(No Model.) 4 Sheets—Sheet 1.

C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.

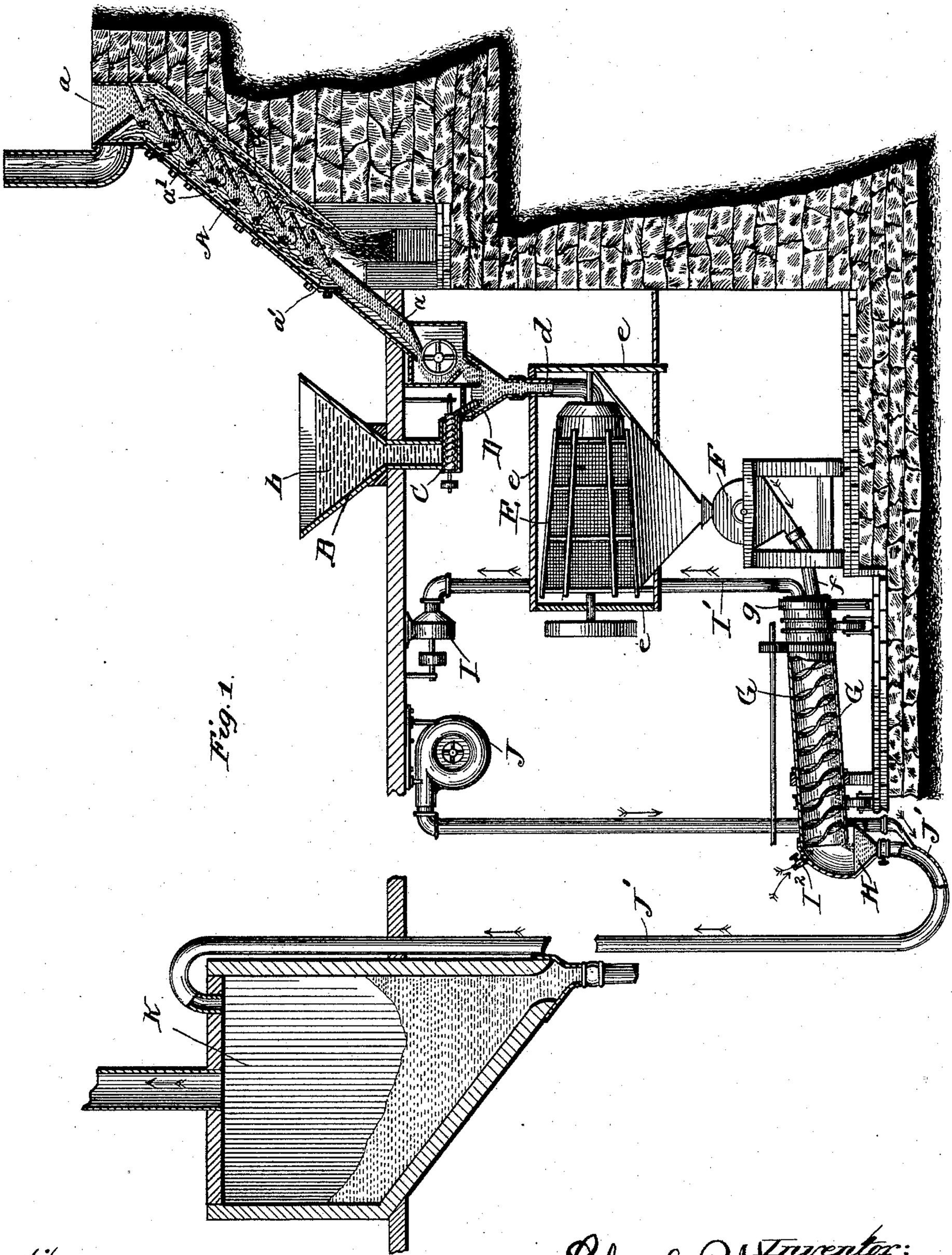

Fig. 1.

Witnesses;
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Flora L. Brown.

Inventor;
Charles B. Hebron,
By Charles T. Brown, Atty.

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C. B. HEBRON.

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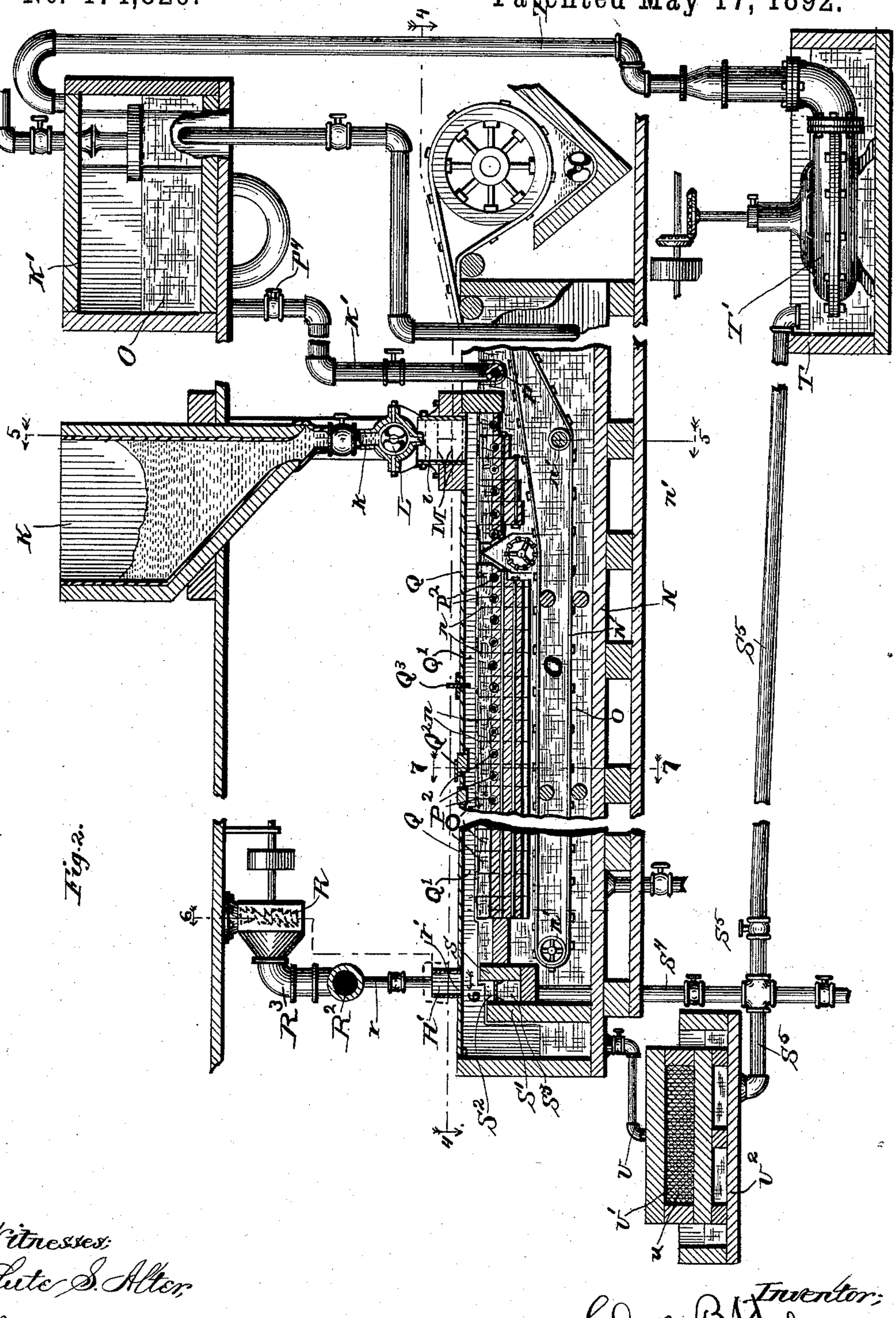

Fig. 2.

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(No Model.) 4 Sheets—Sheet 3.

C. B. HEBRON.

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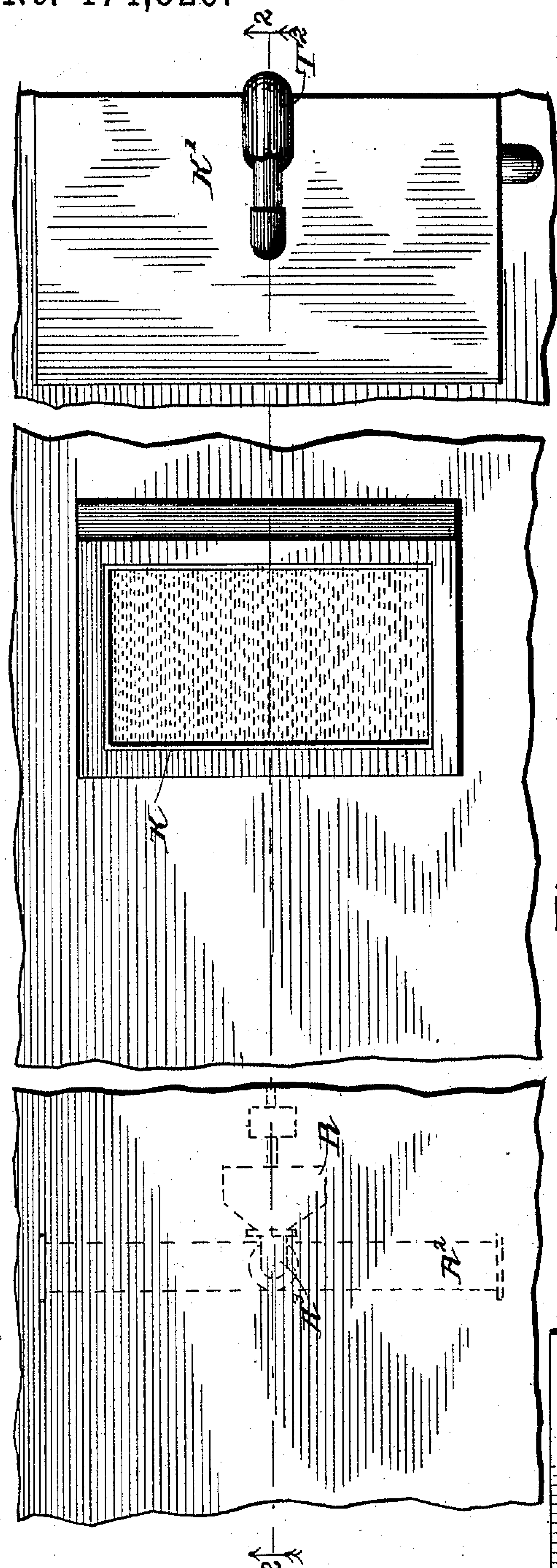

Fig. 3.

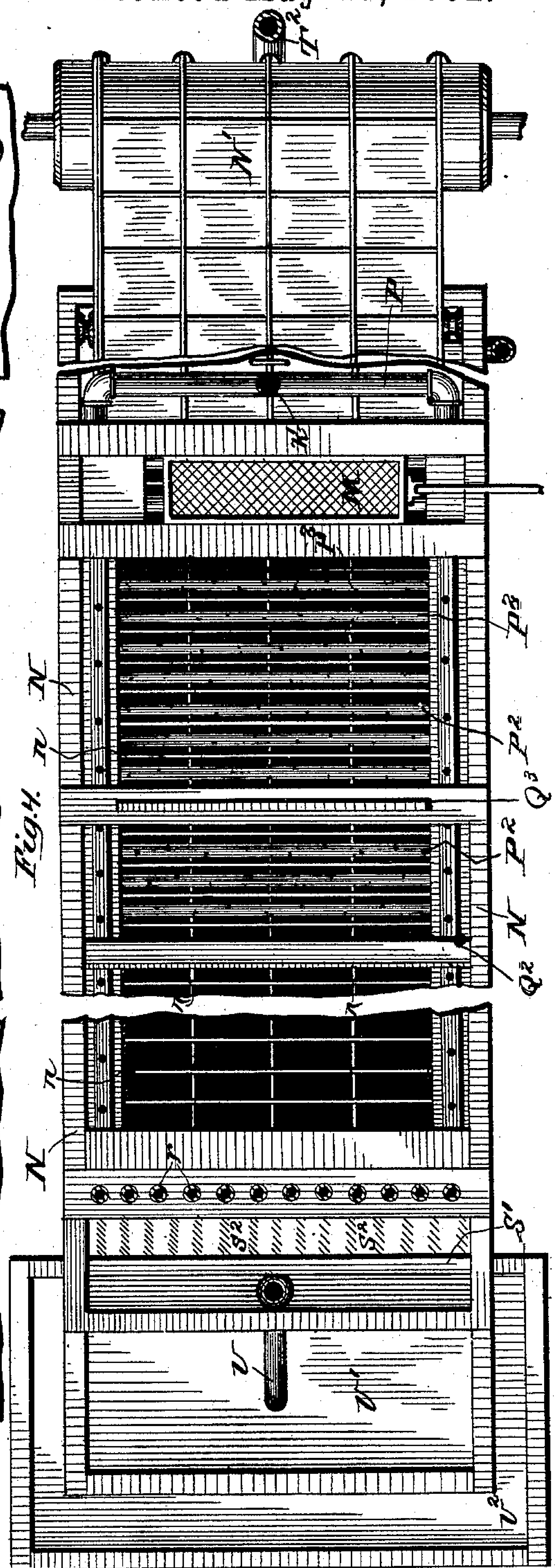

Fig. 4.

Witnesses:

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Flora L. Brown.

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Charles B. Hebron,

By Charles T. Brown. Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 4 Sheets—Sheet 4.

C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

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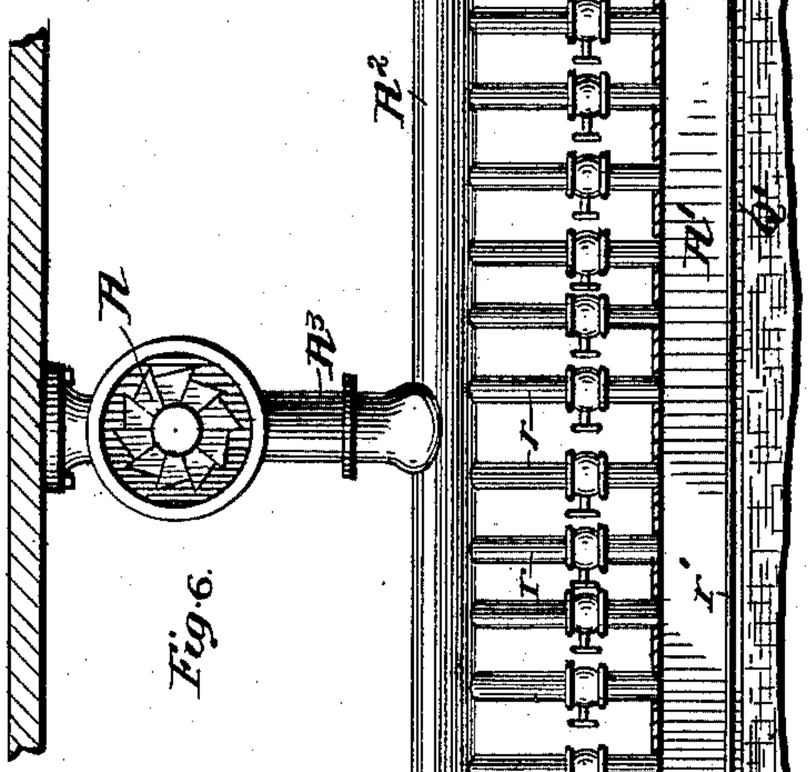

Fig. 6.

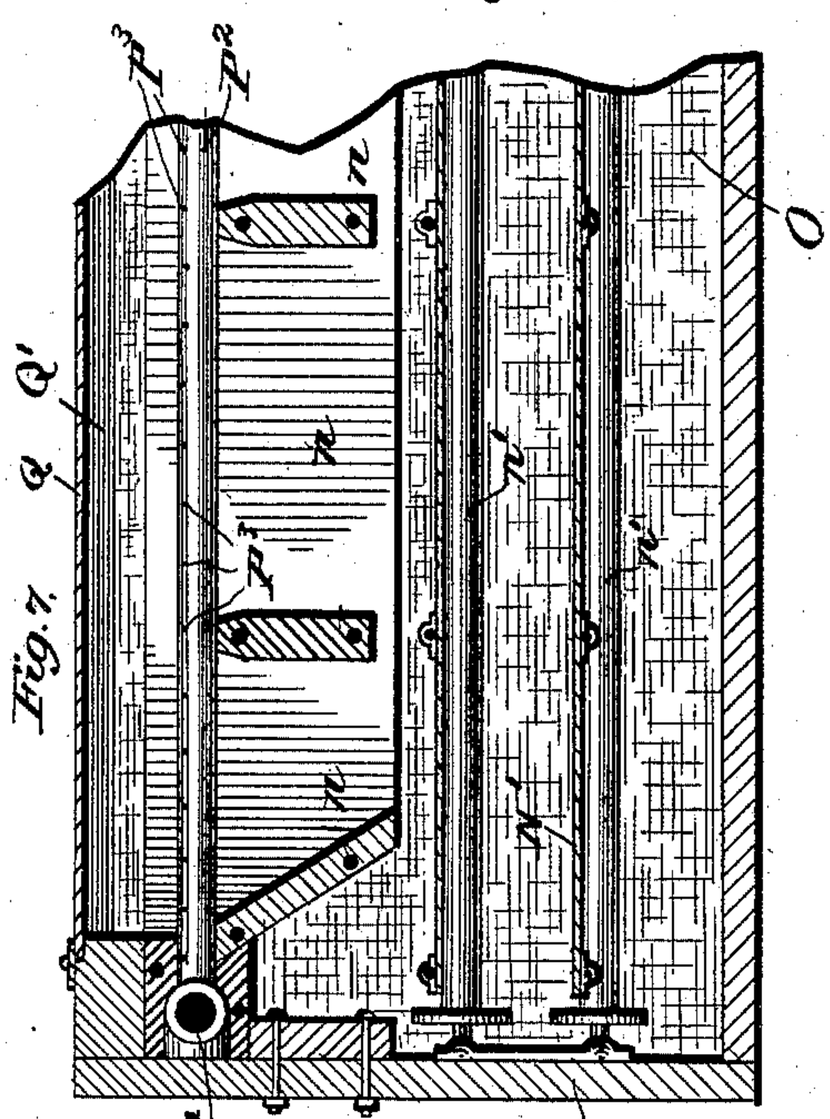

Fig. 7.

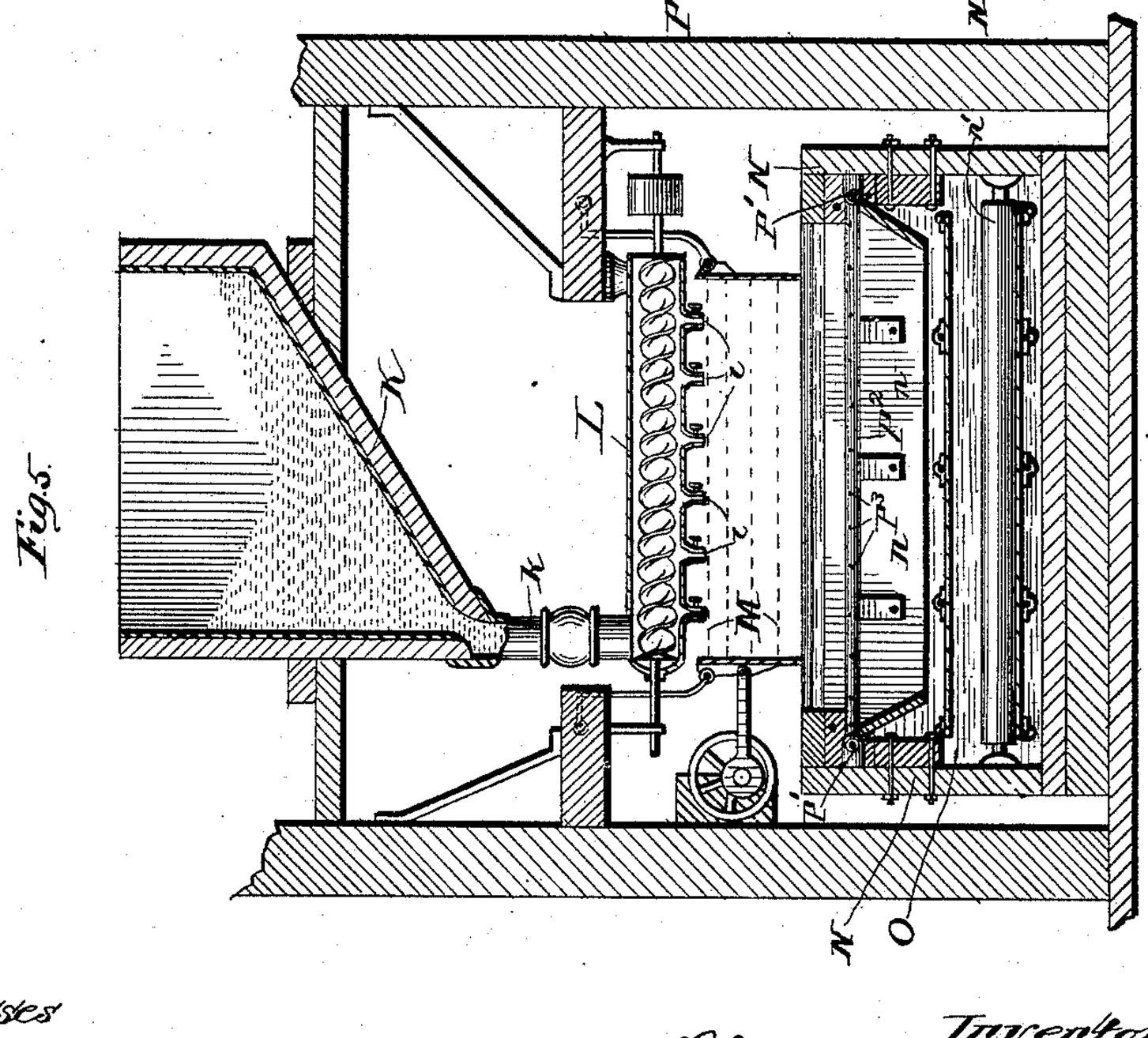

Fig. 5.

Witnesses
Lute S. Alter.
Flora L. Brown.

Inventor;
Charles B. Hebron,
By Charles T. Brown,
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UNITED STATES PATENT OFFICE.

CHARLES B. HEBRON, OF DENVER, COLORADO, ASSIGNOR OF FIVE-SEVENTHS TO CARRIE J. EVERSON, OF SAME PLACE, MAMIE W. HUTCHINSON, OF TOPEKA, KANSAS, AND CHARLES T. BROWN, OF CHICAGO, ILLINOIS.

PROCESS OF CONCENTRATING ORES.

SPECIFICATION forming part of Letters Patent No. 474,829, dated May 17, 1892.

Application filed July 22, 1891. Serial No. 400,354. (No model.)

To all whom it may concern:

Be it known that I, CHARLES B. HEBRON, 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 Processes for the Concentration of Ores; and I do 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 practice the same.

My invention relates to a process for the separation or concentration of certain kinds of ores heretofore found particularly intractable and practically impossible to separate; and it consists of certain doings constituting an improvement on the process heretofore invented by Carrie J. Everson and myself jointly, such joint invention being described and claimed in the application for a patent filed by us on the 1st day of September, 1891, Serial No. 404,400, allowed January 9, 1892, and may be considered as founded upon the same principles as is the process described in the application referred to, in conjunction with other principles not therein set forth. The process described in such joint application consists, briefly stated, in first pulverizing the ore to the proper fineness, (which pulverization must in every instance reach the cleavage or disintegration of the ore and may be much finer than that required to reach such cleavage or disintegration in cases where the mineral particles of the ore are in coarse dissemination in the rock, or where free metal is mechanically combined with rock,) after such pulverization applying to the ore while in a dry state a quantity of dry buoyant material, with proper pressure and movement, as by rubbing under pressure—say with the use of burrs or equivalent mechanical devices—whereby the buoy stock is forced into the openings or interstices existing between the atoms constituting the porous metallic and mineral particles, or is caused to adhere to the irregular or roughened surface of such metallic and mineral particles and said particles thereby made buoyant, and the ore stock thus prepared being subsequently delivered to or upon the surface of the water in suitable manner to subject the same to flotation thereupon, the buoyant mineral and metal particles remaining as a scum upon the water, while the rock matrix of the ore stock, or, in mining parlance, the "gangue" thereof, settles, resulting in separation.

It is to be understood that the foregoing briefly-described process and the herein described and claimed process are based upon the difference in formation between the rock crystals and the mineral and metal particles constituting the ore adapted for treatment by this process, the latter being porous, while the former are crystalline in character and the surface thereof glassy, whereby the buoy stock may be said to attack the disintegrated metallic and mineral particles without affecting the smooth rock crystals, such difference in structure between the mineral and metal particles and the rock crystals being distinctly marked in the class of ores I seek to separate by this process.

My present invention or discovery relates to the preparation of the ore for the presentation thereto of the buoy stock in such manner and by such means that the mineral and metal particles contained in such ore stock are made to receive greater quantities of such buoy stock than has been heretofore possible.

In properly-pulverized ore of the class or kind which this invention relates to the mineral and metal particles, being of the character hereinbefore described, when at about climatic temperature contain and are surrounded by particles of air or other gases, and the presence of such air or other gases retards, hinders, and partially prevents the attachment to and joining with such particles of as large a bulk of buoy stock as is possible when such air or other gases are not present. Further, if the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles in the ore are enlarged, (particularly when such enlargement is obtained in connection with the absence of air or other gases in or on such particles,) and at such time the buoy stock is presented thereto and thoroughly pressed therein, the capacity of such particles for containing and mechanically joining with the buoy-stock material is increased.

The object of my invention is to obtain greater buoyancy in the joined mineral and

metal particles and buoy stock than has heretofore been obtained, and to attain such object I expel from such mineral and metal particles an appreciable quantity of the air and other gases contained in the openings, cells, cavities, depressions, or pores thereof, or surrounding them at the time of presenting thereto and pressing thereinto the buoy stock by producing as far as practicable a vacuum in the receptacle containing the ore and the buoy stock and the mechanism effecting the joining of the mineral and metal particles of the ore with the particles of the buoy stock, or, and preferably, by applying heat to the ore, thereby obtaining the desired expulsion of air and other gases prior to the presentation to and pressing of such buoy stock into and upon the mineral and metal particles of the ore, and retaining such heated condition in the ore until such buoy stock is properly brought in contact with the mineral and metal particles thereof and pressed therein and upon, thus producing at the same time an enlargement of the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles.

In order to heat the previously-pulverized ore, it is placed in a receptacle, where it is subjected to a dry artificial heat of considerable intensity, but not sufficient to materially volatilize the values thereof.

I have found the following-described mechanical devices used in the herein-stated manner efficient in reducing my invention to practice, to wit: an infusion fire-blast rotary cylindrical furnace, or the equivalent thereof, into which the ore stock is continuously fed at one end and conveyed through the fire-chamber thereof to and discharged at the other end onto a shaking or rotating screen, which is closely housed for the purpose of checking radiation of heat, an automatic conveyer by which the buoy stock is fed in a cold and preferably chilled condition from its storage-receptacle to the same screen on which the heated ore is being fed, whereby the buoy stock and the pulverized ore passing through the meshes of the rapidly-oscillating screens are commingled prior to their delivery therefrom; suitably-adjusted rotary burr-disks between which the ore and buoy stock are delivered from the screen, whereby the buoy stock particles are pressed into and upon the heated mineral and metal particles of the ore; a cooling and aerating device by which the ore stock thus far prepared is cooled and aerated, and an ore-separator.

The amount of buoy stock supplied to the ore is determined by the bulk of metal and mineral contained in the ore. The buoy stock should, I find, be approximately equivalent in bulk to the bulk of such mineral, the ore having prior to the delivery thereof to the oscillating or rotary screen where it is first brought in contact with the buoy stock been heated in the furnace to considerable intensity and in excess of the temperature required to properly expel the air and other gases therefrom and obtain the maximum enlargement of the openings, cells, cavities, depressions, or pores thereof. Provision is thereby made for the partial cooling of the ore, which results from contact with the mineral and metal particles thereof, and pressing thereinto and thereon of the cold or chilled buoy stock particles and from radiation, and such excess must be sufficient to maintain in the ore stock while between the burr-disks the heated condition necessary for preserving the practical expulsion of the air and other gases from the mineral and metal particles, so that the partial vacuumed condition attained in the openings, cells, cavities, depressions, or pores of the mineral and metallic particles shall not be broken until the buoy stock particles have been joined thereto. To aerate such joined metallic and mineral and buoy-stock particles a blast or current of cold and preferably chilled air is blown through the so-far-prepared ore stock as it falls from the slots in the hopper, into which it is delivered from the burrs, or as it passes through a conveyer before reaching such hopper. This blast of cold or chilled air, in addition to aerating and cooling the nearly-prepared ore stock, can be of sufficient volume and force to convey the ore stock to a receptacle, from which it is taken by an automatic conveyer in proper quantities to supply the working capacity of the separator.

A suitable separator for use in this process consists of a rectangular tank placed in a horizontal position and nearly filled with liquid, the width of which tank is determined by the capacity desired, the depth being sufficient to have contained under the surface of the liquid therein partitions provided for stalling the current of the liquid in the tank below the surface thereof, and for an endless apron-belt movable beneath such partitions with the necessary idlers, pulley-rollers, and supports thereof, on which apron-belt the rock matrix settles, and by the movement of which it is conveyed from the tank to the determined place of deposit therefor. The movement of the apron-belt is toward the head of the tank, and it rises out of the same on an incline at the head, carrying the rock matrix settled thereon out of the tank, and the liquid in the tank is discharged therefrom at the tail thereof, floating the concentrates thereupon. The partitions designed to stall the liquid in the tank extend from one side thereof to the other, and from near the surface of the liquid—that is, from less than one-half inch thereof—to near the endless apron-belt—say within less than one-half inch thereof. The liquid supplied the tank and forming the overflow at the tail thereof is delivered through horizontal pipes extending across the tank between the stalls, the top of such pipes being about one and one-half inches below the top of the stall-partitions, and such pipes being perforated on their upper halves, the liquid which

is contained therein under pressure will, as it is forced through the perforations, produce an effervescing condition at and near the surface of the liquid in the tank, such effervescing condition of the liquid tending to loosen the rock matrix from the buoyed values of the ore stock in the surface-fed charge, causing the rock particles to break away from the same at the surface of the liquid and settle through it between the stall-partitions to the moving endless apron-belt. These perforated pipes, through which the liquid is supplied to the tank, extend from a point underneath the feed-screens for about one-fifth to one-third the length of the separator-tank. For the distance between the tail terminus of this series of pipes and the tail of the series of partitions for stalling the liquid all effervescence ceases, allowing the liquid between such partition-stalls to be calm, thereby offering less obstruction to the settling of the more exhausted rock particles which remain suspended in the shallow current above such stall-partitions for a greater time and distance than the coarser particles of the rock matrix, permitting this more exhausted residuum to settle upon the moving endless apron-belt at points nearer the tail of the separator. The prepared ore stock delivered upon the rapidly-oscillating feed-screens passes through the series of screens and is delivered to the surface of the liquid in the tank in the form of a continuous dust-cloud, and the metallic and mineral values of the ore stock contained therein are separated from the rock matrix, as heretofore described. The longitudinal movement of the floating film or scum containing the values of the ore must be in pace with the supply of ore from the feed, which must be only rapid enough to thinly cover the liquid-surface. A chamber exists between the liquid-surface and the tank-covering, (which should be transparent,) through which a gentle suction air-blast is drawn over the scum longitudinally and exhausted through air-flues rising above the tail end of the separator-tank by means of a suction-fan. This air-blast causes the scum or floating film to move upon the liquid-surface rapidly, thereby increasing the capacity of the separator and admitting of the use of a slow and sluggish surface current above the upper edges of the stall-partitions. This torpid movement of the liquid-current allows the rock particles to settle more easily than if capacity was obtained by a rapid movement of the liquid-surface, which would impart such momentum as to hold the rock particles longer in suspension, and therefore requiring much greater length of tank-surface to obtain a good separation.

The liquid commonly used in the separator-tank is water; but in northern latitudes or in a high altitude, particularly in the winter season, it will be found desirable to use a liquid less subject to freezing than water, and as in this process the product and the residuum of the pulverized ore stock are severally removed from the separator-tank, leaving the liquid employed therein when delivered at the tail end of the apparatus in condition to be returned to the storage and again used, any liquid of sufficient fluidity whereof the specific gravity is less than the specific gravity of the rock matrix can be employed, provided, of course, the separator-tank and its appurtenances coming in contact with the liquid are constructed of material well adapted to resist the action thereof. Hence common brine (a solution of sodium chloride) is practically available, and other liquids might be used.

Between ore specially adapted for treatment by this process and ore unfit to be treated thereby there is found ore wherein the mineral and metallic particles are so dense and compact in physical structure that the buoyant character necessary for the best results in the separator-tank where water is employed as the liquid is somewhat difficult to obtain, even by the use of buoyant particles joined thereto in the manner hereinbefore described, and in such case it will be found highly desirable that brine or some liquid having greater specific gravity than water be employed as a substitute thereof.

In the drawings accompanying and forming a part of this specification mechanisms are illustrated adapted to perform the several functions demanded thereof in the carrying out of this process, and in such drawings—

Figure 1 is a cross-sectional view of a continuous fire-blast furnace and an elevation of the machinery employed therewith, whereby the pulverized ore is properly prepared, as herein described, and deposited in the storage-chamber, such storage-chamber being also shown in cross-section in said figure; Fig. 2, a longitudinal sectional view of an ore-separator on line 2 2 of Fig. 3; Fig. 3, a plan view of a liquid-storage and pipes thereinto and therefrom and a prepared ore-stock storage, forming appurtenances to such ore-separator; Fig. 4, a longitudinal sectional view on line 4 4 of Fig. 2, viewed in the direction indicated by the arrows, the top of the tank of the ore-separator being transparent and so exposing to view the several parts in the tank of the separator; Fig. 5, a vertical cross-section on line 5 5 of Fig. 2, viewed in the direction of the arrows; Fig. 6, a vertical cross-section on line 6 6, also viewed in the direction indicated by the arrows; Fig. 7, a vertical cross-section of a portion of the device, on an enlarged scale, on lines 7 7 of Fig. 2, viewed in the direction indicated by the arrows.

Similar letters of reference are employed to indicate a part where more than one view thereof is shown.

A is a continuous fire-blast furnace, *a*, the pulverized ore passing through A, and *a'* the fire-blast of such furnace.

B is a storage-receptacle for the mate-

rial of buoyant character required in this process, which material I prefer shall ordinarily consist of pulverized charcoal.

C is an automatic conveyer, by which the prepared buoy stock is fed from storage-receptacle B to trough D.

E is a rotatory screen, and *e* the housing thereof.

The pulverized and heated ore *a* is delivered from the furnace A, through trough D and pipe *d*, into the rotary screen E, and *b* is the buoyant material contained in storage B, which is also delivered by conveyer C into the trough D, along with the pulverized and heated ore *a*, and passing therewith into the rotary screen E. Rotary burr-disks are contained in the frame F. Such disks being well known in the art, I do not deem it necessary to expose the same to view.

G is a rotary conveyer by which the ore stock delivered thereto from spout *f*, after having passed through the burr-disks, is conveyed to trough H.

I is the fan by which air, preferably cooled or chilled, is drawn through the pipe I′ from cock I^2 in the conveyer G, producing a gentle current over the contents of the conveyer from such cock I^2 to the point in the non-rotatable head *g* thereof, where pipe I′ is secured.

J is a fan by which a current of air can be forced into the pipe J′ and the contents of such pipe be thereby elevated and deposited into the storage-receptacle K, from which they can be delivered to the ore-separator.

The ore-separator which I prefer to use is one wherein liquid is employed as the fluid, through which, by the action of gravity, certain parts of ore stock, as hereinafter explained, will fall and on which other parts of such prepared ore stock will float to the point of delivery therefrom.

K′, Fig. 2, is a storage-receptacle for the liquid required in the separator. From storage-receptacle K a pipe *k*, having a suitable valve therein, extends to the conveyer L, from which conveyer the prepared ore stock is dropped through discharge pipes or nipples *l l* to the shaking-screens M M, through which screens such prepared ore stock passes and from which it is delivered upon the surface of the liquid O, contained in the rectangular tank N. From the storage-receptacle K′ a pipe *k′* extends into the tank N, and through such pipe the liquid O passes into such tank.

n n are the partitions provided in the tank N.

N′ is an endless movable apron-belt beneath such partitions, and *n′ n′* are the idlers or pulley-rollers supporting the belt.

P is a horizontal pipe extending laterally across the tank N below the surface of the liquid contained therein.

P′ P′ are horizontal pipes extending longitudinally for a portion of the length of the tank, and P^2 P^2 are horizontal pipes extending laterally underneath the surface of the liquid in the tank.

P^3 P^3 are holes in the pipes P^2 P^2. The liquid passing from the tank K′ through the pipe *k′* extends through the pipes P P′ P^2 and enters the tank through holes P^3 in pipes P^2. The proper pressure under which the liquid passes out of the holes P^3 P^3 can be determined by valve P^4 in pipe *k′*.

Q is the transparent cover of the tank.

Q′ is the chamber extending between the surface of the liquid and the cover.

R is a suction-fan, and *r r* are pipes extending from chamber R′ to horizontal pipe R^2, such horizontal pipe being connected to fan R by pipe R^3. *r′* is a screen interposed between the chamber R′ and the chamber Q′. The movement of the suction-fan R creates the air-blast hereinbefore referred to in the chamber Q′, between the open slide Q^2 and the chamber R′.

Q^3 is a vertical slide extending from the cover Q through the chamber Q′ to near the surface of the liquid O and prevents any blast or current of air above such liquid between such slide Q^3 and the screens M.

S S′ are bridge-walls over which the liquid and the prepared ore stock thereon passes.

S^2 is a screen or perforated plate between the bridge-walls S S′, through which much of the liquid passing over bridge-wall S can flow into the chamber S^3 underneath the screen, and from thence through pipe S^4 to waste or to pipe S^5, through which it flows to receptacle T, from which, by the pump T′, it can be raised through the pipe T^2 into the receptacle K′. The liquid and prepared ore stock thereon, containing the values of the ore passing over the bridge-wall S′, flow through the pipe U into the receptacle U′.

u u are screens in receptacle U′, through which the liquid can flow into the receptacle U^2, from which receptacle it can flow through pipe S^5 to receptacle T. The prepared ore stock remains in the reeptacle U′, from which it is taken when desired.

It will be evident to those skilled in the art that liquid employed as a suspensive fluid in the manner described is not the sole way in which suspension in different strata for sufficient time to separate the buoyed mineral and metallic particles from the rock matrix of the ore can be effected, as any of the well-known stratifying mechanical devices can be used as an element of this process for the purpose of separating the heavier from the lighter particles, and thereby stratifying the ore stock, and when the ore prepared by this process is properly subjected to such mechanical devices it will be found that the buoyed mineral and metallic particles will, being lighter, obtain the upper strata.

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

1. The herein-described process for concen-

trating ore, consisting of producing a vacuumed condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in such vacuumed condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of aerating such buoyed mineral and metallic particles, and of subjecting such prepared and aerated ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

2. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of subjecting such prepared ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

3. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of presenting such prepared ore stock to the surface of liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock and thereby for such time separated therefrom, substantially as described.

4. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous movement on the surface of a body of liquid by producing an effervescing condition therein below and at the surface thereof, and of presenting such prepared ore stock to the tremulous surface of such liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon such surface for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom, substantially as described.

5. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of presenting such prepared ore stock to the surface of liquid so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and of producing a current of gas moving in relation to the surface of the liquid and in a direction from the place of presentation of the prepared ore stock to the surface thereof, whereby the buoyant mineral and metallic particles of the ore stock are separated from the rock matrix thereof for such time, and particles of the ore stock floating upon the surface of the liquid are moved over and on the surface of such liquid by such current of gas, substantially as described.

6. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous and wavy movement on the surface of a body or liquid contained in a receptacle having stalling-partitions by producing an effervescing condition in the liquid below and at its surface and a current of gas moving over and on such surface, and of presenting such prepared ore stock to the surface of the liquid, so that the buoyed mineral and metallic particles of ore are maintained on the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom and the particles of ore stock floating on the surface of the liquid moved on and over such surface, substantially as described.

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Witnesses:
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CHARLES T. BROWN.