dust chamber or receptacle *g*, and the outlet-opening *f* communicates with the upper end of the retort *a*, and in the present instance the retort is attached to the cylinder or drum by a flexible joint, as will be described. The cylinder *c* is revolubly supported on suitable rolls or wheels *h*, and the retort *a* is also supported by suitable rolls *i*. The rolls *h* are shown as mounted on a shaft 4, which is rotated from a driving-shaft (not shown) by gears 5 6. The retort *a* may have secured to its lower end an extension *j*, preferably detachable therefrom and provided with a lining *k* of non-heat-conducting material, such as fire-brick. The outlet-opening of the cylinder or drum *c* is made of smaller diameter than the said cylinder, so as to leave a pocket or space *m* in the cylinder, so that a body *n* of ore is left in the cylinder at all times while the ore is being roasted, for a purpose as will be described. The ore to be roasted may be fed into the internally-heated combustion-chamber *c* by one or more revolving screws *p*, and the ore previous to its entrance into the dust-chamber may be dried by passing it through a drier, which is shown as a tube or pipe *r*, extended through the furnace *b* above the rotatable retort and into the dust-chamber, the drying-tube *r* being provided with suitable means for feeding the ore through it from a hopper *s* into the dust-chamber. In the present instance I have shown the drying-tube as provided with a shaft 7, extended through it and having attached to it a series of arms or rabbles 8. The shaft 7 may be rotated in any suitable manner and is shown as provided with a pulley 9. The drying tube or pipe *r* may be provided with an open branch pipe 10 near one end, through which air may be admitted into the drier, and with an outlet tube or branch 12 near its opposite end, which communicates with the chimney 13 of the furnace *b* and is provided with a damper 14 to regulate the current of air through the drier to the chimney, which current carries off the moisture expelled from the ore as the latter is fed through the drier. The dust-chamber *g* in practice may be made sufficiently large to have a number of driers *r*, and combustion-chambers *c* communicate therewith, and the said chamber may communicate through a port or opening 16 with one or more settling-chambers 17, provided with suitable discharge-openings 18, controlled by gates or valves 19.

In Fig. 2 two settling-chambers are shown, and the second is provided with an outlet port or opening 20, which is connected to the chimney 13, as shown, by a pipe 21, provided with a damper 22; but, if desired, the settling-chambers 17 may be connected with suitable scrubbers, (not shown, but similar to those employed in chemical works.)

The retort *a* is provided with lifting devices, which may be cast integral with the retort or which may be made separate therefrom, and in the present instance the lifting devices are represented as made separate from the retort and inserted therein sufficiently tight to cause them to rotate with said retort.

To facilitate construction, the lifting devices may be made as shown and comprise two open frames, each consisting of two longitudinal bars 30 31, united by cross-bars 32 33 34, and two longitudinal bars 35 36, disposed, substantially, at right angles to the bars 30 31 (see Fig. 4) and united to the end bars 32 34 by the cross-arms 37 38, the longitudinal bars 35 36 being united by a central cross-bar 39. The frames referred to may be arranged in the retort *a* with their longitudinal or lifting bars in line with each other, or the said frames may be arranged with the longitudinal bars out of line with each other. The lifting devices are extended substantially the length of that portion of the retort within the furnace *b*, and the said lifting devices rotating with the retort act to lift the ore and discharge or shower the lifted portion in a disseminated condition down onto the bottom or lowest portion of the rotating retort, thus exposing the minute particles of the ore to the oxidizing action of the hot fresh air passing through the retort.

The flexible joint between the retort *a* and the drum *c* may be made as represented in Figs. 1 and 5, wherein the head 40 of the drum is shown as provided with an annular hub or flange 41, into which the retort *a* is inserted, the said hub or flange being of larger diameter than the retort, so as to permit of movement of the retort within it in case the said retort and drum are moved out of alinement with each other under the influence of heat. In the present instance the retort is provided with an inclined flange 42, which is adapted to bear against the head of the drum, as clearly shown in Fig. 5. The space between the hub or flange 41 and the end of the retort inserted into it is filled with asbestos or like non-combustible material 43, which is retained in said space by a split ring 44, which is extended into the hub or flange and is also adjustably connected with the head of the drum. This connection may be effected, as shown, by eyebolts 45, attached to the ring and fitted over threaded rods 46, attached to the head of the drum, the eyebolts being moved on the rods 29 by the adjusting-nuts 47. The asbestos packing 43 prevents fine ore or dust from leaking through the joint, thus avoiding waste of material. The inner circumference of the hub or flange is made curved for the whole or a portion of its length, as at 48, the curvature being in the arc of a circle having a radius equal to the external diameter of the retort at its end.

The eyebolts 45 and the rods 46 are designed

so as to have a limited spring action, so that if the retort becomes out of alinement with the drum by warping the retaining-ring will move with the packing practically as one piece, and thus insure the joint being maintained dust-tight under all conditions.

In operation with the apparatus shown in Fig. 1 the ore discharged into the hopper *s* is fed forward through the drier into the dust-chamber *g*, from which the dried ore is fed by the screw *p* into the combustion-chamber *c*. The combustion-chamber *c* is set in motion, and the ore is caused to pass from said chamber down through the retort and, as shown in Fig. 1, through the extension *j*, from which it discharges into a suitable receptacle. While the ore is passing in one direction through the combustion-chamber, retort, and extension thereof it is subjected to the action of a current of fresh air which is drawn through the apparatus in an opposite direction either by the natural draft of the chimney or by a fan. (Not herein shown.) The ore in the dust-chamber *g* is more or less exposed to oxidation in the flames which escape from the combustion-chamber *c;* but as the air from the combustion-chamber is already impoverished in its oxygen contents it is incapable of sustaining active combustion. The ore in a hot and partially-oxidized state is projected into the rotating combustion-chamber and is therein subjected to the direct action of heated air and hot gaseous products created as will be described, and the said heated air combines with the sulfur or arsenic, or both, in the fresh ore and creates a combustion, which internally heats the combustion-chamber to a substantially high temperature—that is, to a temperature sufficiently high to effectively eliminate the greater portion of the sulfur or arsenic, or both, contained in the ore. The ore after treatment in the internally-heated combustion-chamber passes into the rotatable retort and is in a state no longer capable of maintaining its own temperature in a current of air, and consequently the said retort is externally heated by the products of combustion in the furnace. The partially-roasted ore in the rotatable retort is elevated by the lifting devices and showered down upon the bottom or lowest part of the retort, thus presenting the ore in a disseminated condition to the action of the heated air passing through the retort, and the substantially small amount or quantity of the sulfur or arsenic, or both, remaining in the partially-roasted ore is practically eliminated from the ore, and the latter is brought to a condition known as a "dead-roast," which is the condition desired.

The roasted ore may pass directly out of the retort; but I prefer to pass it through the extension *j*, wherein it meets the cool entering air and imparts its heat to the same, thereby at the same time becoming cooled rapidly and reduced to a sufficiently low temperature to enable it to be subjected directly to the chlorination or other process for extracting the precious metal or metals therefrom.

In case the ore to be roasted does not of itself contain enough heat units for its oxidation in the combustion-chamber these may be supplied by mixing carbon or sulfurets with the ore previous to or while in the combustion-chamber.

The combustion-chamber may and preferably will be made of larger internal diameter than the rotatable retort, as shown in Fig. 1, so that a certain quantity or body of highly-heated ore may remain in the said chamber to furnish heat in the combustion-chamber and assist in the proper roasting of the fresh ore; but while I may prefer to make the combustion-chamber of larger internal diameter than the retort substantially the same result may be obtained by providing the retort with an internal ring or flange 50, (see Fig. 3,) which forms a restricted discharge-opening for the combustion-chamber and forms the pocket desired within the said chamber. The dust which may gather in the chamber *g* is returned into the combustion-chamber by the feeding-screws *p*, and that which passes into and settles in the chambers 17 may be removed by opening the valves 19.

If a fan is used to draw the air through the apparatus, it may be desirable to connect the settling-chambers 17 with a scrubber, (not herein shown, but which may be similar to those used in chemical works and in which the sulfurous oxid, arsenic, and other fumes are absorbed by the water passing through the scrubber.) The sulfurous oxid may be recovered from the water by heating the latter and is then pure enough for any technical application.

In practice it is preferred that the temperature of the retort be lower than the temperature of the combustion-chamber, as in this manner balling of the ore is prevented or at least reduced to a minimum, which if it takes place renders it substantially impossible to bring the ore to a dead-roast, in which condition it should be brought in order to enable the precious metals to be extracted therefrom.

In order to prevent fumes from the dust-chamber being drawn into the drying-tube *r*, a stop or damper 51 is provided in the upper portion of the tube *r* near the end leading into the dust-chamber.

Instead of the particular construction of drier herein shown other forms may be used—as, for instance, instead of the tube *r* being fixed it may be arranged to revolve, in which case the revolving rabbles may be dispensed with.

In practice I have effected a dead-roast of refractory oxidizable ores with an apparatus like that shown in the drawings, the drum being eight feet in length and two and one-half feet in diameter and the retort being twelve feet long and one foot in diameter and both

having an inclination of one-third of an inch to the foot, the drum and retort making five revolutions a minute. With this apparatus from one and one-half to four tons of ore could be dead-roasted in twenty-four hours, depending upon the character of the ore, the greatest time being required by auriferous arsenopyrite concentrates.

I claim—

1. An apparatus of the class described, comprising a rotatable combustion-chamber, a rotatable retort communicating with said combustion-chamber, a flexible joint for connecting said retort with said combustion-chamber, means within said retort for disseminating the ore on its passage through said retort, means for externally heating said retort, means for rotating said retort and said combustion-chamber, and means for feeding the ore successively through said combustion-chamber and said retort, substantially as described.

2. An apparatus of the class described, comprising a rotatable combustion-chamber having a non-heat-conducting wall and into which the fresh ore is fed, and wherein the greater portion of the sulfur or arsenic or both in the ore is eliminated therefrom, means for feeding the ore into said combustion-chamber, a rotatable retort or muffle communicating with the combustion-chamber for the passage of the partially-roasted ore in said retort wherein said roasting is practically completed, means within the retort for lifting and disseminating the ore on its passage through said retort, means for externally heating the retort, an extension of said retort removed from the influence of the external heat and wherein the roasted ore is cooled, and means for rotating said retort, its extension and said combustion-chamber, substantially as described.

3. An apparatus of the class described, comprising a furnace, a rotatable retort having heat-conducting walls extended through said furnace, means within said retort for disseminating the ore on its passage through said retort, a rotatable combustion-chamber provided with a non-heat-conducting wall and communicating with said retort, means for rotating said combustion-chamber and said retort, a drier extended through the said furnace, and means for connecting said drier with said combustion-chamber, substantially as described.

4. An apparatus of the class described, comprising a furnace, a rotatable retort having heat-conducting walls and extended through said furnace, a rotatable combustion-chamber having a non-heat-conducting wall and communicating with said retort, means for rotating said retort and combustion-chamber, a drier extended through said furnace, a chamber with which said drier and said combustion-chamber communicate, and means within said chamber for feeding the ore into the combustion-chamber, substantially as described.

5. An apparatus of the class described, comprising a furnace, an inclined rotatable retort extended through the same, a combustion-chamber detachably secured to the upper end of said retort to rotate therewith, and provided with a non-heat-conducting wall, means for rotating said retort and combustion-chamber, a dust-chamber, means for feeding ore from the dust-chamber into said combustion-chamber, and a drier for said ore extended through said furnace and communicating with said dust-chamber, substantially as described.

6. An apparatus of the class described, comprising a furnace, a rotatable retort extended through said furnace, a rotatable combustion-chamber communicating with said retort, means for rotating said retort and combustion-chamber, a drier extended through the said furnace, means for connecting said drier with said combustion-chamber, and means for partially closing said drier to the passage of fumes, substantially as described.

7. An apparatus of the class described, comprising a rotatable combustion-chamber having a non-heat-conducting wall, means for feeding ore into the outer end of the combustion-chamber, a rotatable retort having heat-conducting walls and communicating with the inner end of said combustion-chamber, means within said retort for disseminating the ore on its passage through the retort, means for externally heating said retort only, means for rotating said retort and said combustion-chamber, and means for feeding the ore successively through said combustion-chamber and retort, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HENRY CARMICHAEL.

Witnesses:
JAS. H. CHURCHILL,
J. MURPHY.