No. 676,418. Patented June 18, 1901.

H. CARMICHAEL.

METHOD OF ROASTING ORES.

(Application filed Jan. 24, 1901.)

(No Model.)

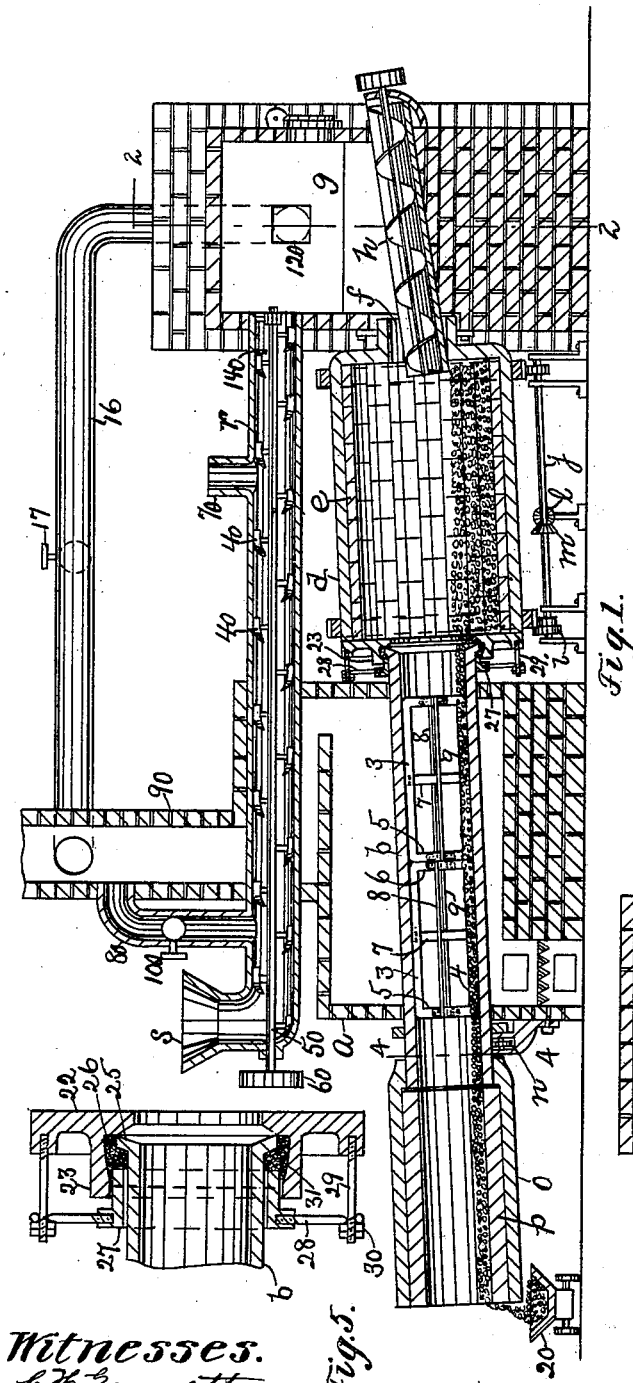

Fig. 1.

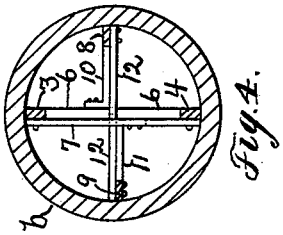

Fig. 4.

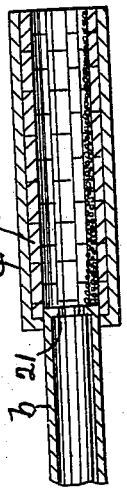

Fig. 3.

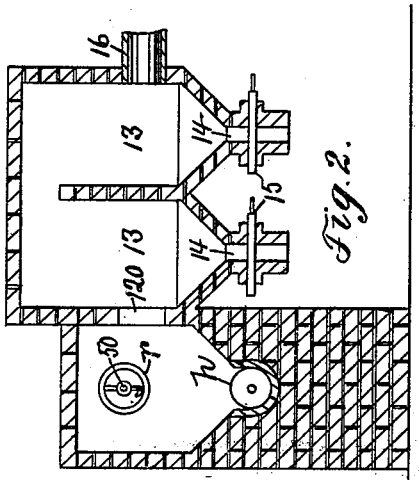

Fig. 2.

Fig. 5.

Witnesses.
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UNITED STATES PATENT OFFICE.

HENRY CARMICHAEL, OF MALDEN, MASSACHUSETTS, ASSIGNOR TO THE CARMICHAEL REDUCTION COMPANY, OF PORTLAND, MAINE.

METHOD OF ROASTING ORES.

SPECIFICATION forming part of Letters Patent No. 676,418, dated June 18, 1901.

Application filed January 24, 1901. Serial No. 44,585. (No specimens.)

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 Methods of 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 a novel method of roasting ores, and especially refractory oxidizable ores containing substantially large amounts of sulfur or arsenic, or both, whereby a dead-roast may be obtained 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. The flame resulting from the exposure of the ore in a disseminated condition passes into the first-mentioned zone in such volume as to effectively heat the ore therein. While the ore is passing in a continuous manner in one direction through the heated zones referred to a current of pure air, uncontaminated by products of combustion, is maintained in an opposite direction to carry on the oxidation in the extraneously-heated zone and to start the oxidation in the first or internally-heated zone.

Figure 1 is a section of one form of apparatus with which my invention may be practiced; Fig. 2, a section on the line 2 2, Fig. 1; Fig. 3, a modification of the apparatus to be referred to; Fig. 4, a sectional detail on the line 4 4, Fig. 1; and Fig. 5, a sectional detail to be referred to.

Referring to Fig. 1, *a* represents a furnace of any suitable construction and of sufficient length, as will be described, through which is extended an inclined iron or steel tube or pipe *b*, attached at its upper end by a flexible joint to a cylinder or drum *d*, provided with a lining *e* of refractory material and having an ore-inlet port or opening *f*, which communicates with a chamber *g*, provided with one or more feeding-screws *h*, by which the ore is fed from the chamber *g* into the cylinder or drum *d*. The tube or pipe *b* constitutes an externally-heated retort or muffle and the cylinder or drum *d* an internally-heated combustion-chamber, and these parts may be rotated, as shown, by rolls or wheels *i* on a shaft *j*, driven from a main shaft (not

shown) by gears *l m*, the retort at its lower end being supported on rollers or wheels *n*.

The retort *b* 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 3 4, united by cross-bars 5 6 7, and two longitudinal bars 8 9, disposed substantially at right angles to the bars 3 4 (see Fig. 4) and united to the end bars 5 6 by the cross-arms 10 11, the longitudinal bars 8 9 being united by a central cross-bar 12.

The frames referred to may be arranged in the retort *b* 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 *a*, 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 retort *b* preferably has attached to its lower end an extension or regenerator *o*, provided with a lining *p* of non-heat-conducting material. The chamber *g* has communicating with it a tube or pipe *r*, which is extended through the furnace *a* above the retort *b* and constitutes a drier for the ore fed into it through the hopper *s*. The drying tube or pipe is provided with means for feeding the ore through it, shown as a series of arms or rabbles 40, attached to a rotatable shaft 50, provided with a pulley 60. The drying tube or pipe *r* is provided with a branch pipe 70, open to the atmosphere, and with a branch pipe 80, connected with the chimney 90 of the furnace, and provided with a damper 100. The chamber *g* communicates through a port 120 with settling-chambers 13, provided with discharge-ports 14, controlled by valves 15, the said settling-chambers being connected, as herein shown, to the chimney 90 by a pipe 16, provided with a damper 17.

The ore deposited in the hopper *s* is wholly or partially dried on its passage through the drier and is discharged upon the bottom of the chamber *g*, from which it is fed continuously into the combustion-chamber *d*, and from said combustion-chamber the ore passes in a continuous manner into and through the retort and out therefrom through the regenerator or extension into a suitable receptacle 20.

The flexible joint between the retort *b* and the drum *d* may be made as represented in Figs. 1 and 5, wherein the head 22 of the drum is shown as provided with an annular hub or flange 23, into which the retort *b* 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 25, which is adapted to bear against the head of the drum, as clearly shown in Fig. 5. The space between the hub or flange 23 and the end of the retort inserted into it is filled with asbestos or like non-combustible material 26, which is retained in said space by a split ring 27, 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 28, attached to the ring and fitted over threaded rods 29, attached to the head of the drum, the eyebolts being moved on the rods 29 by the adjusting-nuts 30. The asbestos packing 26 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 31, the curvature being in the arc of a circle having a radius equal to the external diameter of the retort at its end.

While the ore is passing in one direction through the combustion-chamber, retort, and regenerator it is subjected to the action of a current of fresh air, which is drawn through the apparatus in an opposite direction, and the products of combustion created in the externally-heated retort pass into and heat the combustion-chamber and the ore therein, which heat is augmented by the heat units wholly or partially supplied by the sulfur or arsenic, or both, contained in the ore, the heat in the combustion-chamber being retained as much as possible, which is effected in the present instance by the refractory lining *e*. It will thus be seen that the ore after being dried is first passed through a zone in which the temperature is maintained by heat units supplied by the ore itself—namely, while the ore is passing through the internally-heated combustion-chamber—and then the ore is passed through a comparatively long zone, in which it is presented in a disseminated condition to the action of fresh air raised to a suitable temperature by heat supplied from a source extraneous to the ore—namely, in the externally-heated retort—and in the absence of products of combustion of said source of heat.

As a result of this method of treating refractory ores the greater portion of the sulfur or arsenic, or both, contained in the ore is removed while the ore is passing through the internally-heated combustion-chamber, and practically all of the remaining portion of the

sulfur or arsenic, or both, is removed while the partially-roasted ore is passing through the externally-heated retort, and the ore is thus brought to a dead-roast, which is the condition desired for extracting the precious metals from it by chlorination or other processes. The roasted ore is cooled on its passage through the regenerator or extension *o* by contact with the fresh air drawn into said regenerator, and the air is thus heated.

I prefer to cool the roasted ore by passing it through the regenerator, as the air is thereby more efficiently heated and the ore is cooled sufficiently to permit it to be used directly; but I do not desire to limit my invention in this respect, as the ore may be discharged directly from the retort.

In some instances the ore may be deficient in heat units, and in this case the deficiency may be made up by the addition of carbon or sulfurets to the ore. In order to obtain superior results, it is desirable to retain in the internally-heated combustion-chamber a considerable body of heated ore, and this result may be accomplished, as shown in Fig. 1, by making the outlet-opening of the said chamber of smaller diameter than the said chamber or, as shown in Fig. 3, by providing the retort *b* with an internal annular flange 21.

In order to effect a dead-roast of sufficient ore in a given time, to render the process of practical value and commercially successful, a substantially large quantity of the ore is fed into the drum and the latter and the retort are given but a substantially slight inclination and a substantially rapid rate of rotation, whereby the showering effect and consequent exposure of the ore to the action of the hot fresh air is repeated many times during the passage of the ore through the externally-heated zone, and to insure a dead-roast to the substantially large quantity of partially-oxidized ore passing through the retort the latter is made substantially long.

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.

In order to prevent fumes from the dust-chamber being drawn into the drying-tube *r*, a stop or damper 140 is provided in the upper portion of the tube *r*, near the end and leading into the dust-chamber.

By the method herein described a greater quantity of refractory oxidizable ore may be brought to a dead-roast with the least expenditure of time and fuel and with greater uniformity in the roasted product than by any method or apparatus heretofore used and known to me, and as a result practically complete extraction of the values in the ore may be made with the least expenditure of chemicals, thus permitting low-grade ores and waste products, such as refractory concentrates, to be successfully treated at a profit.

I claim—

1. The method of roasting refractory oxidizable ores, which consists in passing the ore forward through a combustion zone, oxidizing the combustible ingredients of said ore as completely as possible within said zone by the action of air, and heating said ore within said zone substantially wholly by the oxidation of the ore therein, and substantially retaining the heat produced by said oxidation; then passing the nearly-oxidized ore through a second zone and simultaneously subjecting it in a disseminated condition to extraneous heat and to the action of air uncontaminated by products of combustion, whereby further oxidation of the ore is effected and practically all of the sulfur and arsenic are removed, and a dead-roast obtained; positively disseminating the ore on its passage through said second zone, and supplying the requisite air by moving a current of air in contact with the ore and through the disseminated portion thereof but in the opposite direction to the line of feed of the ore, substantially as described.

2. The method of roasting refractory oxidizable ores, which consists in passing the ore forward through a combustion zone, oxidizing the combustible ingredients of said ore as completely as possible within said zone by the action of air, and heating said ore within said zone substantially wholly by the oxidation of the ore therein, and substantially retaining the heat produced by said oxidation; then passing the nearly-oxidized ore through a second zone, and simultaneously subjecting it in a disseminated condition to extraneous heat and to the action of air uncontaminated by products of combustion, whereby further oxidation of the ore is effected and practically all of the sulfur and arsenic are removed, and a dead-roast obtained; positively disseminating the ore on its passage through said second zone, then passing the roasted ore through a third zone, simultaneously cooling the roasted ore and heating the fresh air; and supplying the requisite air by moving a current of air in contact with the ore through the said zones but in a direction opposite to the line of feed of the ore, 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.