R. H. RICHARDS.

APPARATUS FOR CLASSIFYING MINERALS.

APPLICATION FILED JULY 25, 1907.

943,101.

Patented Dec. 14, 1909.

2 SHEETS—SHEET 1.

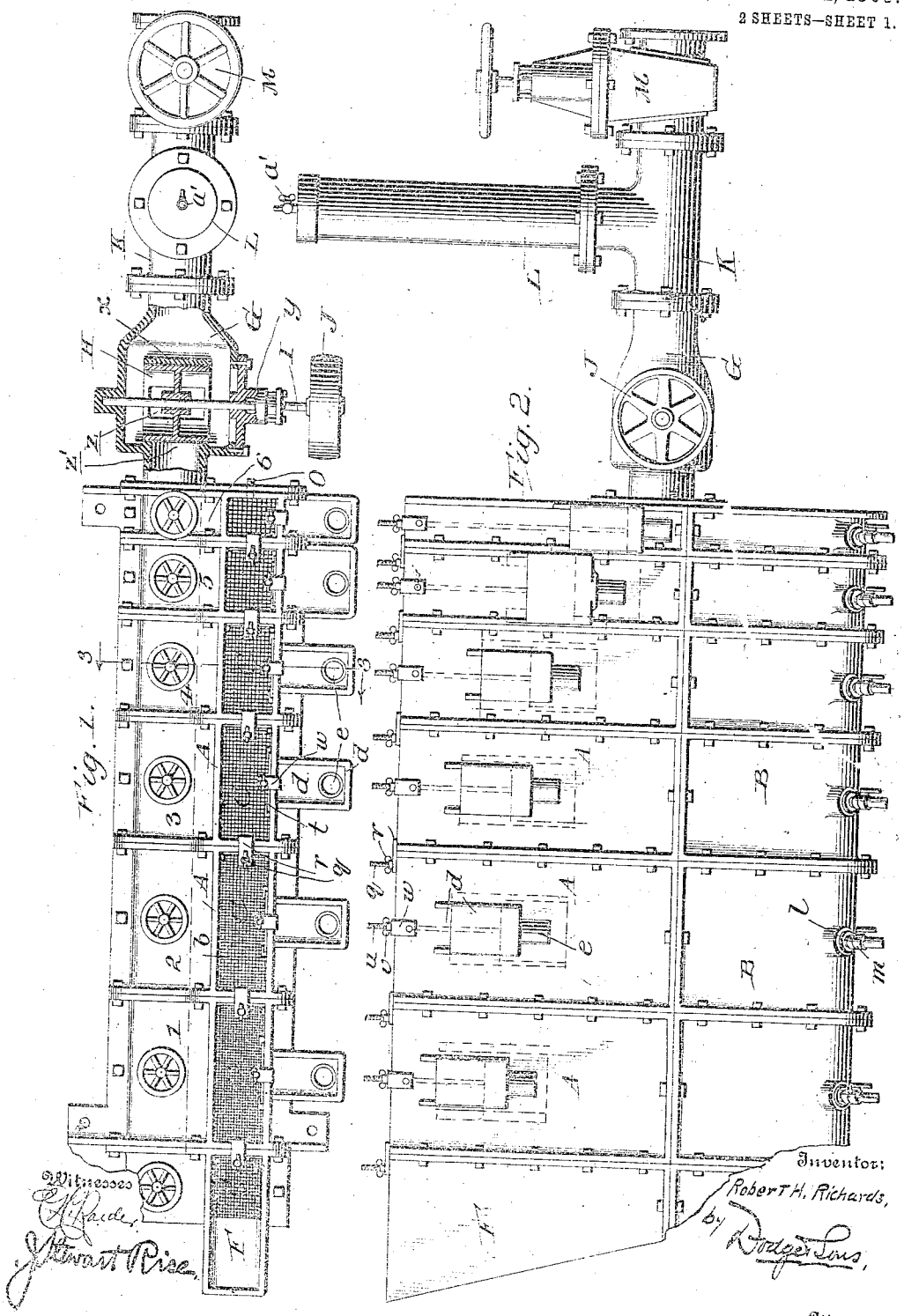

Fig. 1.

Fig. 2.

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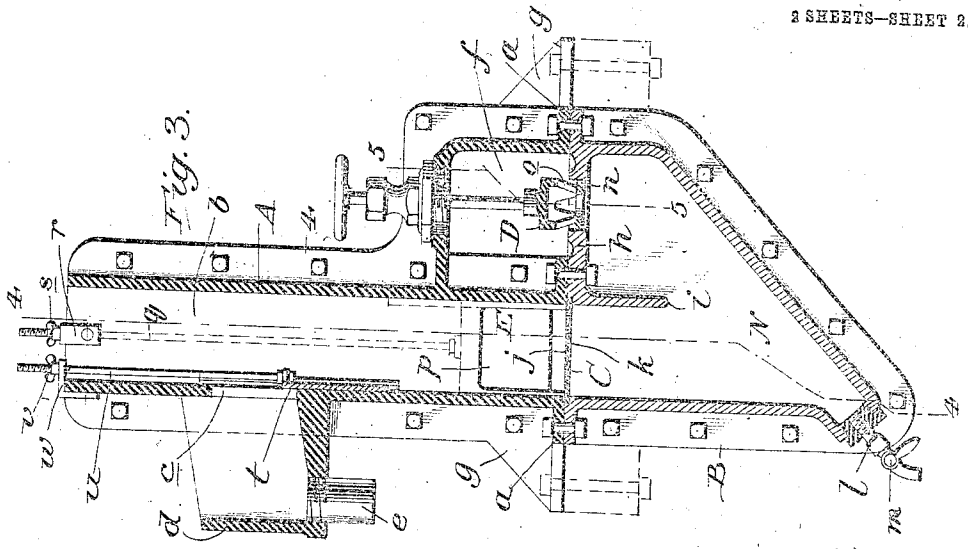
2 SHEETS—SHEET 2.

Fig. 3.



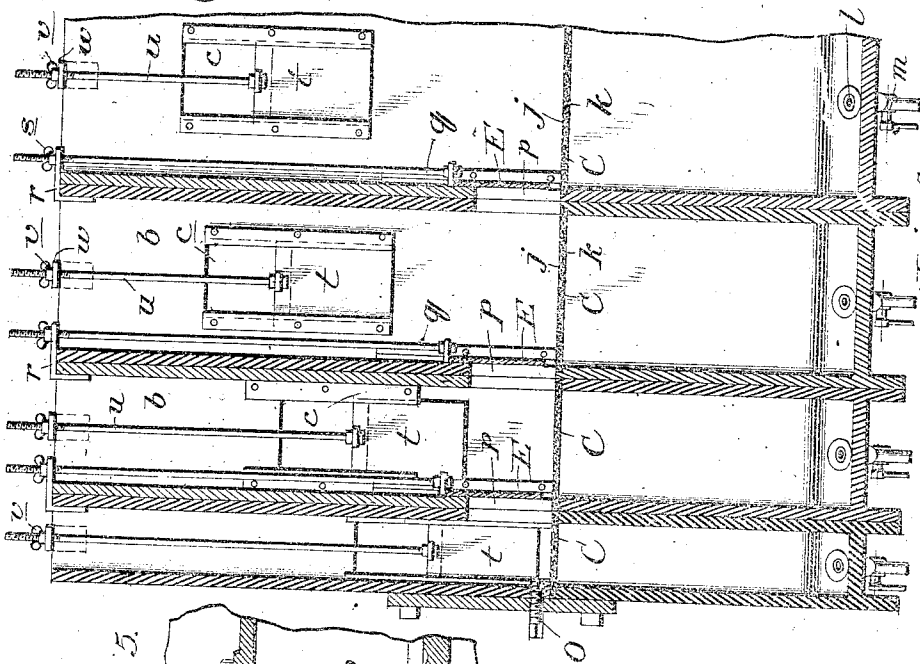
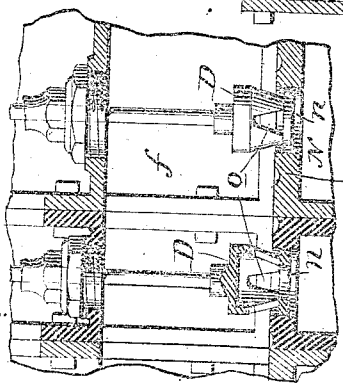


Fig. 4.

Fig. 5.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR CLASSIFYING MINERALS.

943,101. Specification of Letters Patent. Patented Dec. 14, 1909.

Application filed July 25, 1907. Serial No. 385,502.

To all whom it may concern:

Be it known that I, ROBERT HALLOWELL RICHARDS, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Classifying Minerals, of which the following is a specification.

This invention relates to an apparatus for use in concentrating mills to separate, grade or classify ores by the aid of water, and by what may well be termed "hindered settling." This principle of separation or classification of ores is susceptible of somewhat varied embodiment, a preferred form being here illustrated and described.

In the accompanying drawings: Figure 1 is a top plan view with the valve by which the pulsating action is effected, and its casing, shown in section; Fig. 2 is a side elevation of the apparatus; Fig. 3 a vertical cross section on the line 3—3 of Fig. 1 looking in the direction of the arrows in said figure; Fig. 4 a vertical section on the line 4—4 of Fig. 3 to better show the overflow dams; and Fig. 5 a section on the line 5—5 of Fig. 3 illustrating more in detail the valves controlling the water inlets.

In order to make clear the nature and scope of my present invention, I will first define or explain the settling action of mineral grains in water. There are two conditions under which sands or mineral grains of mixed sizes and of different specific gravities can and will settle in water, viz: First. Where the grains are entirely free from one another; each assuming its natural rate and speed of settling, due to its size, weight and shape. When, for example, mixed grains of quartz and galena are allowed to settle in water under these conditions, it is found that the grains of the lighter quartz, which settle at the same rate with the heavier galena, have a diameter of (approximately) four times that of the latter. This is called classifying under free settling conditions. Second. If, on the other hand, water be admitted through a small aperture or series of apertures to the bottom of a vessel in which a mass of grains of quartz and galena is resting, the rise of the current of water through the mass causes the quartz and galena grains to arrange themselves according to their ability to settle under such conditions, and it is found that the grain of quartz that settles in juxtaposition with the grain of galena has (approximately) six times the diameter of the latter. This method of classification is called classification under hindered settling conditions.

Classifiers used in mills up to the present time and employing water, have more commonly operated under free settling conditions. The present invention is based upoff the hindered settling principle.

In carrying out this mode of separation or classification, water under adequate head is delivered through a suitable perforate or foraminous floor into the foot of a vertical chamber or column, or a series of such chambers or columns, the water being suddenly admitted and as suddenly cut off so as to produce a rapid succession of pulsations, which by reason of the upward action tends to elevate the particles of matter, and to let them fall back through the water column and arrange themselves according to their specific gravities and their dimensions.

In the construction of an apparatus of this sort it is desirable to provide for its convenient shipment, assembling and repair, and hence is found expedient to make it of a series of castings of like form or outline, though of variable dimensions in the direction of the length of the assembled apparatus, if desired. In other words, the apparatus is advantageously formed of a series of sections of like cross section formed with flanges to receive fastening bolts whereby the sections may be united one to another to produce an apparatus of any desired length. This will be readily understood upon referring to the accompanying drawings in which the apparatus will be seen to consist of a series of sections 1, 2, 3, 4, 5 and 6 each composed of an upper casting A and a lower casting B, respectively of the cross sections shown in Fig. 3. These castings are formed with flanges *a* by which the two castings A and B may be bolted to each other, and the several sections may be bolted one to another to make up the complete structure.

Each upper casting A comprises a vertical chamber *b*, one wall of which is provided with an opening *c* communicating with a lateral extension *d*, the walls of which rise somewhat above the top of the opening *c* and the bottom of which is provided with an outlet pipe *e*; and it further comprises at one side of the chamber *b* a water passage or

conduit *f*. Suitable brackets *g* are formed upon the casting A to rest upon timbers or other supporting framework.

The lower casting B is or may be of a cross sectional width corresponding to that of the upper casting A, and has a horizontal plate or web *h* which forms a roof to the lower casting and a floor to the water conduit, but which is omitted from or does not extend across that portion of the casting B which stands immediately below the chamber *b* of the upper casting.

The plate or web *h* is formed with a depending skirt *i* which is in vertical alinement with the wall of the chamber *b*, and forms a continuation thereof. The boundaries of the opening in the top of the casting B are recessed to receive a screen or diaphragm C of perforate or foraminous material. This is preferably made of two layers, *j* and *k*, one of the requisite fineness of wire and mesh, and the other of heavier wire and larger mesh to give adequate supporting or sustaining capacity.

The vertical side walls of the lower casting B are respectively in alinement with the outer wall of the upper chamber *b* and with the outer wall of the water passage or conduit *f*, but are of unequal length or depth, the wall which in effect forms a continuation of a wall of the conduit being of about the same vertical depth as the skirt *i*, while the other is of about three times such depth or vertical length. These vertical walls are connected by an inclined wall forming the bottom of the chamber, and thus giving to the space within the casting B the form of a hopper with the lowest point at one side and at the foot of the deeper vertical wall. At this point an outlet pipe *l* is provided, and this in turn is furnished with a cock, valve or gate *m* through which to discharge the contents of the hutch or chamber N within the casting B. The chambers N form pressure chambers, and also collecting chambers for whatever may fall through the perforate floors of the upper chambers.

The plate or web *h* constituting the diaphragm or partition between the water passage *f* and the interior of the hutch or chamber N of casting B is provided with a circular opening *n* through which water may pass from the conduit *f* to said hutch. This passage is controlled by a hollow valve plug D of circular form in horizontal cross section, and of a diameter at its upper and lower portions to accurately fill the opening *n*. Between its upper and lower portions the valve is, however, tapered or reduced from the upper portion downward, and within the tapering walls are formed openings *o* for the passage of water, widening from the top downward.

It will be observed that by reason of the peculiar form of the valve plug or body and of the openings *o* therein, the area of the openings through which water may pass rapidly increases as the valve is lifted, and as rapidly decreases when it is lowered, thus giving a very sensitive or quick control of the flow of water.

The plug D is raised or lowered by a threaded stem movable through a stuffing box or gland, and provided with a hand wheel as usual.

As the sections 1, 2, 3, 4, 5 and 6 are bolted directly one to another it is evident that three walls will be sufficient for all except the end sections, one wall serving for two adjoining chambers, but each may be formed with four complete walls if deemed desirable. The partition walls separating the chambers *b* are each provided with openings *p* of the full width of the chambers *b*, or approximately so, and of a height about equal to their width. These openings constitute a continuous passage through the apparatus from the first to the last section, directly above the perforate or foraminous floor C. It is desirable that the height of these openings be variable at will; hence each opening is guarded by a vertically movable gate or slide E movable in ways, and carried by a vertical rod *q* passing through a bracket *r* at the upper end of the casting A, and provided above said bracket with a nut *s* which may conveniently be in the form of a thumb-nut as shown in Figs. 1 and 2. By backing the nut the gate is permitted to fall, and to approach more or less nearly to the surface of the screen or perforated floor C. By turning the nut in the direction to screw upon the rod it will lift the rod and its gate, and increase the distance between the gate and the perforated floor C. In like manner it is desirable to regulate the height or level of the overflow from each chamber *b* to the outlet *c*. Accordingly each outlet opening *c* is guarded by a vertically movable gate or dam, movable in guideways at the sides of said opening, and provided with a lifting rod *u* threaded at its upper end and raised or lowered by a thumb-nut *v* resting upon a bracket *w* at the top of the casting A. The gate or dam *t* can be lowered so that its upper edge is flush with the lower wall of the opening *c*, or may be raised to the top of said opening, and thus the level of the overflow may be located at any point between these extremes, or the overflow entirely closed. Each section being thus equipped, its water supply, overflow and communication with adjoining chambers may be controlled as desired.

Preceding the section 1 is the feed hopper section F, which is the same in all material respects as the other sections save that it has no overflow, and that the chamber *b* is made of hopper shape to facilitate the introduction of material for treatment and its deliv-

ery into the first of the series of chambers 1, 2, 3, 4, 5 and 6.

G indicates a valve shell or casing which is formed with a flange to receive the fastening bolts by which to secure it to the end section, which in the drawings is designated 6, it being understood, however, that the number of sections may, and in practice will, vary according to the character of the material to be treated, the extent to which the classification is to be carried, etc. This valve shell or casing is of the form shown in horizontal section in Fig. 1, and has formed within it an annular wall *x* within which is placed a rotary annular valve H, carried by a shaft or spindle I, one end of which passes through a suitable gland or stuffing box *y*, and is provided outside the shell or casing with a band-wheel J, or other means for the application of power to effect its rotation. The wall *x* has an opening on the side toward the section 6, and the valve H is provided with a corresponding opening or openings *z* to register with the opening in the wall *x*.

The annular drum or body of the valve H is carried by a central web, the hub of which is keyed or otherwise made fast to the shaft I, and the water entering at the ends of the annular body H passes through the opening or openings *z* on registration of the opening or openings with the opening in said wall *x*. It will be observed that this construction of a rotary valve causes it to be in balance, or practically so, and enables it to be rotated freely and with comparatively small expenditure of power so that it may be operated rapidly, and open and close communication between the water supply pipe K and the conduit *f* as frequently and as suddenly as may be desired. An air chamber L is provided just in advance and on the supply or receiving side of the rotary valve H, the air in which chamber becoming more or less compressed, serves to overcome the inertia of the arrested water current, and to force the water through the valve the instant the latter is opened and before it can close again. Without this provision the requisite frequency, regularity, suddenness, and certainty of impulses cannot be attained. Incidentally, "water hammer" is prevented. To guard against undue accumulation of air within the chamber L, a small pet cock *a'* is provided, as shown in Figs. 1 and 2. The water supply pipe K is provided with a gate valve M to control or entirely shut off the flow of water to the apparatus.

The gage of the wires of which the different screens C are made and the mesh thereof, will or may vary in the different chambers as required, and as different classes of material require different mesh, no fixed rule or relation can be formulated.

It will be seen upon referring to Fig. 2 that the overflow openings *e* are placed at different elevations, that of chamber 1 being highest, and those of the other chambers being progressively lower from the first to the last chamber of the series, thus giving water columns of progressively less height or depth from the receiving toward the delivery end of the apparatus.

It will, of course, be understood that the entire structure may be built of other materials as, for instance, wood with or without metal linings, and that the precise form is not essential, but I have shown and described a construction which, considered both from the standpoint of the builder and the user, is deemed best adapted to practical results.

The apparatus constructed as above set forth operates in the following manner: The several valves D are adjusted to permit a proper quantity of water to pass from the conduit *f* into the hutches or collecting hopper bottoms of each section of the series, the flow to each being graded according to requirements in any given instance. Similarly, the gates E are adjusted to determine the opening from the base of each chamber or column *b* to the next, and the slides or dams *t* are adjusted to determine the height of the overflow in each column. This done power is applied to the valve shaft I by belt or otherwise, and it is caused to make a given number of revolutions per minute, varying according to the character of the material, the fineness of classification desired, and like considerations. The mineral substances to be classified are introduced with water into the feed hopper F, and fall to the perforate floor C thereof. Water admitted by the valve H to the conduit *f* passes by the openings *n* to the hutches N, and descending beneath the skirts *i* and directed in a general way by the inclined bottom of the hutches, turns upward and enters each chamber *b* through its perforate or foraminous bottom.

Owing to the frequent opening and closing of the valve, the water comes in a series of pulsations, which have the effect of throwing upward the mass of material contained in each chamber or column *b*, and this sudden upward movement is followed during the time that the valve H is closed by a falling back of the particles contained in the water column. This recurs with greater or less frequency according to the speed of rotation of the valve H, and the particles being thus constantly thrown upward and allowed to fall back, re-arrange themselves according to their dimensions, shape and specific gravities. The pulsating current gives more even classification, and hence more perfect classification of the sands or particles than can be obtained with a steady current.

The screens or perforate floors of the respective chambers may be graded, the finest being in the first chamber and the coarsest in the last chamber, with any gradation between that may be deemed desirable in each given instance, or they may be alike. The water column in the first chamber or column *b* being of greater depth than the others and the mass of material being there first acted upon and containing all the different grades and qualities of material it is in this chamber that the finest pulps are classified, and from which they are delivered. The lightest of the floating particles being gradually carried to the top by the successive pulsations of the water, float off through the overflow *c* and its outlet pipe *e*, while the finest of the heavy particles fall through the perforate floor C, and are collected in the hutch N of the first section or separating chamber and ore concentrator.

By reason of the opening from each chamber to the next the material under treatment gradually works from the first to the second chamber, from the second to the third, and so on through the entire series, the agitation of the material by the pulsating action of the water tending to facilitate this movement, which, however, is regulated or controlled by adjustments of the gates E so that the material may be held a longer or a shorter time in each chamber as deemed advisable. In the second chamber the water column being of less vertical height, a somewhat heavier or coarser grade of particles may be carried off through the overflow, and, similarly, a coarser grade of particles will gravitate into the hutch or chamber N below, and this same difference in action, varying only in degree, will follow throughout the successive sections or chambers.

As portions of the material under treatment are taken out in each section of the apparatus, and as the action is not carried to the same extent in each of the chambers, it is found expedient to make the chambers of progressively less horizontal measurement as the delivery end of the apparatus is approached. Thus chamber 1 is approximately three times the measurement of chamber 6 as shown in the drawing, in the direction of the length of the apparatus. This proportion, however, is merely suggestive, and may be varied if desired. The last chamber or column is provided just above the level of the screen or perforate floor with an opening normally closed by a plug O, serving when necessary as a means of drawing off or removing accumulated concentrates. The concentrates are usually delivered from this compartment.

By constructing the apparatus of a series of sections of like form I am enabled by merely introducing or removing sections to vary the extent to which the separation and classification shall be carried, and in some measure to vary its capacity.

Having thus described my invention, what I claim is:

1. In an apparatus for grading, separating, and classifying ores, a structure provided with a series of vertically extended chambers or columns, communicating at their lower ends with one another, and provided also with a series of hutches or lower chambers, one beneath each upper chamber or column, each upper chamber after the first being provided with an overflow, and said overflows being placed at progressively lower levels from the receiving toward the discharging end of the apparatus; a perforate partition separating each upper chamber from the chamber beneath it; gates or cut-offs controlling the passageways between the upper chambers; a water supply conduit communicating with the several hutches or lower chambers; valves, one between said conduit and each lower chamber; a valve controlling the delivery of water to said conduit; and means for opening and closing said last mentioned valve with considerable frequency and regularity.

2. In an apparatus for classifying ores, a series of separable sections each comprising an upright chamber or column and a lower collecting chamber or compartment, each upper chamber after the first one provided with an overflow; a water conduit communicating with each lower chamber or compartment; adjustable gates controlling communication between the upright chambers or columns; valves for controlling the delivery of water to each lower chamber; a perforate floor or diaphragm separating the upper chambers or columns and the lower chambers; and means for delivering to the conduit a pulsating water current without back flow.

3. In an apparatus for separating, classifying, and concentrating ores, the combination of a series of separable sections each comprising an upper and a lower chamber, a foraminous diaphragm separating said chambers, a depending skirt extending downward from said diaphragm into the lower chamber, a water conduit at one side, and, (except in the case of the first section), a lateral extension communicating with the upper chamber or column and provided with an outlet, the water conduits of the several sections being joined to form a continuous conduit; and a valve controlling the supply of water to the common conduit, and serving to open and close communication with the source of supply with frequency and regularity, whereby a single valve is caused to produce a pulsating action in the chambers of the several sections.

4. The herein described grading, classifying and concentrating apparatus, comprising

or containing a feed hopper, a series of upright columns or chambers communicating with each other at their lower ends and the first communicating with the hopper, and comprising, further, lower chambers, one beneath each upper chamber and the hopper; a perforate diaphragm or partition separating the upper and the lower chambers; gates controlling the passages of communication between the upper chambers and the feed hopper, said upper chambers being provided with overflow outlets at progressively lower levels toward the delivery end of the series; a conduit communicating with the several lower chambers; regulating valves between said conduit and the respective lower chambers, one for each; and a valve located between the head or source of water supply and the conduit and adapted to be opened and closed with considerable frequency, whereby water is caused to be delivered to the conduit in a series of pulsations without reflux and thence through the lower chambers to the upper chambers or columns under control of the valves between the conduit and the lower chambers.

5. In an apparatus for separating, grading and classifying substances, a casting containing an upright chamber provided at one side with a lateral extension communicating with said chamber by an opening or passage, said extension also provided with an outlet opening; a water conduit at the opposite side; a perforate floor or diaphragm at the base of the upright chamber; a second casting secured to the lower end of the first and having a laterally extended top wall provided with an inlet opening, a depending skirt, an inclined bottom wall, and an outlet pipe; an adjustable dam controlling the passage of communication between the upper chamber and the lateral extension; a valve controlling the inlet opening from the conduit to the chamber within the lower casting; and a valve located between the source of water supply and the conduit and adapted to be rapidly opened and closed, whereby a pulsating current without reflux is produced in the respective chambers.

6. In an apparatus for separating, grading and classifying minerals, in combination, a body or structure containing an upper chamber or column, a lower chamber, and a perforate diaphragm separating said chambers; a water conduit communicating with the lower chamber; and a valve comprising an outer shell or casing having a water inlet at one side, an inner annular shell or wall open at its ends and having a passage of communication opening into the conduit, and a rotatable drum arranged within said annular shell, open at its ends, and provided with diametrically opposite openings to register with the passage of communication opening into the conduit, whereby the valve is balanced and is adapted to open and close frequently and easily.

7. The herein described apparatus for treating mineral substances, comprising a feed hopper, and a series of columns or chambers with which the feed hopper communicates and which in turn communicate with each other at or near the bottom, each of said chambers being provided with an overflow outlet; a water conduit extending past the several chambers; a series of hutches, one beneath each upright column or chamber and beneath the hopper, and extending thence laterally beneath the water conduit; draw-off pipes for the respective hutches; valves or cocks applied to the conduit and controlling communication with the respective hutches; regulating gates for controlling the height of the overflow from the respective chambers; gates controlling communication between the hopper and the first chamber and between the several chambers; a perforate diaphragm separating the upper and lower chambers; and a valve adapted to be opened and closed with frequency, and serving to control the delivery of water into the conduit supplying the several lower chambers or hutches.

8. In combination with a separating, grading and classifying apparatus of the character described, a valve adapted to open and close communication between said apparatus and the water supply with considerable frequency; an air chamber located between said valve and the source of supply and serving to take up the shock incident to the sudden stoppage of the flow of water and to quickly start the flow when the valve is open, and a vent cock applied to said air chamber and serving to permit the escape of air when the compression becomes too great.

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

ROBERT H. RICHARDS.

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