D. COLE.

APPARATUS FOR SEPARATING OR CONCENTRATING ORES.

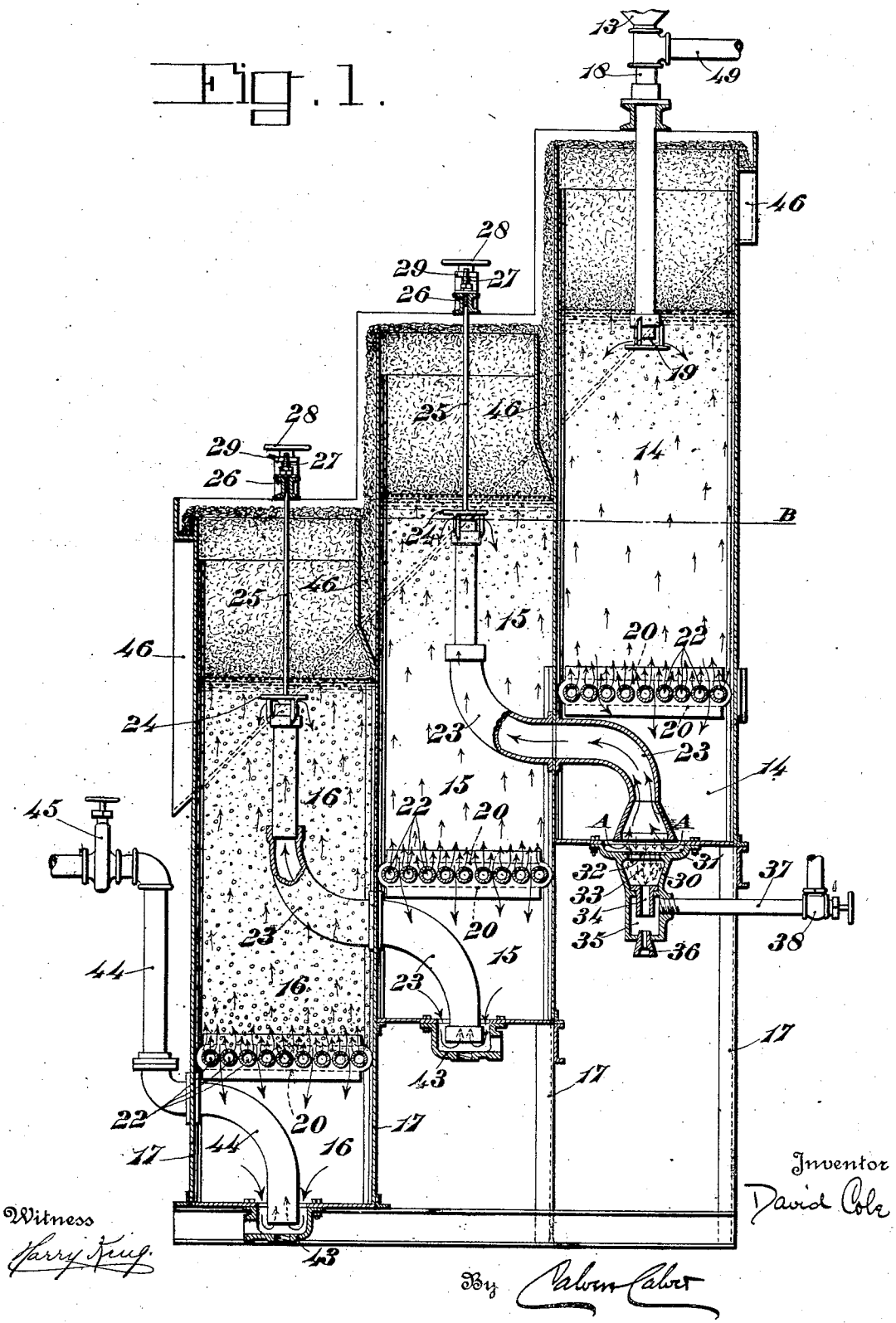
APPLICATION FILED DEC. 4, 1915.

1,319,208.

Patented Oct. 21, 1919.

3 SHEETS—SHEET 1.

Fig. 1.



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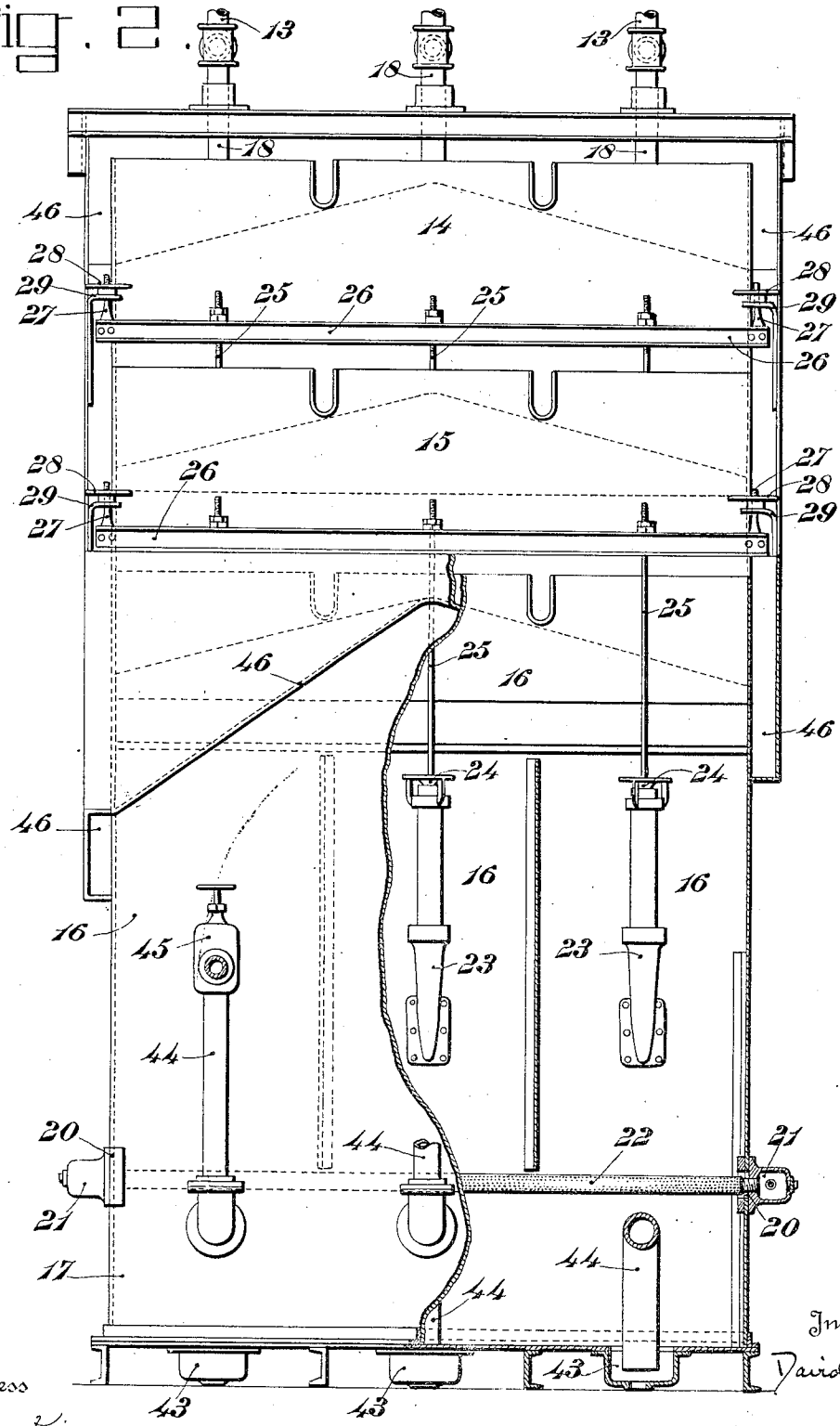
APPLICATION FILED DEC. 4, 1915.

1,319,208.

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3 SHEETS—SHEET 2.

Fig. 2.



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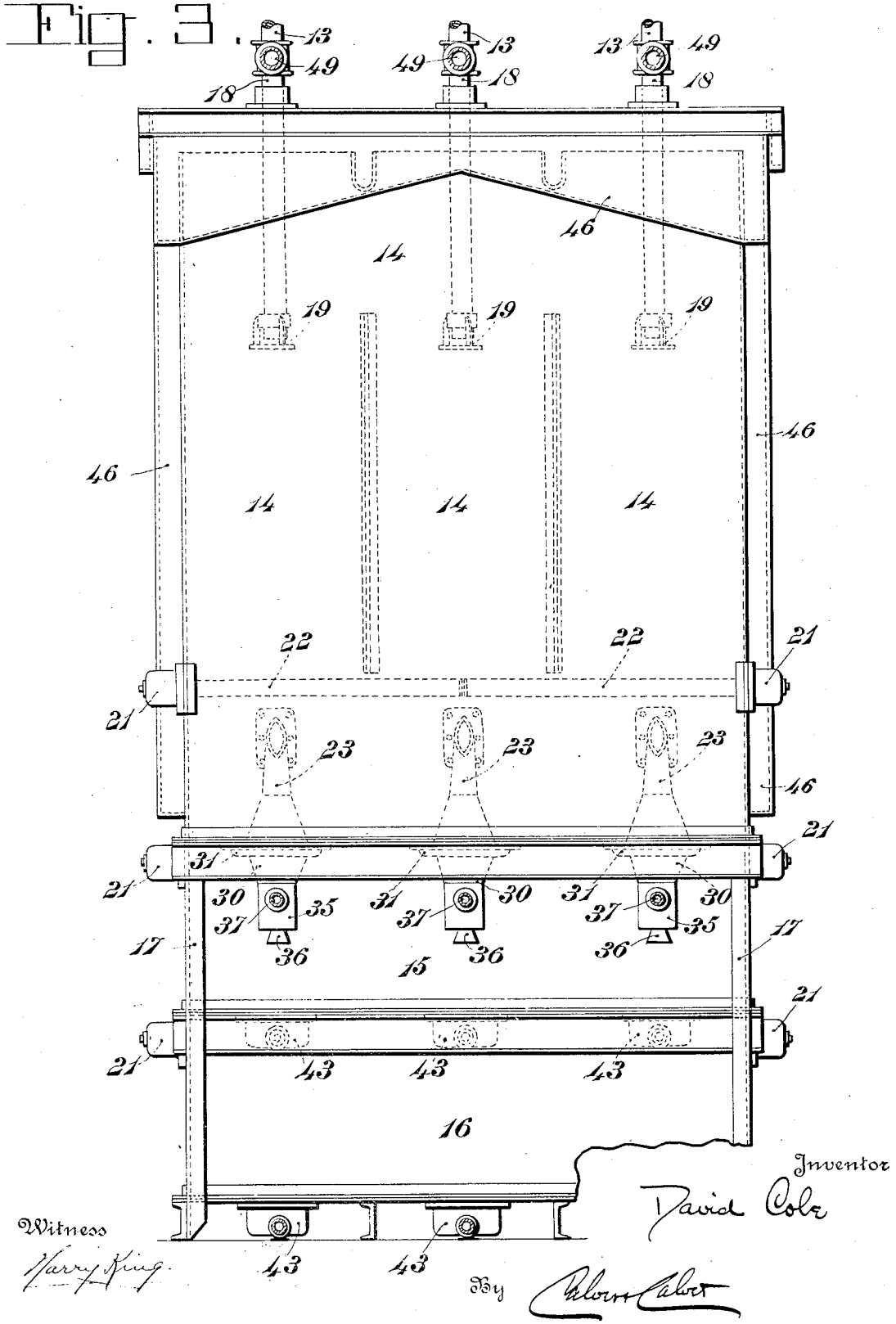
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3 SHEETS—SHEET 3.

Fig. 3.



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APPARATUS FOR SEPARATING OR CONCENTRATING ORES.

1,319,208. Specification of Letters Patent. Patented Oct. 21, 1919.

Original application filed August 3, 1915, Serial No. 43,442. Divided and this application filed December 4, 1915. Serial No. 64,992.

To all whom it may concern:

Be it known that I, DAVID COLE, a citizen of the United States, residing at El Paso, in the county of El Paso and State of Texas, have invented or discovered certain new and useful Improvements in Apparatus for Separating or Concentrating Ores, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to the hydraulic classification, separation, or concentration of ore and the like, and more particularly to hydraulic separators adapted for (although not limited to) use in connection with that process known as frothing classification, the latter being an amplification of the well known flotation method.

The invention has for its general object the preparation of the rejections of the flotation treatment in such a way that maximum recoveries may be made by the usual gravity methods upon the grains and sizes in the pulp which were not within the range of, and were not susceptible to, recovery by flotation treatment. Grains which will pass a screen having ten thousand openings per square inch will be within the possible range of flotation recovery, but substantially all grains coarser than this size will not be within the range of recovery by flotation.

The mineral grains constituting the product separated and recovered by flotation methods are so fine that substantially ninety-five per cent. of them will pass through a screen having forty thousand apertures per square inch. Therefore the range of flotation sizes is substantially limited to the minus one hundred mesh sizes (*i. e.*, ten thousand holes per square inch above referred to) and since it is impracticable commercially to reduce all of the ore to be treated to this very fine state of division it is necessary either to separate the flotation treatment sizes from the gravity treatment sizes and treat them separately, or to so prepare the combined sizes during flotation treatment that the gravity treatment to follow will not be embarrassed in making maximum recoveries upon sizes of grains in the pulp which are amenable to gravity treatment, this preparation constituting the frothing classification process.

In accordance with the last named process the material to be subjected to the treatment is pulverized in the presence of water and usually also small amounts of oils and the like to a size which will yield the best commercial recovery, and the resulting "pulp" is introduced into a suitable tank provided with means in the lower part of same for liberating air in a finely divided state through a suitable porous medium, said air forming very numerous streams of very small bubbles which expand in size as they rise toward the surface of the pulp in the tank, carrying with them the particles of mineral which have greater affinity for air than for water, and which are sufficiently finely divided to be enveloped in the films of the bubbles and be carried by the rising air, thereby forming a mineral froth above the surface of the pulp in the upper part of the tank, which froth, with its load of mineral, builds a column high enough to overflow the edges of the top of the tank; while the particles of ore which have more affinity for water than for air, together with the particles too large to be lifted by the bubbles will find their way to the bottom of the tank and be withdrawn therefrom.

The process is usually carried on continuously, the pulp flowing into the tank at a suitable rate, the froth with its content of fine mineral being continuously discharged in the "mineral froth" at the top of the tank, and the water and coarser material being continuously discharged at the bottom of the tank.

In order that such apparatus of the previous art may operate properly and not become clogged it is necessary that the ore or other material being treated be all of a certain degree of fineness. It is therefore necessary that said material be either carefully pulverized primarily to a very even degree and sufficiently fine, or else that said material be screened or receive other previous treatment for removing the coarser particles, or "oversize," which would embarrass the apparatus and would tend to clog it. It is one of the objects of the present invention to provide means, associated with a flotation or frothing classifier itself, for automatically removing the oversize, such removal being effected during and in

connection with the normal operation of the apparatus, thus preventing embarrassment to the operation and making it possible to apply the flotation or frothing process primarily in the treatment of ores in a much coarser state of reduction, that is to say, to the ordinary mill run, without subjecting the same to previous screening or other treatment for the purpose of protecting the frothing machine. In carrying out this feature of the invention the separating tank is preferably provided with one or more classifying cones each having an outlet and an inlet through which "hydraulic" water is introduced, said water driving or holding back material of a predetermined fineness (depending upon the form of chamber and pressure or velocity of the water so admitted) and permitting the oversize to pass out through the outlet, so that, by regulating the amount of hydraulic water admitted, the size and quality of material escaping may be controlled and varied, thus accomplishing, by the mere regulation of an inlet valve, a result which, in the case of mechanical separation, would require the complete changing of screens or other troublesome operations.

In the flotation separation of ores and the like it is found to be advantageous to subject the material under treatment to more than one passage through the apparatus, and the present invention accordingly has for a further object the provision of a frothing classifier which provides in a simple and efficient manner for the repeated treatment of the material, said apparatus comprising a series of tanks or compartments and means whereby the material is automatically transferred from one of said tanks or compartments to the next by gravity and without the necessity of pumping, said transferring means being of such a nature as not to interfere with the efficient operation of the apparatus. In carrying out this feature of the invention the transferring means is constructed and arranged to cooperate with the classifying cones in such a manner as to materially assist the operation of the latter and to reduce materially the amount of hydraulic water required for the proper separation of the oversize and returnable portion.

Additional objects of the invention are to provide a simple and convenient apparatus for frothing classification which combines efficiency of operation with economy in material required for its construction and of mill space necessary for its accommodation, said apparatus being provided with simple and effective means for making such adjustments as may be required by the conditions of use.

The foregoing and other objects of the invention, together with means whereby the same may be carried into effect, will best be understood from the following description of one form or embodiment thereof illustrated in the accompanying drawings. It will be understood, however, that the particular construction described and shown has been chosen for illustrative purposes merely, and that the invention, as defined by the claims hereunto appended, may be otherwise practised without departing from the spirit and scope thereof.

In said drawings:

Figure 1 is a vertical sectional view of the classifier.

Fig. 2 is an end elevation partly broken away of the apparatus shown in Fig. 1, as viewed from the left in the latter figure.

Fig. 3 is an end elevation partly broken away of the apparatus shown in Fig. 1, as viewed from the right in the latter figure.

The apparatus herein shown comprises a series of tanks or compartments 14, 15, 16 supported by suitable uprights 17, said tanks or compartments being of any desired number (herein shown as three). Adjacent tanks of the series have common intermediate or dividing walls, while the several tanks are disposed in stepped arrangement, as shown, each succeeding tank or compartment being at a somewhat lower elevation than the preceding one. A suitable conduit 13 delivers the comminuted material, together with an amount of water (introduced through branch pipes 49) sufficient to produce a mixture or proper consistency, into one or more feed pipes 18 which discharge into the first tank or compartment. The feed pipes 18 are preferably provided at their lower ends with deflectors 19 which cause the streams to spread out into thin sheets for the purpose of preventing the formation of violent currents in the tank 14.

At a proper distance above the bottoms of each of the tanks 14, 15, 16, slots 20 are formed in the ends of said tanks, and secured to said ends adjacent said slots are manifolds 21 communicating with a suitable source of compressed air. The manifolds 21 of each tank support and communicate with a series of horizontally disposed tubes 22 which extend throughout the length of the corresponding tank and form a tubular grating substantially covering the entire horizontal cross-sectional area of said tank at a point suitably elevated above the bottom thereof. The tubes 22 are so constructed as to have a finely porous, air emitting surface, as by forming said tubes of a porous material, such as carborundum, or by covering the same with filtering fabric or the like, whereby the compressed air supplied to the manifolds 21 is discharged through said tubes into the tanks in the form of numerous streams of fine bubbles. The pores of the

tubes 22 are too small to allow solids to enter from the outside, under hydraulic pressure when the air pressure is cut off, as would occur in the case of a perforated pipe or the like, thereby preventing the internal clogging of said tubes. The tubes 22 of each grating are spaced from one another a sufficient distance to permit easy downward passage between them of the pulp and water under treatment, while being sufficiently close together to provide for the thorough aeration of the contents of the tanks above them. The outlet from each tank, as will presently be more fully described, is at the bottom thereof, while the tubes 22, as above explained, are located some distance above the bottom. By this arrangement, as also by reason of the spacing of the tubes 22 as above described, all violent downward currents or vortices in the vicinity of said tubes, tending to draw the bubbles downwardly, are avoided, and all possibility of improper discharge of the finer material from the bottom of the tank reduced to a minimum. The construction of the tubes 22 is preferably such as to permit a discharge of air throughout their circumference, thereby providing a greatly increased air emitting surface, and, at the same time, free downward passages for the liquid, as above explained. By virtue of this form and arrangement all possibility of such accumulation of sediment as would clog the exterior of the tubes and interfere with the proper discharge of air therefrom is prevented, it being obvious that, even though the entire upper surfaces of the tubes were covered by deposits, there would still be left a total unobstructed air emission surface equal to or greater than the entire transverse area of the tank, notwithstanding the passages between the tubes.

The bubbles from the tubes 22 pass upwardly through the tanks, combing out and carrying with them the finer particles of material, particularly metallic sulfid, and form in the upper part of said tanks bubble or froth columns which overflow into a launder 46 arranged to discharge the froth with its content of fine material at any suitable point.

For the purpose of leading the material from one tank or compartment to the next for successive treatment the transfer tubes 23 are provided. Said transfer tubes are preferably of the S-shaped form shown, pass through the wall separating adjacent tanks or compartments at points below the tubes 22 of the upper tank, and are preferably flattened laterally, as shown in Figs. 2 and 3 in order to oppose the least possible resistance to the upward passage of the bubbles in the lower tank. Each tube is arranged with its inlet adjacent the bottom of the tank from which it discharges and with its outlet in the upper portion of the next adjacent tank, the difference in elevation of succeeding tanks providing a sufficient hydrostatic head to force the material from the lower part of one tank by gravity.

Arranged adjacent the outlet of each transfer tube 23 in each of the tanks 15 and 16 is a valve 24 carrying a deflector similar to the deflector 19. The deflector valves 24 are adjustable with respect to the outlets of the tubes 23 and are carried by stems 25 supported at their upper ends by beams 26. As shown in Figs. 2 and 3 a plurality of transfer tubes 23 is preferably provided for discharging material from each tank to the next succeeding, and the deflector valves 24 in each tank are supported from a single beam 26. Each of the beams 26 is provided at each end with a threaded stem 27 coöperating with a hand wheel 28 supported by a bracket 29 suitably secured in stationary position, as to the launder 46. By operating the hand wheels 28 of any pair the deflector valves 24 of any tank may be simultaneously adjusted, thereby providing for an even flow through all of the transfer tubes 25 discharging into said tank.

Secured to the bottom of the tank 14 adjacent the inlets of the corresponding transfer tubes 23 are classifying cones 30, said classifying cones being preferably in the form of separate castings bolted in position to the bottom of said tank adjacent suitably formed openings in said bottom. Each of the classifying cones 30 is formed at its top with a depression 31 into close proximity to which extends the inlet end of the corresponding transfer tube 23, said end being preferably of the flaring or conical form shown and of a diameter at its bottom slightly less than the diameter of the depression 31. The bottom of the depression 31 is provided with an opening in which is located a coarse screen or perforated plate 32, said opening leading to a chamber 33 which communicates through a bushing 34 with a second chamber 35 provided with an outlet 36. Communicating with the chamber 35, preferably at a point above the bottom of the bushing 34, is an inlet pipe 37 for hydraulic water, said pipe being controlled by a suitable valve 38.

In the operation of the apparatus, considered with respect to each classifying cone and the corresponding transfer tube, the water in the tank 14, together with the material not carried away by the bubbles, reaches the bottom of said tank and is discharged through the transfer tube 23 to the next adjacent tank or compartment 15, as indicated by the full line arrows on Fig. 1. Hydraulic water entering the chamber 35 through the pipe 37, under a predetermined pressure regulated by the valve 38, passes

upwardly through the bushing 34, chamber 33 and perforated plate 32 (said plate diffusing the upward current), a part of said water, of course, passing downwardly and being discharged through the outlet 36. The adjustment of the valve 38 is such that, in addition to the hydraulic water discharged through the outlet 36, a sufficient quantity of said water passes upwardly through the bushing 34 with the proper velocity to prevent slime or fine sand from descending in opposition thereto, but to allow the oversize to pass downwardly, as indicated by the downwardly directed arrows on Fig. 1 said oversize being discharged at the outlet 36. This operation is greatly facilitated by the construction and arrangement of the transfer tubes 23 with reference to the classifying cones. The material in the tank 14 gravitates to the points indicated by A in Fig. 1 where the swift current due to the constricted opening carries the same horizontally toward the center of the funnel-shaped inlet of the transfer tube and upwardly into said tube upon reaching the enlarged chamber in the bell mouth of the transfer tube. The oversize tends to separate out and fall into the chamber 33. This tendency is opposed by a gentle upward current composed in part by the hydraulic water flowing upwardly through the bushing 34 and perforated plate 32, and in part by the lessened speed of upward flow into the transfer tube, caused by its bell shaped construction, so that said material, minus its oversize particles, after more or less circulation, passes upwardly into the mouth of the transfer tube 23. By this arrangement of parts, enabling the transfer tubes 23 to assist the hydraulic water in carrying away the finer material, very much less hydraulic water is necessary than would otherwise be required, this being a very desirable feature inasmuch as the hydraulic water tends to dilute the pulp and to interfere with the frothing operation in the next tank. It will of course be understood that the size of material discharged through the outlet 36 will be dependent upon the pressure at which the hydraulic water is admitted through the pipe 37, and this may be regulated at will, and in accordance with requirements, by means of the valve 38.

Ordinarily one set of classifying cones will serve to remove all of the oversize discharged into the tank 14, practically none passing through the transfer tubes 23 into the next tank. For this reason, as herein shown, the first tank 14 only is provided with classifying cones, the other tanks 15, 16 etc. being provided at the corresponding points with normally closed cup-shaped castings 43 into which the inlet ends of the corresponding transfer tubes 23′ depend. If desirable, however, any or all of the tanks 15, 16, etc., may be provided with classifying cones 30 in place of the castings 43. In the latter case, by varying the pressure of the hydraulic water admitted to the classifying cones of succeeding tanks, material of different and successively graded sizes may be removed from the successive tanks.

The tailing leaving the last tank 16 through the last transfer tube 23 is discharged to any suitable point through a pipe 44 controlled by a suitable valve 45.

The complete operation of the apparatus is as follows. In starting the operation clear water is first introduced into the apparatus through the feed pipes 18. As soon as the water in the first tank or compartment 14 reaches the level indicated by the dotted line L, the second tank or compartment 15 will commence to fill through the first set of transfer tubes 23, and when this compartment is filled to the level of the outlets to the transfer tubes leading therefrom, the third compartment will fill, and so on until the level of the mouth of the final outlet from the last compartment is reached in that compartment. Compressed air is then admitted through all of the grates 22. The consequent aeration of the water in all of the compartments causes the level thereof to be raised, and by adjustment of the deflector valves 24 through the wheels 28, as well as by adjustment of the valves 45 of the final outlets, the surface of the liquid is caused to rise above the deflector valves 24 to or adjacent the tops of the tanks as may be desired. After a proper balance has been established the mill is started and substantially the same volume of pulp to be treated is substituted for the clear water. On account of the presence of the solids transported by the water, and because of the colloidal and other matter in the pulp which will produce froth, additional adjustments, such as the opening or closing of the deflector valves 24 and discharge valves 45, the admission of a greater or less amount of air through the tubes 22, etc. are usually necessary in order to establish a new condition of equilibrium, after which no other adjustments are necessary under normal and even conditions for use. The finest particles of metallic sulfids in the pulp are discharged with the froth from the top of the tanks into the launder 46, the coarser particles both silicious and metallic find their way to the bottoms of the tanks, are transferred through the tubes 23 from one tank to the next for successive treatment, and are finally discharged through the pipes 44, while the oversize is discharged through the classifying cones 30.

The tubular gratings and associated parts herein shown and described for the purpose of admitting air to the several tanks or compartments are not claimed herein, being

covered by the claims of a prior application filed by me August 3, 1915, Serial No. 43,442, of which this case is a division.

Having thus fully described my invention what I claim as new and desire to secure by Letters Patent is:—

1. In a hydraulic classifier, a tank, a plurality of inlets for said tank, deflector valves for controlling said inlets and distributing the incoming material, and means for simultaneously adjusting all of said deflector valves.

2. A hydraulic classifier comprising a plurality of tanks or compartments, a plurality of transfer tubes leading from the bottom of a tank or compartment to the upper part of the next adjacent tank or compartment, deflector valves for controlling the discharge from said tubes and distributing the incoming material, and means for simultaneously adjusting all of the deflector valves in each tank.

3. In a hydraulic classifier, a tank, a plurality of inlets for said tank, deflector valves for controlling said inlets and distributing the incoming material, said valves being provided with stems, a beam by which all of said stems are supported, and means for adjusting said beam.

4. In a hydraulic classifier, a tank, a plurality of inlets for said tank, deflector valves for controlling said inlets and distributing the incoming material, said valves being provided with stems, a beam by which all of said valve stems are supported, threaded stems at the ends of said beam, stationary brackets through which said threaded stems pass, and hand wheels on said threaded stems and engaging said brackets for adjusting said beam.

5. In a hydraulic classifier, in combination, a tank having an opening in its bottom, a classifying cone comprising a casting secured to the bottom of said tank adjacent said opening, said classifying cone having upper and lower chambers and a bushing connecting said chambers, and said lower chamber having an outlet in its bottom and a water inlet located above the bottom of said bushing, and a discharge tube for said tank having its inlet arranged immediately over said classifying cone.

6. In a hydraulic classifier, in combination, a tank, a classifying cone communicating with said tank and having a water inlet and an outlet, a perforated plate at the top of said classifying cone, and a discharge tube for said tank having its inlet arranged adjacent said perforated plate.

7. In a hydraulic classifier, in combination, a tank having an opening in its bottom, a classifying cone comprising a casting secured to the bottom of said tank adjacent said opening, said classifying cone having a depression in its top, upper and lower chambers, a perforated plate between said depression and upper chamber and a bushing connecting said upper and lower chambers, said lower chamber having an outlet in its bottom and a water inlet located above the bottom of said bushing, and a discharge tube for said tank having a downwardly flaring lower end arranged adjacent said depression.

In testimony whereof I affix my signature.

DAVID COLE.