W. H. STERLING.

PROCESS AND APPARATUS FOR REDUCING ORES.

No. 184,554. Patented Nov. 21, 1876.

Fig. 2

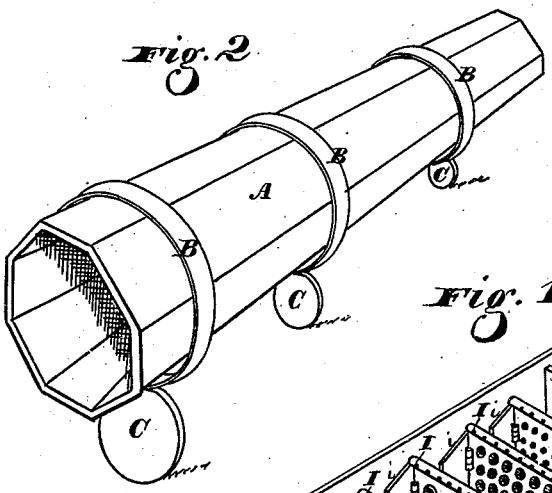

Fig. 1

Fig 3.

Witnesses

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IMPROVEMENT IN PROCESSES AND APPARATUS FOR REDUCING ORES.

Specification forming part of Letters Patent No. **184,554**, dated November 21, 1876; application filed August 14, 1876.

To all whom it may concern:

Be it known that I, WILLIAM H. STERLING, of the city and county of San Francisco, and State of California, have invented an Improved Process and Apparatus for Reducing Ores and Condensing Metallic Vapors; and I do hereby declare the following to be a full, clear, and exact description thereof, reference being had to the accompanying drawing.

My invention relates to an improvement in condensers or condensing apparatus for collecting and condensing the volatile portions or metallic fumes arising or generated in the roasting and smelting of metallic ores or compounds.

A furnace is constructed of iron, lined with fire-brick or clay, and shaped in the tapering form of a cone or pyramid. When the body of the furnace is constructed in the form of a pyramid, which I prefer, I place at appropriate points at each end and middle of the pyramid circular bands or cogs B B, which afford the necessary means of revolving the pyramid upon its axis. When the furnace is made in shape of the cone, then of course these bands are not necessary. These cogs or bands rest upon suitable revolving wheels C C, which give the furnace the proper revolutions. This pyramid or cone shape sloping body of the furnace is mounted upon these revolving wheels in such a manner as to slightly incline or invert the pyramid or cone toward its smaller end, in order that in its revolutions the ore may be slowly moved toward and discharged out of its terminal end into the cooling or discharging chamber at that point. This inclination is effected by having the wheels at the larger end of sufficiently greater diameter than those of the smaller as to overcome the difference in diameters, and thus give the incline or descent. At the base end of the pyramidal or conical body of the furnace is the usual fire-place with the most approved form of mechanical devices for feeding the ore into the furnace. At the terminal end is an improved form of cooling and discharging chamber, consisting of a chamber with two discharge valves or gates at the bottom, so placed one above the other as to form a double bottom with a space of several feet between them, both gates being worked by levers outside the chamber and discharging the ore either alternately or simultaneously into a chute or incline below, as may be required.

The object and advantage of having the furnace thus constructed in the tapering form of a pyramid or cone are that, by such a shape, the ore upon entering the furnace is very gradually heated, by reason of the heat being radiated over or throughout the wide diameters at the base, and the ore distributed over a large surface; and as the diameter of the pyramid or cone decreases, the ore simultaneously moving into the smaller space by the revolutions of the furnace, the heat is concentrated upon it and the ore becomes intensely hot, receiving all the benefit of the concentrated heat, thereby effecting a great economy of fuel, and at the same time most thoroughly roasting the ore.

The action of this furnace combines the effectiveness of the reverberatory with the economy of manipulation of the revolving cylindrical.

The principle of action of this furnace being to concentrate the heat and ore simultaneously by a sloping or tapering form of furnace body, combined with a revolving motion given to it, the body of the furnace therefore may be constructed either conical or pyramidal. That form which I prefer is a seven-sided or septangular pyramid, but it may be made in any polygonal form, or in that form which is very effective, a combination of the cone and pyramidal forms, such as that with the sloping or tapering sides of the furnace constructed alternately a cone and pyramid, one side conical and the next side pyramidal.

When it is desired to use the furnace for chloridizing gold and silver ores I construct two man-holes or openings in the body of the furnace for the purpose of adding the chloride of sodium or other chloridizing agent at the proper time when the ore is in the most suitable condition for the chemical changes to take place. One of these man-holes is placed about four feet from the base end, and the other in the longitudinal center of the furnace.

In the process of roasting the ores the fur-

nace is revolved very slowly about one-quarter to four or five revolutions per minute, according to the ores treated. In its revolutions the ore is turned over and over, constantly bringing a fresh surface of ore to be exposed to the direct action of the flames and heat, the angular sides of the pyramidal body of the furnace affording this facility of stirring the ore more after the effective manner of the reverberatory furnace than any other of those usually employed.

The essential part of my invention relates to a novel process for aggregating the minute particles of metals which do not possess sufficient specific gravity to cause them to settle. My said improved process also involves an improvement in the construction of condensing apparatus for collecting and condensing the volatile metallic particles and fumes arising and generated in the process of roasting and subliming metallic ores, and the escape of which, in the case of quicksilver sublimations, occasions so great a loss of valuable metal.

The very volatile nature of certain metallic fumes, such as those arising in the process of subliming quicksilver ores, renders them exceedingly light and diffusible as infinitesimal atoms throughout the entire atmosphere of the furnace and condensing-chambers, be they ever so large or extended. These infinitesimal atoms of metal are in fact so diffusible that a large percentage, variously estimated from twenty to sixty per cent. of the whole amount or assay quantity originally contained in the ores, are never brought, in the ordinary condensing-chamber employed, into sufficiently intimate contact with each other to form that aggregation of atoms necessary to produce a cohesive condensible globule. Therefore they float upon the air-currents wherever they may flow, no matter how extended the space of the chambers, and eventually they pass out the chimney or outlet-flues and are irrecoverably lost. This is so much the case and practice in the reduction of quicksilver ores that not only are great losses sustained in the working of high-grade ores, but the losses in the low grades are such that, in many instances, these latter ores cannot be profitably worked at all, even though they contain an assay quantity large enough to be profitable if these large losses were not made, the loss being relatively larger than in high-grade ores, from the fact that the metallic vapors arising from low grades are associated with a much greater relative proportion of atmospheric air, and consequently the metallic atoms are so much the more diffused and so much the less condensible. With the object, therefore, of not only cooling the metallic vapors to the condensation-point, but also of subjecting these infinitesimal and diffused atoms to the centripetal, rotary, spiral, gyrating, compressing, and whirling motions necessary to bring them into the intimate and cohesive contact and aggregation required to produce a condensible particle and metallic globule, I have devised the following novel contrivances, which substantially are thus described.

At the end of the outlet side of the ore-discharging chamber above described, or, if preferred, at the outlet of any of the condensing-chambers heretofore in use, I place a series of refrigerating-surfaces, D D D, which are constantly flushed with cold water to cool the fumes, condense the metallic vapors, and wash down the soot, dust, and unreduced particles of powdered ore. These cleansing-refrigerators are constructed substantially as follows: A chamber is formed of brick, wood, or clay lined iron walls of the desired dimensions, the dimensions depending upon the size or capacity of the roasting-furnace, and quantity and quality of ore to be hourly treated.

In the interior of this chamber are arranged the cooling, cleaning, and condensing surfaces, which consist of either hollow bodies, through which cold water circulates, as represented, or solid bodies, over which cold water is passed. The most convenient form of these refrigerating-surfaces, and which I recommend as being economical in cost and effective for this purpose, is that of pipes D D, made of earthenware, metal, or wood. They may be made of any desired shape, either round, triangular, square, rectangular, or polygonal. I have illustrated them in the drawings as being round, the ordinary ironstone earthenware being a very economical material for their construction. The exterior surface may be made rough or serrated, in order to break up the air-currents as much as possible, and thereby arrest and condense the metallic vapors, and give more surface for the collecting and washing down of the soot and dust. If pipes or hollow bodies are employed, a circulation is kept up through their interior of cold water, connections being made for that purpose outside the chamber. Solid bodies giving the same surfaces, however, may be employed, with their surfaces constantly flushed with cold water by the means hereinafter described; but I recommend that the hollow pipes, as illustrated, be used, as being economical in cost of construction and most effective. These pipes may be arranged in the chamber either horizontally, perpendicularly, or diagonally; but I prefer the horizontal form as most convenient. They are placed, therefore, horizontally in rows, as seen in the accompanying drawings, one below or beneath the other, the number in each row being from six to ten, depending, of course, on the dimensions of the chamber. The drawing represents the front row as comprising six in number, which is about the ordinary number. These pipes are placed horizontally, with a space of from one to three inches between them for the passage of the fumes or gases. Immediately behind these is arranged another set in like horizontal manner, but with the

pipes directly opposite the openings or spaces of the first set, and the openings or spaces of the second set behind the solid portions or surfaces of the first, about one inch space being between the two sets of pipes. The chamber is thus filled with pipes arranged in a similar manner, the solid portions or surfaces of each succeeding set being directly opposite the openings or spaces of the preceding ones.

Toward the outlet of this refrigerating-chamber the pipes or surfaces may be placed closer together, in order that after the air-currents and vapors are cooled and cleansed of the soot and dust they may pass through smaller spaces and over or against still greater areas of solid surfaces.

At the top of each pipe or condensing-surface, and accompanying or running parallel to it, is a small perforated pipe, G, which supplies a constant stream of cold water, by which, as it jets and flows over each pipe or surface, the entire condensing-surfaces, front and back, are constantly flushed with cold water and the chamber filled with cold spray.

I do not confine myself to any particular shape of these pipes or condensing-surfaces. They therefore may be made in any convenient or desirable form, and may be arranged horizontally, as illustrated in the accompanying drawings, or placed either vertically, diagonally, or in curves, the object and principle of the device being to so arrange the spaces or openings between the condensing-surfaces or pipes and their contiguity that each succeeding set may present a solid cold-water-flushed front opposite the spaces of the preceding ones, and thus cause the currents of fumes or gases to break up and pass against and impinge upon the cold surfaces of the pipes or condensing bodies, and not escape actual contact, by having anywhere in the chamber a passage in a straight or direct curved line through the intervening spaces of the condensing-surfaces.

Pipes or hollow bodies with cold water circulating through them may be used to present the necessary cold surface, without the use of water-flushing their exterior surfaces; but they are not so effective as when flushed as above described, from the reason that, a strong draft or current being produced, the air-currents from the furnace, laden with metallic vapors, soot, and dust, strike and impinge upon some one of these numerous cold-water-flushed surfaces, and at once all dust, soot, and unreduced powdered ore are washed down and the fumes cooled to that point which condenses all the heavy or dense metallic particles, leaving only the exceedingly subtle and infinitesimal atoms to pass over and be caught and condensed by the subsequent means employed.

After the vapors are thus cooled and washed by the refrigerators above described, they are passed into or through certain novel devices, by which those very subtle and exceedingly diffused portions that may have passed over uncondensed are now subjected to the action necessary to cause cohesion and aggregation of the infinitesimal atoms, by which they may become a particle large enough to condense and fall from their own gravity. I employ several devices to accomplish this purpose, and use them either in series or singly, as the case may be, the object of each being to give to the atoms that centripetal, rotary, spiral, gyrating, compressing, and whirling motion, and crowding together, required to form a condensable particle and metallic globule.

I will describe in succession how they are constructed, substantially as follows: First, about one to two feet from the last row of the refrigerating-surfaces are placed a series of perforated plates, screens, or diaphragms, H H H H. These are placed upright, one succeeding the other, with a distance of from about two to three feet between them. They are in series, of about three to six in number to each series, and the perforations in each succeeding plate or diaphragm are smaller than the preceding one. Thus, if the first plate of the series has holes half-inch in size, then the last will have perforations one-sixteenth in diameter, the object and principle being to decrease the diameters or reduce the size of the holes of each succeeding diaphragm or plate, and thereby increase the pressure under or through which the metallic vapors must pass on their way outward, and by that means give the atoms of metal that revolving, compressing, and centripetal motion, which conglomerates them into a globule. These diaphragms are made of wood, earthenware, iron, or other suitable material; and, in order to still further facilitate the inducing of the necessary revolving and compressing motions, they are made about an inch in thickness, with their inlet-apertures beveled, as represented at Fig. 3, forming a funnel-shaped passage-way through the plates.

To give the necessary facilities for removal and examination, they may be made in sections, and at the sides of the furnace may be constructed suitable openings, closed with air-tight coverings. At the top of each plate is placed a perforated pipe, J, jetting a small stream of water, by which the plate is always kept clean and cold.

These diaphragms may be in one series, or several of such series may be placed in succession in the same chamber, or a series of them may be placed after or between any one of the other devices herein described.

In order to regulate the number of holes or areas of the diaphragms according to the amount of metallic vapors passing from the furnace, and to maintain a greater or less pressure or exhaust in the chamber in which the plates or diaphragms are situated, several devices may be employed. Those two which I prefer as being the most convenient and practicable in ordinary use, and which I use either one

singly, or the two combined, are shutters or movable partitions, marked *i i*, mounted upon hinges or pivots at the top or sides of the plates, and swinging upon and closing a certain portion of the holes or apertures. The other form is that of a mercury or water seal at the bottom of the perforated plates, the height of the fluid in the seal being regulated from the outside. This seal is made in rectangular form, with its sides about half the height of the plates, and about twelve inches wide. They may be made of wood or metal. The perforated diaphragms may be made of any desired form, either square, circular, triangular, or polygonal; but the rectangular shape, as illustrated in the drawing, is convenient and desirable.

If desired, this control of the areas of the perforated diaphragm may also be accomplished by having the diaphragms movable up and down in the seal by means of rods and weights; but I prefer the methods just described, as being the most convenient, economical, and practical manner of using them in quicksilver-condensers. The illustration of this device is seen in Fig. 1.

The next device which I shall describe as having the same desirable object of giving the required centripetal and conglobing motions and consequent cohesion to the infinitesimal atoms, is substantially as follows: I construct a double chamber, one within the other, or place within the continuation of the condensing-chamber already described, an inner apartment. This inner chamber J is formed with six sides, each of the six walls being perforated with small holes with conical or beveled apertures one-fourth to one-sixteenth of an inch in diameter. The top is solid, and the bottom has an opening through which the vapors enter the chamber.

It being desirable, as in the case of the diaphragms just described, to control the areas of perforated holes, and to maintain a certain pressure or exhaust in the chamber, this inner apartment or vessel is fitted with certain contrivances by which this object may be accomplished.

These contrivances are as follows: Within the perforated chambers are arranged two shutters, K K, placed on opposite sides from each other, and of the exact size to fit closely and tight against the walls or sides. A post of wood or iron is placed vertically in the center of the apartment, by which a jamb is formed, upon which these shutters may close whenever it is desired to divide the chamber into two compartments. These shutters may be made of thin hard wood, iron, or any suitable material, and are opened or closed, or the openings regulated, by an iron or wooden rod suitably fastened on a pivot or hinge, and passing outward through the sides of the inner and the side walls of the outer chambers to the outside, to give perfect control of the dimensions or capacity of this inner perforated chamber or vessel. The inlet to this inner chamber is through the bottom and nearer to one side, and not in the middle, or it may be through one of the side walls, in order that, when it is desired to diminish the area of the chamber or perforated holes one-half, the closing of these inside shutters against the jamb divides the chamber into two apartments, with the vapor-inlet in one only, and the other apartment entirely closed against the ingress of vapors.

Another way in which I maintain this certain pressure or exhaust in the chamber, and govern the number of holes exposed to the passage of the vapors, is by employing a similar water or mercury seal as described in the device of perforated diaphragms, conforming the shape of the seal to the form of the chamber, and constructing it to a height half-way up the sides of the chamber, and leaving a space of from six to twelve inches between the sides of the seal and the chamber. The height of the fluid in the seal is regulated from the outside, as in the case of the diaphragm-seals.

I use either one or both of these contrivances for regulating the pressure or exhaust, as may suit my convenience.

This perforated chamber may be constructed of any desired shape—either round, oval, cylindrical, circular, square, triangular, or polygonal—and the currents drawn through it by either an exhaust or suction fan, or forced by direct pressure of pump or pressure blower, the object being to cause the vapors to pass, under a certain pressure or exhaust force, with a revolving or gyrating motion, through the small perforations in the sides or walls; but I prefer the six-sided form as being the most convenient and practical in accomplishing all of the objects of its construction.

The vapors, entering the inner chamber through a flue at the bottom, are forced to pass through the small perforations in the walls in order to gain access to the outer space between the inner and outer chamber, which forms the flue or outward passage-way. In thus passing through these small perforations under pressure, the metallic atoms are revolved, gyrated, crowded together, compressed, and adhere together, forming metallic particles, and fall from their own weight or gravity, as metallic globules, to the bottom of the chamber.

The direction of the currents through the perforated walls or sides of the inner chamber may be, as thus described, from the chamber outward with the ingress-flue at the bottom, or the reverse from the outside inward, with the egress or outlet flue at the bottom, whichever may be most convenient, the object of the gyrations of the metallic particles being accomplished either way. I prefer, however, the currents to pass as described, as giving a more perfectly uniform action upon all sides of the chamber.

The shutters and water or mercury seal mentioned give that control over the pressure upon the passing vapors by which, when the amount of mercurial vapors is small, the capacity or dimensions of this device is diminished, and vice-versa. Such inner shutters as described may be fitted to each wall or side of the chamber, if desired, and thus reduce the capacity to any desirable amount.

The next device to be described is the gyrating-tubes L, which consist of tubes about one-fourth to one inch in diameter and one to three feet in length, constructed in such a manner as to give a gyrating, rotary, and spiral motion to the vapor-currents passing through them. This may be accomplished by either bending or twisting the tubes spirally, or by making a screw-shaped gyrator, M, running centrally and longitudinally the whole length of the tube, which makes, in the plain tube, a spiral passage-way, through which the air currents and vapors must rotate on their passage outward. These tubes may be made of any suitable material—such as porcelain, earthenware, glass, wood, or iron—and may be placed at any desired angle; but I prefer them placed vertically, as illustrated in the drawings. The screw-shaped gyrator, in the longitudinal center of the tubes, may be made in two equal parts or lengths, with the thread or pitch of each half-screw running in reverse directions, and forming, in the middle length of the tube, a chamber, in which the vapor-currents are reversed and given an opposite gyrating or rotary motion from that in which they first entered the tube. The ends of the tube may be flared or expanded into a bell shape, so as to give free entry and free exit to the fumes, and aid in consolidating or compressing them together as they pass through the body of the tube. These gyrating-tubes may be with or without the gyrator in the center, the object of giving the spiral direction to the vapors being to induce, by the most rapid centripetal gyrating and spiral motions, a cohesion of the infinitesimal atoms, or mercurial vapor, as described, into a particle of sufficient size to be condensable by contact with a cold surface, and of sufficient gravity to settle from the atmosphere of the condensing-chamber.

The tubes are placed vertically in series, each set or series being composed of any convenient number of tubes, with their inlets on the same horizontal line and running in the same direction. The next set or series have their inlets on the same horizontal line as the outlets of the first, there being a suitable partition between the two sets in the upper and lower part of the chamber, as shown in the drawings. Thus, as the vapors pass from one set into the other, a reverse spiral or gyrating movement is given, and when the gyrator is placed in the tubes in two parts, as described, the spiral direction of the currents would be reversed four times in passing through two sets or series of tubes.

At the top of the chamber in which these tubes are located, and directly over their orifices, is placed perforated pipe or pipes, (not shown,) supplying a small stream of water, by which the tubes are at all times kept cool and free from dirt or dust. The number of orifices kept open for the passage of vapors is regulated by means of a shutter or shutters swinging from a suitable frame at the top or sides of the tubes, and closing down and upon any number that may be desirable to close when the amount of vapors are small, and vice versa, and thus maintain a certain velocity or pressure of the vapors through the tubes. After passing through the gyrators or gyrating-tubes described, which may be in two or more sets, and placed either parallel or at an angle to each other, the vapors enter a set of conical or pyramidal shaped tubes, *n n*, about two feet in length, with the base or inlet ends about four to six inches in diameter and the outlets or nozzles from about one-fourth to one-half inch in diameter. These may be arranged in plate N at any angle; but the horizontal form is preferable. These tubes may be made straight, with their orifices brought to a point; but the conical or pyramid shape gives that compression and crowding together of the atoms better than a straight form, and therefore is desirable. These may also have a screw-shaped or spiral gyrator placed in their longitudinal center similar to the gyrating tubes just described, with the exception that in this case the pitch or incline of the screw would not be reversed, but continued the same pitch, and decreasing in size until near the outlet, where the screw would cease. These latter tubes may be made of any suitable material, such as wood, earthenware, or iron, and have the same contrivance of regulating-shutters as the previous device, controlling their inlet-apertures. The exhaust-fan, producing the necessary rapidity and force of currents or draft, may be placed either between the refrigerating-chamber and the other devices described, or at the extreme outlet at the chimney, and a compensating-governor of approved construction may regulate the pressure or exhaust throughout the entire apparatus.

These novel compressing, condensing, and vapor gyrating or rotating devices above described, being each in themselves complete, may be used in series, singly or combined, and may be applied to any one of the quicksilver-reduction works now in use without any additional construction-expense beyond that of their own cost. They can be readily placed at the outlet of the condensing-chambers now employed. This is a valuable feature of this invention, and one that can be appreciated by those who have already expended large sums of money in the erection of their works.

It will be seen at once that in this novel and valuable invention for collecting and condensing the volatile and diffusible mercurial vapors and metallic atoms I have departed en-

tirely from the old and inefficient methods. The old methods of condensing the very subtle and extremely diffused mercurial vapors are most unsatisfactory and wasteful, and after centuries of experiment the losses, particularly in the reduction of very-low-grade ores, are almost as great as when the science of metallurgy was in its rudimentary state, all the improvements hitherto attempted in this direction being based upon the same unsound and non-scientific principle that all vapors or atoms of a substance of greater density, when in the bulk, than the atmosphere must, of necessity, immediately condense and fall when brought into contact with a cold surface or cold atmospheric air; the fact in this connection, however, being that particles of metal or any other substance may be so volatilized and divided into such infinitesimally small atoms as to be as light and diffusible as ordinary atmospheric air, and capable of floating with its currents to any distance and for any ordinary length of time in the atmosphere.

The principle of construction applied in this within-described condensing apparatus accepts this natural law and applies the true remedy for the great losses hitherto made by the volatilization of metals in the process of their reduction. This consists, as aforesaid, in the aggregation, conglomeration, compression, and cohesion of these infinitesimal atoms into a particle which shall be of sufficient size and density to be condensable and fall by its own gravity. This aggregation and cohesion are produced or induced by the refrigerating action and the rotating, gyrating, compressing, and condensing movements given by the various devices employed in this invention, which throw together and bring into condensable contact those diffused atoms, which, under the old methods, escape from the condensers and float for an indefinite distance upon the atmospheric currents.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. In a metallic vapor-condensing device, the plates or diaphragms H H, provided with tapering perforations, substantially as set forth.

2. In a quicksilver-condensing device, the extended tubes *n*, having contracted ends *n'*, inserted in and in combination with the vertical partition N, substantially as set forth.

3. The combination of the furnace, the refrigerating chamber and pipes, the perforated diaphragms, the perforated chamber or vessel, the gyrating tubes, the conical tubes, and straight tubes, all constructed and arranged substantially as herein set forth.

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