R. H. RICHARDS.

APPARATUS FOR SEPARATING AND CLASSIFYING MINERALS.

APPLICATION FILED AUG. 2, 1905.

901,474. **Patented Oct. 20, 1908.**

3 SHEETS—SHEET 1.

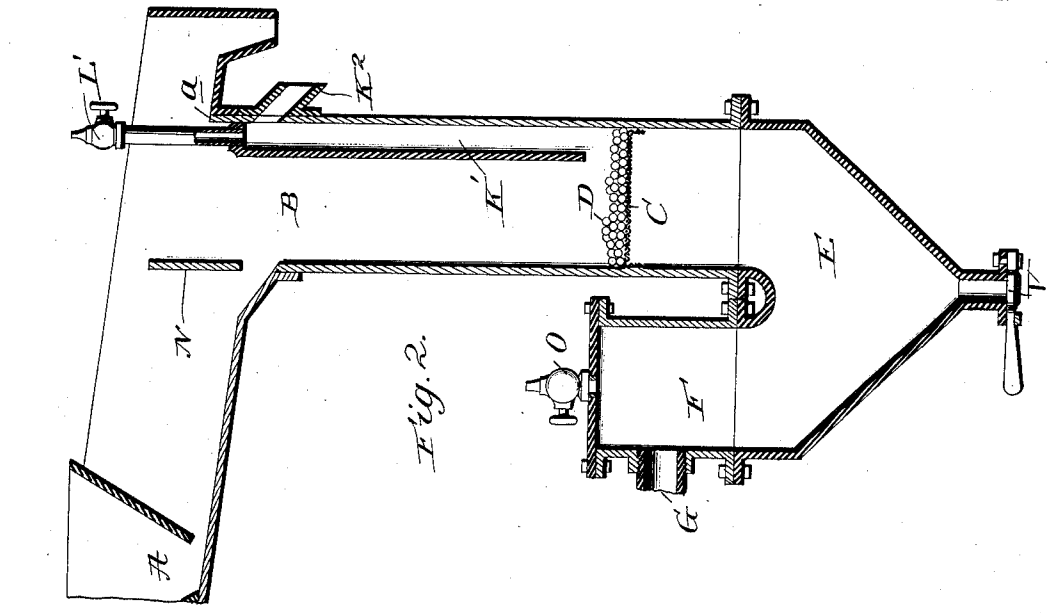

Fig. 2.

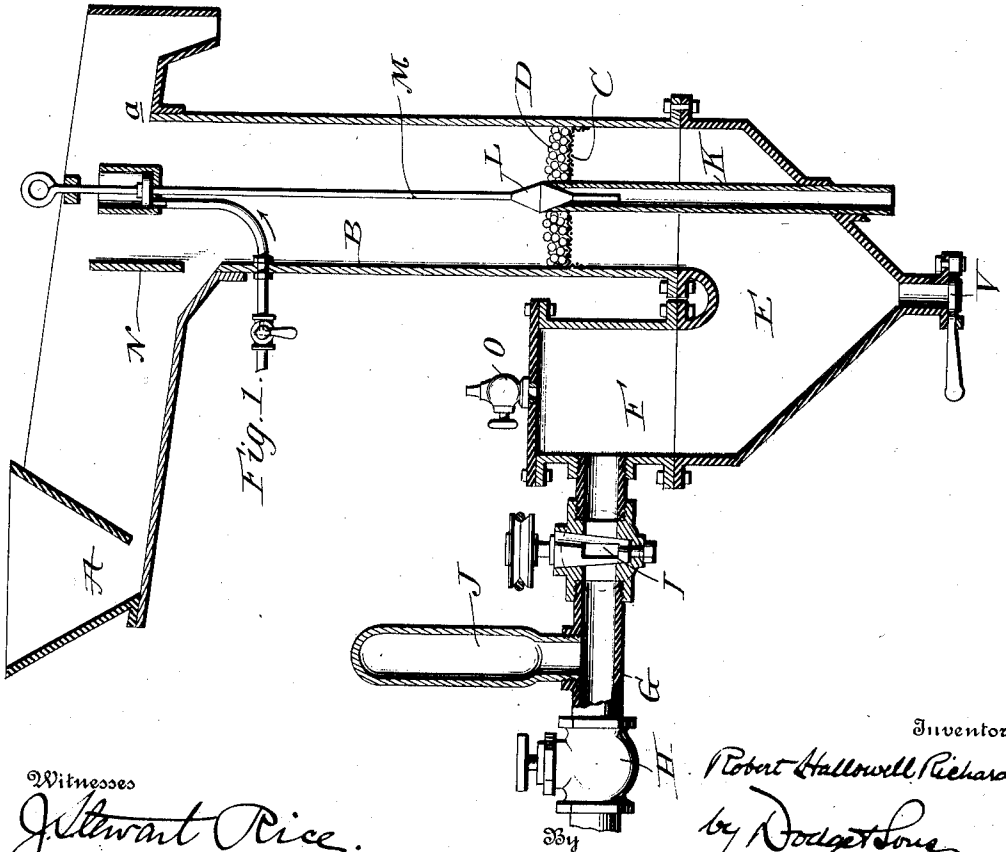

Fig. 1.

Witnesses

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Fig. 3.

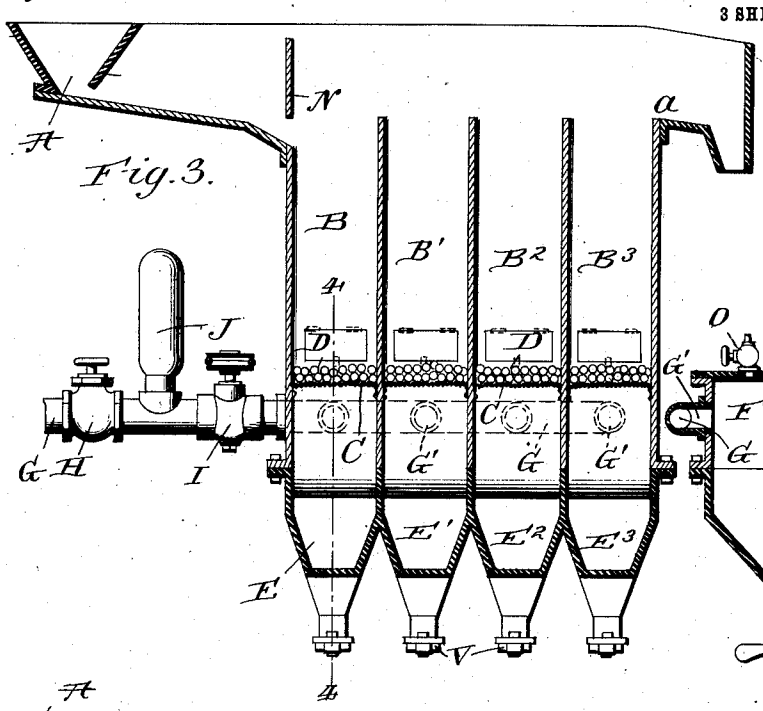


Fig. 4.

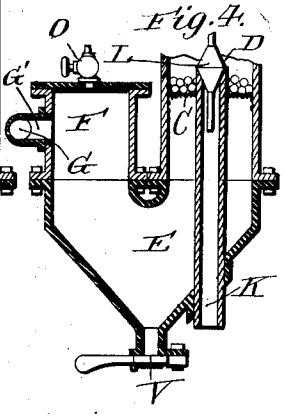


Fig. 5.

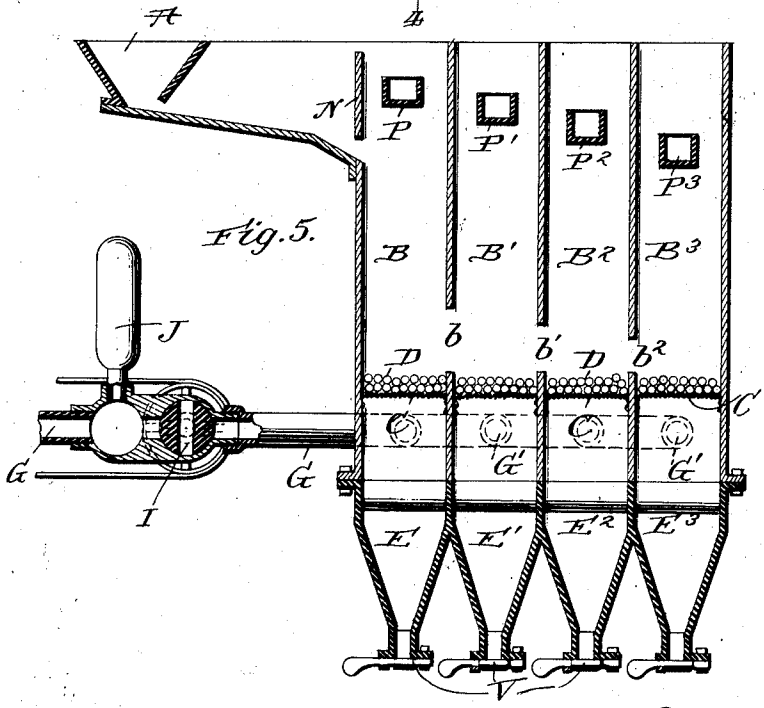
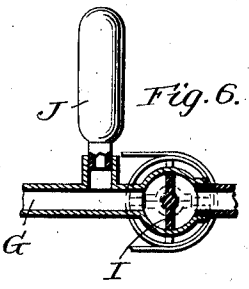


Fig. 6.



Witnesses

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3 SHEETS—SHEET 3.

Fig. 7.

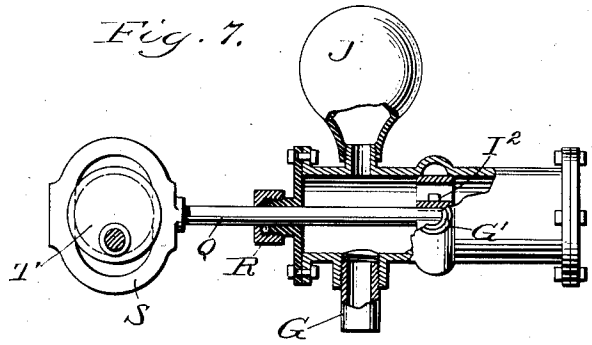
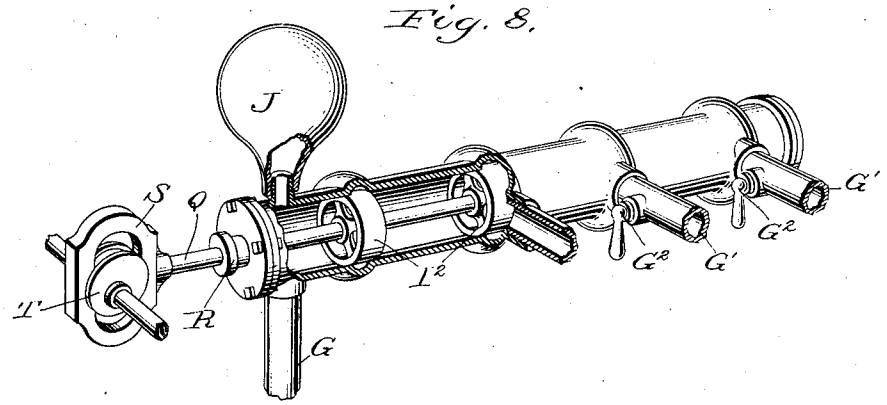


Fig. 8.



Witnesses

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR SEPARATING AND CLASSIFYING MINERALS.

No. 901,474. Specification of Letters Patent. Patented Oct. 20, 1908.

Application filed August 2, 1905. Serial No. 272,349.

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 Separating and Classifying Minerals, of which the following is a specification.

My invention pertains to apparatus for concentrating, classifying, grading, or separating mineral substances.

The apparatus partakes in a measure of the nature both of jigs and of hydraulic classifiers, as such machines are at present known in the art, but possesses certain advantages over both, as hereinafter pointed out.

In the accompanying drawings I have illustrated my apparatus in several slightly different forms, but all embodying the same general principles or features of construction and operation.

In these drawings: Figure 1 is a sectional elevation of apparatus embodying my invention in simple form; Fig. 2, a similar sectional view (with portions broken away or omitted), showing a different plan for discharge of material collecting above the porous bed or screen; Fig. 3, a similar sectional view of an apparatus having a series of compartments in which the minerals are successively treated; Fig. 4, a transverse sectional view on the line 4—4 of Fig. 3; Fig. 5, a vertical longitudinal section of an apparatus analogous to that of Fig. 3, but with the compartments communicating just above the screens or porous beds; Fig. 6, a detail view of a modified form of valve for effecting a pulsation of the water current; Figs. 7 and 8, views illustrating the application of a balanced valve or valves to the inlet pipe or pipes of the pulsator.

The apparatus herein set forth will find its place among jigs, used for concentrating ores, coals and other minerals, and also among machines commonly known as "hydraulic classifiers," which are used for grading ores or minerals into a series of products ranging from coarse sizes down to fine sizes, according to their rate of settling in water, preparatory to concentration by other machines.

The present apparatus, which I term a pulsator, occupies a place between the classifier and the jig, possessing some qualities of each; under certain conditions doing the work of each, and in a more efficient manner than either.

The construction and operation of the pulsator is based upon the fact that if grains of two minerals of different specific gravities, for example, quartz and galena, be dropped into water and allowed to settle freely, those grains of the two minerals which settle at the same rate of speed will bear a certain ratio of diameters, depending upon their specific gravities. In the case assumed, quartz and galena, the ratio is 4 to 1, or a little less,—that is to say, the quartz grain will be about four times the diameter of the grain of galena, when the two settle at the same ratio. This is about the ratio commonly obtained in the classifiers of concentrating mills. On the other hand, if a mixture of quartz and galena be treated in or by a jig, with the grains of the two minerals in a mass resting upon the sieve, the pulsating action or the rising current of water of the jig will arrange the grains in layers in which the grains of said two minerals have a ratio of approximately 6 to 1, the quartz grains being six times the diameter of the galena grains, when the two are in juxtaposition. But with the jig, the return movement of the plunger or piston, which under certain circumstances is advantageous in drawing down the heavy fine grains into the hutch below, is disadvantageous in hindering the work of the jig and causing it to act much more slowly, thereby cutting down its capacity.

The pulsator is designed to gain the advantages of the jigging ratio, that is, the hindered settling ratio of 6 to 1 for quartz and galena when the apparatus may be doing the work of a classifier, which, as above noted, has a ratio of 4 to 1, the free settling ratio, and to do this with a diminished consumption of water as compared with that required by the classifier. It is designed also to do the work of a jig under conditions which do not require the suction due to the return of the plunger, gaining the advantage over the jig of greatly increased speed of treatment.

Referring again to the drawings, and first to Fig. 1, which shows an elementary form of the apparatus, A indicates a hopper, into which are fed water, and ores of mixed sizes and gravities. From hopper A they pass to a compartment B, for treatment.

Said compartment B is provided at a suitable distance below its top with a bed comprising a screen C, and a body or mass D, of shot or other heavy material in globular or granular form resting thereon. Beneath the bed C, D, is a hopper-shaped chamber or hutch E, into which any finer and heavier particles which may find their way through the bed and screen, fall, and in which they will be collected. Any sediment carried in by the water through main G will also collect in and may be removed from said chamber.

The hutch or chamber E is preferably of the form shown in Fig. 1, that is to say, it has a second short leg or compartment F. At the lower end of the hutch E there is a gate or valve through which its contents may be withdrawn from time to time, as required.

G indicates a water pipe, in communication with any suitable source of supply having proper head, and also in communication with hutch E. This pipe G is furnished with a cock or valve H by which communication between the supply and the hutch may be completely cut off, or regulated, as desired; and it is further provided with a valve I, represented in Figs. 1, 3, 4 and 6 as a rotary plug or cock, by which the water supply may be alternately admitted to and cut off from the hutch with any desired frequency when valve H is open. Between the cocks or valves H and I, there is placed an air chamber J, designed to perform the double office of protecting the pipe and valve against the hammering effect of the water, incident to suddenly shutting off its flow, and of insuring a prompt flow and sudden impulse of the water whenever valve I is opened.

It will readily be seen that the inertia of the water limits the number of impulses that may be produced per minute under given head, but the air in chamber J being compressed by the pressure of the water suddenly arrested by valve I, tends to hasten the forward movement of the water when the valve is next opened, and hence the impulses may follow in closer succession. This is sometimes important in practice.

K indicates a pipe, extending from a point slightly above the bed C, D, down through hutch or chamber E and through the lower wall thereof. At its upper end the pipe is slightly reamed out to receive a conical plug or valve L, which normally seals the pipe. A rod M, extending upward from the valve or plug L and passing through a cross bar or guide, is fashioned into a handle, by which the valve may be lifted from its seat to open pipe K and permit the outflow of material collected upon or above the bed C, D. This valve may be opened manually, or mechanically, as preferred. In Fig. 1 I have shown a motor comprising a cylinder, and a piston carried by the rod M, and adapted to be raised by fluid under pressure admitted to the cylinder, beneath the piston, and have shown a three-way valve for controlling the supply and waste. This is merely suggestive and any convenient form of motor may be employed, and arranged to come into operation automatically or under manual control, as preferred.

The apparatus being thus constructed and a stream of mingled ore and water caused to flow into hopper A, and thence to chamber B, said chamber and the chambers E and F soon become filled, and the water overflows at *a*, a baffle-plate or board N preventing a direct flow of water across the top of chamber B. Simultaneously with this inflow from hopper A, water is admitted to chambers F and E by rotation or rapid opening and closing of valve or cock I, the volume being regulated by valve H. Each opening of cock or valve I permits the water to rush forward momentarily, and consequently to produce a sudden upward flow through the bed C, D, through the material lying upon it, and through chamber B above the bed. The rapid opening and closing of the valve or cock produces a series of pulsations, the force of which is in an upward direction in chamber B. As the several chambers are practically full of water, there can be no return movement thereof except when the discharge spigot V is open.

As shown, the chamber F is provided with an escape valve or vent O, by which the air may be let out whenever necessary or desirable, and to whatever extent deemed expedient.

The pulsating flow of the water upward through chamber B lifts the solid particles which gravitate to the bed D, and those in suspension, the grains or particles of greatest specific gravity settling back thereon, while light particles are carried upward, and flow off with the overflow at *a*. This action is eminently suited to the classification of mixed ores and to the complete separation of the heavier from the lighter mineral, in closely sized products, grains or particles. It happens, then, that the heavier mineral collects around the discharge pipe K, and when the layer is sufficiently deep it may be drawn off by lifting momentarily the plug L.

Some of the finer grains of the heavier mineral naturally find their way through the bed C, D, into hutch or chamber E, and these may be withdrawn from time to time through the outlet V at the bottom of said chamber.

If desired, the discharge or delivery of material from the surface of bed D may be made automatic, by any of the usual or well known arrangements, and without employing valve L. One such construction is illus-

trated in Fig. 2, where all parts are constructed as in Fig. 1, except that outlet pipe K and valve L are omitted and an up-take pipe or trunk K′ is substituted, with or without an air cock or vent L′, located at the top of the trunk, as shown. The outlet pipe K^2 may be extended downward a greater or less distance, according to the lifting force desired to be exerted on the current rising in the trunk K′; or this may be controlled by the head and consequent pressure of the water entering chamber B or E, or both. Under this arrangement the lighter particles remaining in suspension in the water will eventually flow off over the dam or overflow point *a*, without coming within the influence of the upward current in the trunk K′.

In Figs. 3 and 5 I have illustrated the application of the invention in a more elaborate form. In each of these a plurality of separating chambers or legs, each with its own granular or permeable bed, hutch or collecting chamber, and outlet, is provided, and the mingled mineral substances, being acted upon in the several chambers successively, are effectually separated and graded according to size of particles, the chamber into which the ore first enters receiving and retaining the heavier particles, and succeeding chambers receiving and retaining progressively lighter particles. While in some degree this is done with the forms shown in Figs. 1 and 2, the separation or gradation of particles of the heavier mineral is through stratification, that is to say, the larger and heavier particles lie mainly at the bottom and the smaller and lighter particles at the top of the mass, accumulating or collecting upon the bed D. With the forms represented in Figs. 3 and 5, however, there is a separation of the particles into bodies of progressively smaller size in the successive chambers.

Referring first to Fig. 3, it will be seen to comprise the hopper A, baffle-plate or board N, overflow dam *a*, chamber or leg B, with its bed C, D, its hutch or collecting chamber E, chamber F, and supply pipe G, with valves H and I, and air chamber J, as under the construction shown in Figs. 1 and 2. It also further comprises additional chambers B^1, B^2, B^3, of which there may be a greater or less number, from one upward, according to the requirements of the work. The chambers B^1, B^2, etc., have hutches or collecting chambers E^1, E^2, etc., in all respects similar to those of the first section of the apparatus, and including the vent or valve O, and the discharge L, K.

Water pipe G, under this arrangement, extends along one side of the apparatus and is connected by short branch pipes G′, Fig. 4, with each of the chambers F in turn; hence at each opening and closing of valve or cock I, there will be a sudden flow and impulse in the several chambers of the apparatus, followed by a momentary rest during which the particles thrown upward settle or fall back. It may prove necessary, or at least desirable under some conditions, to provide the branch pipes with regulating cocks, in order to divide the water properly between the several compartments, and thus to vary the action in each. This provision will be again referred to and explained in connection with other figures.

In the first chamber B into which all but the very lightest matters fall, and in which the heavier particles gravitate to the bed D, the pulsating current will tend to lift or throw upward the particles, arranging them according to their specific gravity and dimensions, upon the bed D. Such particles as are unable to withstand the upward movement of the water will be carried to the top of Chamber B and will fall into chamber B^1, or be carried across the top thereof, according to the specific gravity and dimensions of the particles, strength of current and like factors. Naturally, the pulsations will need to be made strongest in the first chamber B (by properly adjusting the regulating cocks in the branch pipes G′,) when the heaviest product is dealt with. Each successive section will have a milder pulsating action than the one preceding, and hence in each succeeding chamber progressively smaller and lighter particles will be deposited.

Either of the methods of discharge illustrated in Figs. 1 and 2 may be employed in connection with this apparatus and also with that of Fig. 4, for removing the mineral collected upon the beds D, or any other convenient means may be adopted.

In Fig. 3 I have indicated doors just above the beds D, through which the accumulated material may be removed from the beds D, if desired. These doors will, if used, be made to close water-tight.

In Fig. 5 the hopper A, baffle-plate or board N, legs or chambers B, B^1, B^2, B^3, with their hutches or collecting chambers E, E^1, E^2, E^3, and their beds C, D, are shown essentially as in Fig. 3, but the legs or chambers B, B^1, etc., communicate with each other just above the beds C, D.

Each chamber E, E^1, E^2 and E^3 will be provided with a preliminary chamber F arranged in the same manner as indicated in Fig. 4, and the pipe G with its branch pipes G′ will be employed, each branch opening into one or another of the chambers F, as above indicated. These branches will advisably be provided with regulating cocks or valves, though it is possible so to proportion the pipes as to secure proper relative flow and action in each chamber.

Each chamber B, B^1, B^2, B^3, is provided with an overflow trough, designated as P, P^1, P^2, P^3, open at the top and at the end

outside the structure, so that water rising in the respective chambers may flow off through said troughs. These troughs are placed progressively lower, trough P being at the highest and trough P^3 being at the lowest level.

It is to be understood that the number of legs or chambers B, B^1, etc., may be increased or diminished at will, the minimum number for this particular embodiment of the invention being two. Under this construction the mass of material falling into leg or chamber B is acted upon by the pulsating upward current, and the muddy water will flow off through the spout or trough P. The lighter floating particles will naturally pass off with this current. Such particles as are not lifted to trough P will settle to the bed D of said chamber or will be carried off laterally to the next or to a succeeding chamber B^1, B^2, etc. In each of these there will be the pulsating action, but progressively stronger from chamber B to chamber B^3, this relation being effected by regulation of the cocks on the branches G'. The troughs or overflows P, P^1, P^2, P^3, will carry off and discharge grains of progressively greater size and weight.

The openings or passages b, b^1, b^2, permit the lower layer of heavier grains in each compartment to move on to the next compartment for further treatment.

Summing up the action, the crude ore entering at A is separated in B by the pulsating current into lighter grains which overflow at P, and heavier grains which pass through b into B^1, there to be again separated into lighter grains to overflow at P^1, and heavier grains which pass through b^1 into B^2, and so on, making a series of products ranging from the finest and lightest passing off at trough P, to the coarsest and heaviest passing off at trough P^3.

The revolving cock, which may be of the form shown in Fig. 5 or that shown in Fig. 6, as preferred, will have its shaft or spindle carried through stuffing boxes and suitably packed to prevent leakage, and may need bearings to give it support.

In the foregoing description I have referred to a rotary valve, plug or cock as a suitable device for giving the pulsatory effect. Where a considerable head of water is made use of it will be advisable to employ some form of balanced valve, as otherwise undue consumption of power might be necessary to the actuation of the valve, and the valve and its packings and bearings might be injured by the impact of the water. Accordingly, I have shown in Figs. 7 and 8 a familiar type of balanced valve suited to this work. In these figures G indicates the supply pipe, as before; J the air chamber; G^2 the regulating cocks, of which mention has above been made, applied to the branch pipes G'; and I^2 the valve or valves.

In Fig. 7 one branch pipe, air chamber and valve only are represented, the valve being in the form of a hollow cylinder or tubular valve carried by a stem Q passing through a suitable stuffing box R, and provided at its outer end with a yoke S to receive a rotary cam or eccentric T by which the rod or stem Q may be reciprocated a distance sufficient to carry the valve alternately to a position to open and to a position to close the communication with the air chamber J and branch pipe G', which it controls.

Whether there be but one valve I or a series of them, each valve will be formed with a hub having radial spokes or wings extending therefrom to the tubular or annular valve body, each hub being made fast upon the actuating rod Q in any convenient manner. Owing to the tubular or open construction of the valves the water is free to pass through the same and to bear equally on opposite sides of each, hence the valve will be completely balanced at all times.

It is believed that a balanced valve of some form will be practically necessary in machines of considerable size, and this feature as an element of the combination is deemed an important one, and it is my purpose to claim broadly any suitably balanced valve in the combination or relation here set forth. The form of valve shown is simply illustrative and is intended to stand for or represent balanced valves generally.

The balanced valve may obviously be operated more rapidly than is practicable with an unbalanced valve, particularly when the valve and the opening controlled by it are of large dimensions.

As above indicated, there may be a single separating chamber as in Figs. 1 and 2, or a plurality of chambers, in any number from two upward, as illustrated in Figs. 3 and 5, the number of chambers therein represented being taken merely for purposes of illustration and not as restricting me to any particular number.

It is important that the chambers or legs B, B^1, etc., be made of considerable depth in order that the pulsating current may be effective and may act upon the particles in suspension in or at the foot of said chambers practically uninfluenced by the cross-flow or current of water over the top or tops of such chamber or chambers. It will be noticed that under each of the embodiments of my invention here represented, the lowest outlet or overflow point is at a higher level than the inlet into chamber B. While this may not be essential it is deemed quite desirable, since it more perfectly insures the upward flow and lifting action of the water and relieves the material under treatment from the effect of the cross-flow of water over the top of the chamber or chambers.

While I have specifically set forth a valve to effect the pulsating action, it is to be understood that any known device for producing the pulsation of the inflowing water, without permitting reflux or back flow, may be employed, and the term valve in the claims is to be read with this understanding.

In referring to the separating chambers as vertically elongated it is not intended to convey the impression that their vertical measurement of necessity exceeds other dimensions, but merely that there is a definite chamber of depth sufficient to permit stratification to take place in the body or column therein contained; in other words, to differentiate the chamber from a mere flume or trough.

Having thus described my invention, what I claim is:

1. In an apparatus for the treatment of minerals and in combination, a vertically elongated chamber having near its top an inlet for mingled water and mineral substances; a water outlet for said chamber at a higher level than said inlet; a permeable bed in the lower part of said chamber; a chamber below said bed; a water inlet beneath said bed communicating with a source of water under pressure; and means for opening and closing said water inlet with considerable frequency.

2. In an apparatus for the treatment of minerals, the combination of a vertically elongated separating chamber; a porous or permeable bed therein; a chamber beneath the bed; a water pipe delivering under constant head, communicating with the chamber beneath the bed; a valve intermittingly interrupting the delivery of water through said pipe to the chamber; means for opening and closing said valve with frequency; and an air vent or valve located at a point between the water inlet of the chamber and the permeable bed, whereby air accumulating in the chamber may be released.

3. In an apparatus for treating minerals, the combination of a vertically elongated separating chamber; a permeable bed or support therein; a water supply or conduit opening into the space beneath said bed; a valve controlling the delivery of water through said pipe; means for opening and closing said valve with considerable frequency and regularity; and an air chamber communicating with the water pipe at a point between the head or source of supply and the valve, and serving to confine a body of air which becoming compressed by the sudden arrest of the flow of water to the separating chamber serves, when the valve is opened, to hasten the flow of water through said valve and into the separating chamber, and thereby to give to the water column in the separating chamber the requisite suddenness and frequency of pulsation.

4. In combination with a vertically elongated separating chamber provided with a permeable bed or mineral support; a water pipe opening into the space beneath said bed and provided with a valve by which wholly to cut off the water supply; a second valve or cock in said pipe; means for opening and closing the latter valve with frequency and regularity; and an air chamber located on the receiving side of the latter valve, substantially as and for the purpose set forth.

5. In an apparatus for separating and classifying minerals, the combination of a supply hopper; a vertically elongated separating chamber; a guard or baffle-plate between the hopper and the chamber, tending to prevent a rapid cross flow of water over said chamber; a permeable bed in said chamber; a chamber beneath said bed; a chamber above and communicating with said lower chamber to one side of the separating chamber; a water pipe opening into the last-mentioned upper chamber; a valve in said pipe adapted to be rapidly opened and closed; means for thus opening and closing said valve; and an air chamber on the receiving side of said valve communicating with the water pipe, and serving to contain a body of air which, upon the closing of the valve and sudden stoppage of the water, becomes compressed and serves, upon the re-opening of the valve, to hasten the flow of water therethrough, whereby pulsations of requisite frequency to effect proper separation and stratification of particles are produced in the separating chamber.

6. In a separating apparatus for grading and classifying minerals, the combination of a feed or supply hopper; a series of vertically elongated separating chambers arranged to receive material in succession from the hopper, and each provided with a permeable bed in its lower part; a water pipe arranged to deliver water to the several separating chambers beneath their permeable beds; a valve or cock in said pipe; means for opening and closing said valve or cock with considerable frequency; and an air chamber on the receiving side of said valve or cock, serving to cushion the water column when the valve is suddenly closed, and to hasten the flow of water when the valve is opened, and thereby to produce in the separating chambers pulsations of requisite frequency to effect separation and stratification of the mineral particles.

7. In an apparatus for the treatment or separation of minerals, the combination of a series of vertically elongated chambers arranged side by side, and adapted successively to receive at their upper ends a supply of mingled water and minerals, each chamber having an overflow or outlet at or near its top; permeable beds below said chambers, one for each; a water pipe communicating

with a source of water under constant head or pressure, and having branches opening into the spaces beneath the respective beds; valves for controlling said branches independently of one another; and a valve serving to open and close the main water pipe with considerable frequency, the chambers above the beds serving as distinct and independent settling or separating chambers in which the minerals undergo successive treatment, and the valves of the branch pipes serving to effect a varying water impulse in the different chambers.

8. In an apparatus for separating minerals, the combination of a vertically elongated chamber provided with a permeable bed or mineral support; a water pipe opening into the space beneath said bed or support; means, substantially as described, for opening and closing the water inlet with frequency; and an air chamber, communicating with the water pipe, close to and on the supply side of the water inlet adapted to confine a body of air which, when the water inlet is suddenly closed, serves to cushion the water column and prevent injury to the apparatus, and when the inlet is opened, serves to start the water forward through the inlet with great promptness, thereby securing requisite frequency of pulsation in the separating chamber.

9. In an apparatus for treating minerals, the combination of a vertically elongated separating chamber; a permeable bed or support therein; a water supply or conduit opening into the chamber beneath the bed; a balanced valve controlling the delivery of water through said pipe; means for actuating said valve; and an air chamber communicating with the interior of the water supply pipe on the inlet side of said valve, substantially as and for the purpose set forth.

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

ROBERT HALLOWELL RICHARDS.

Witnesses:
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H. CLOHESSY.