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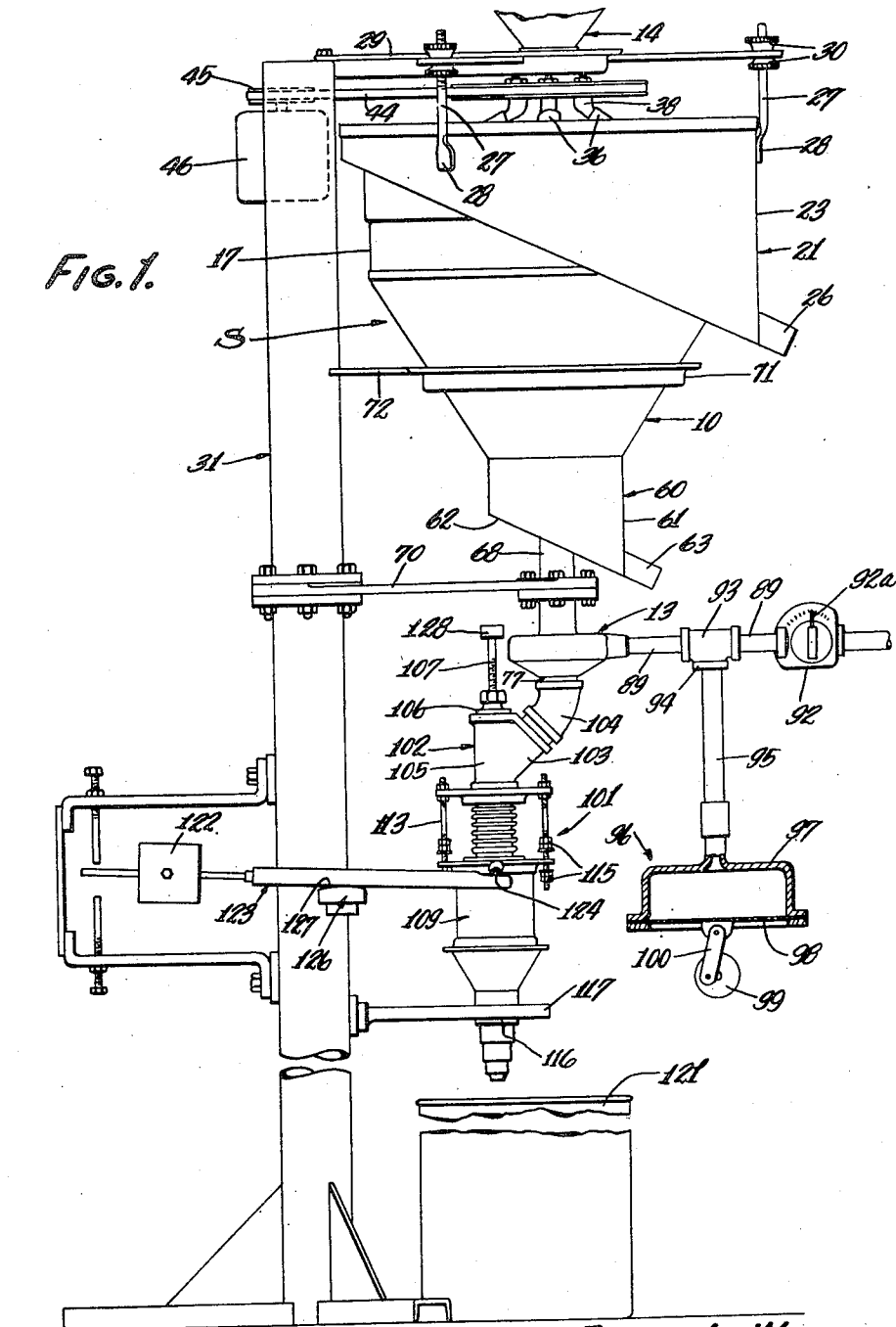
E. L. WIEGAND

2,442,522

HYDRAULIC CLASSIFIER EMPLOYING VERTICAL AND VORTICAL CURRENTS

Filed Dec. 16, 1944

4 Sheets-Sheet 1



EDWIN L. WIEGAND

INVENTOR

BY Freeman, Albrecht, and Williams
ATTORNEYS

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E. L. WIEGAND

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EDWIN L. WIEGAND
INVENTOR
BY *Freeman, Albrecht, and Williams*
ATTORNEYS

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E. L. WIEGAND

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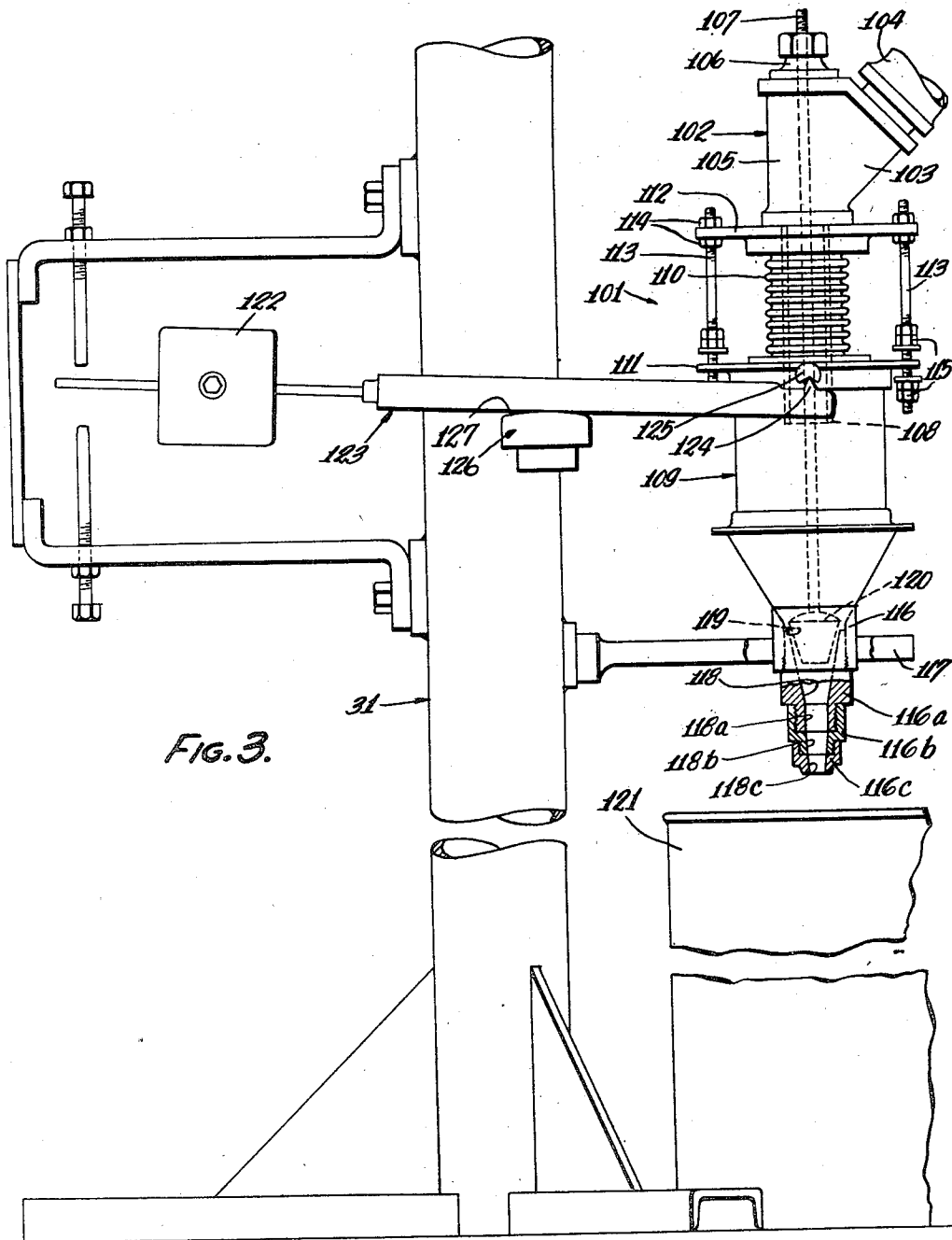


FIG. 3.

EDWIN L. WIEGAND
INVENTOR

BY *Freeman, Albrecht and Williams*
ATTORNEYS

June 1, 1948.

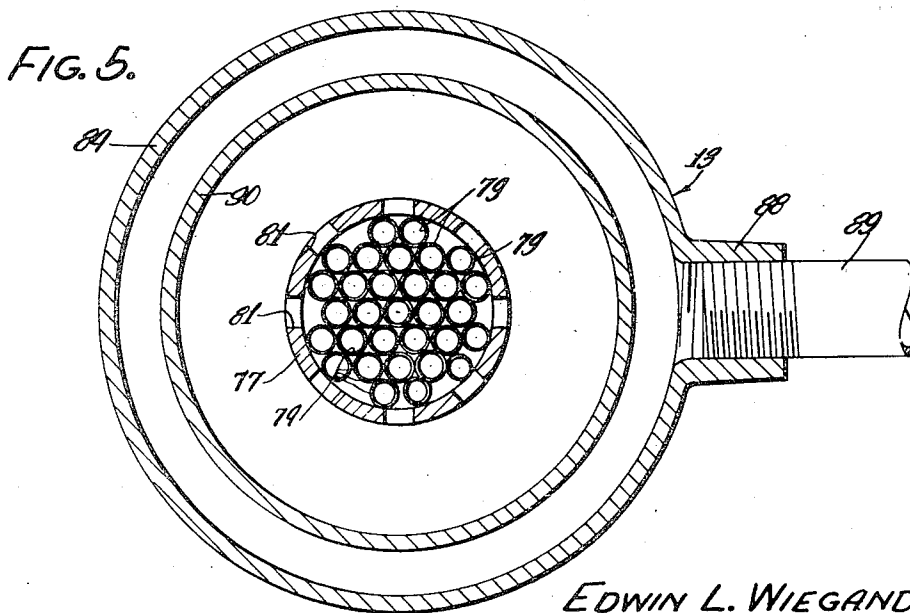
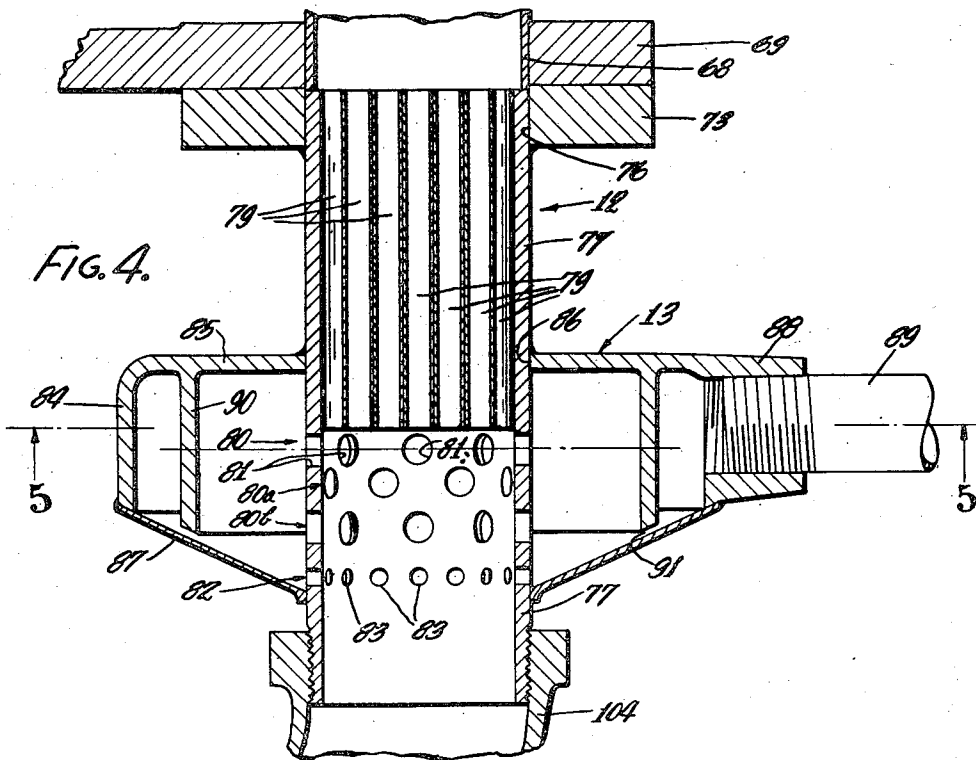
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INVENTOR

BY *Freeman, Albrocht, and Williams*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,442,522

HYDRAULIC CLASSIFIER EMPLOYING VERTICAL AND VORTICAL CURRENTS

Edwin L. Wiegand, Rye, N. Y., assignor to Ore-fraction Incorporated, Pittsburgh, Pa., a corporation of Pennsylvania

Application December 16, 1944, Serial No. 568,459

7 Claims. (Cl. 209—159)

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My invention relates to the classification of material particles by hydraulic means, and the principal object of my invention is to provide new and improved classification, particularly of a precision character, and new and improved apparatus for carrying out such classifications.

In the drawings accompanying this specification, and forming a part of this application, I have shown, for purposes of illustration, an embodiment of apparatus which my invention may assume, and in these drawings:

Figure 1 is a side elevation of this illustrative form of apparatus,

Figure 2 is a fragmentary, enlarged view, of an upper portion of the apparatus shown in Figure 1, a portion being in longitudinal cross-section,

Figure 3 is a fragmentary, enlarged view, of a lower portion of the apparatus shown in Figure 1,

Figure 4 is a longitudinal cross-section, on an enlarged scale, of a sorting column forming part of the apparatus shown in Figure 1, and

Figure 5 is a cross-section taken on the line 5—5 of Figure 4, looking in the direction of the arrows.

Referring more particularly to Figures 1 and 2, the apparatus comprises settling chamber means S which includes a downwardly tapering conical chamber 10 having an opening 11 connected to a sorting column 12 which may be fed with water, or other suitable liquid, by means of a water jacket 13.

The particles to be separated or classified are fed, in a desirably wetted condition, usually in the form of a slurry, to the settling chamber means S through a funnel 14, here shown as communicating with a plurality of pipes 15 the lower open ends 16 of which terminate well below the upper end of the chamber means.

By reason of the water fed to the jacket 13, the particles fed to the chamber means S are subjected to hydraulic counter-current settling. The particles which succeed in descending through the hydraulic counter-current and are discharged from the lower end of the apparatus, I term underage, and the particles which are carried upwardly by the counter-current and are discharged from the upper end of the apparatus, I term overage. As will appear more fully hereinafter, the apparatus is so constructed and arranged that, if desired, two separate and distinct overage products may be obtained simultaneously, or one or the other of different overage products.

At the upper margin of the conical chamber 10 is here shown a cylindrical portion 17, soldered or otherwise suitably fastened, water-tight to the

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conical chamber 10. Slidable up and down on the cylindrical portion 17 is a cylindrical ring 18, preferably provided on its inner periphery with a packing member 19 so that the ring 18 will form a water-tight joint with the cylindrical portion 17 in any adjusted position of the ring.

Dependent upon the position of the ring 18, overage is adapted to be discharged over the upper margin 20 of the ring into a launder 21. The launder 21 comprises an inner wall 22 which fits the outer surface of the ring 18 and is soldered or otherwise suitably fastened, water-tight, to said outer surface. The launder 21 further comprises an outer wall 23, of larger diameter and spaced concentrically from the inner wall 22, the upper margin 24 of the outer wall 23 being disposed above the upper margin 20 of the ring 18. The lower margins of the outer wall 23 and inner wall 22 are suitably joined, water-tight, to a bottom wall 25 which defines an inclined plane. The launder 21 has a discharge spout 26 at its lowest level, through which overage which has flowed into the launder may be discharged.

Means is provided for raising and lowering the ring 18, and, of course, with it the launder 21, this means being here shown as three threaded rods 27, 120° apart. Each rod 27 has a flattened part 28 here shown as soldered or otherwise suitably fastened to the outer wall 23 of the launder 21. The threaded rods 27 pass freely through apertures in support means 29; and knurled nuts 30, cooperating with the threaded rods, are provided respectively to move and hold the rods in adjusted position. The support means 29 is here shown as extending laterally from a standard 31 to which it is suitably fastened.

My invention contemplates whirling of the liquid in the conical chamber 10 and its upward extension comprising the cylindrical portion 17 and the ring 18, to produce a vortex therein. This may be accomplished in various ways one of which is shown in the drawings. In the construction illustrated rotatable vanes 32 are provided. Any suitable number of vanes 32 may be used, four being used in the present instance. Each vane 32 is pivotally mounted on a pivot 33 adjustably carried by a stem 34, as will more fully appear, a nut 35 being provided, for cooperation with threads on the outer end of the pivot 33, to fasten the respective vane 32 in adjusted rotative position about the pivot 33. Each stem 34 is adjustably carried by a sleeve 36, as will more fully appear, the sleeve 36 being adjustable slidably on a rod 37. Each rod 37 is here shown as extending downwardly at a slight angle, so that adjust-

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ment of a sleeve 36 on the respective rod will adjust the respective vane 32 in a direction generally transverse to the wall of the conical chamber 10. Thus a vane 32 may be positioned as shown in full lines or in the dotted lines 32a, or in any intermediate position, and also in the position shown in dotted lines 32b.

Each primary rod 37 has a vertically upwardly extending portion 38 having a reduced stud 39 extending through a hole in a rotatable wheel 40. The studs 39 are threaded at their ends and cooperate with nuts 41 which serve to hold the primary rods 37 fastened to the wheel 40, and also to hold a sheave 42 to the wheel, the sheave 42 having apertures through which the studs 39 pass. The sheave 42 has a groove 43 adapted to receive a belt 44 which also passes around a sheave 45 carried by the shaft of an electric motor 46 suitably carried by the standard 31. Speed control means (not shown), of any suitable type, is preferably provided for the motor 46.

The wheel 40 has a journaled hub 47, fitting rotatably about a stationary bearing stud 48. The bearing stud 48 has a reduced lower end 49 about which fits a thrust bearing ring 50 engaged by the lower end of the hub 47 and held in place by a set screw 51 bearing against the reduced end 49.

The upper end of the bearing stud 48 is enlarged and is suitably carried by the support means 29. The enlarged end of the bearing stud 48 has formed therein the funnel 14, and, extending downwardly from the funnel, a recess 52 with which communicate three downwardly extending passages 53. In the lower end of each passage 53 is fitted and suitably fastened a pipe nipple 54 adapted to be inserted freely into the respective upper end of one of the tubes 15, whereby the assembly comprising the bearing stud 48 and associated parts may be readily disassembled from the remainder of the apparatus, leaving the tubes 15 undisturbed.

The upper ends of the tubes 15 are desirably held in circumferential spaced position by having them disposed through and suitably fastened in holes in a ring member 55.

The lower ends 16 of the tubes 15 terminate at circumferentially spaced apertures in an auxiliary conical wall 56, the ends 16 of the tubes 15 being soldered water-tight to the margins of the apertures, so that material flowing in the tubes 15 will be discharged into the space between the auxiliary conical wall 56 and the wall of the conical chamber 10.

Desirably the taper of the conical wall 56 is approximately the same as that of the chamber 10, so that the normal distance between the wall 56 and the inside surface of the chamber 10 is approximately the same at any level.

The lower end of the auxiliary conical wall 56 is here shown as closed, water-tight, by a disc 57, and as provided with a suitable number of discharge spouts 58, in this instance four. Each spout 58 passes through an aperture 59 in the wall of the conical chamber 10 into the space provided by a second launder 60. Each discharge spout 58 is soldered or otherwise fastened, water-tight, to the margin of the respective aperture 59 in which it is disposed. The second launder 60 is here shown as having a wall 61 soldered, at its upper margin, to the outside of the conical chamber 10 and having an inclined bottom 62 leading to a discharge spout 63.

The auxiliary conical wall 56 is here shown as

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having an upward cylindrical extension 64. Tele-scopically cooperable with the extension 64 is a cylindrical wall part 65 unitary with an upwardly and inwardly tapering wall part 66. The conical wall part 66 terminates in a circular aperture the margin 67 of which is here shown as below the upper margin of the cylindrical portion 17 of the settling chamber. It will be evident that the construction just described provides central discharge wall means for receiving overage, as will more fully appear.

The cylindrical wall part 65 while slidable up and down in the cylindrical extension 64 is frictionally held in the desired adjusted position. It will, of course, be evident that the amount of possible up and down adjustment of the cylindrical wall part 65 in the cylindrical extension 64, and hence the adjustment of the margin 67, will depend upon the length of the cylindrical parts 64, 65 and this length can be made any desired, suitable amount.

The opening 11 in the lower end of the conical chamber 10 has its margin connected, water-tight, to a relatively short length of pipe 68. As can be seen in Figure 4, the lower end of the pipe 68 fits in, and is connected, water-tight, in an aperture in a flange 69, the flange 69 having a lateral extension 70 suitably supported by the standard 31. Thus the flange 69 supports the settling chamber means S, and to further support and steady it, a ring 71 having a lateral extension 72 suitably supported by the standard 31, is provided.

The flange 69 supports and is connected, water-tight, to a second flange 73, by bolts and nuts 74 (Figure 2). Within the pipe 77 are disposed a plurality of tubes 79, desirably thin-walled. The tubes 79 are of sufficient number so as to fit snugly in contact with each other in the pipe 77 when pushed therinto. This produces longitudinally extending passages within the pipe 77, of honey-comb effect. When the tubes 79 have been pushed into the pipe 77, they are sweated or tinned together in place, leaving free passages through the tubes and any interstitial spaces.

The tubes 79 extend vertically downward in the pipe 77 from about the level of the upper side of the flange 73 to a level just above a row 80 of circumferentially spaced holes 81 extending transversely through the pipe 77. Below the row 80 of holes are additional rows of holes at successively lower levels, in this instance two rows 80a, 80b the holes in which are of the same size as in row 80, the holes in the successive rows being desirably staggered, circumferentially. In addition, there is a lowermost row 82 of circumferential spaced holes 83, there being a greater number of holes in the row 82 than in the other rows, and the holes 83 being smaller than the holes 81 in the other rows. The provision of a lowermost row of holes such as the row 82, prevents clogging or bridging of the underage that might occur across the lower part of the pipe 77.

The water jacket 13 is here shown as comprising a cylindrical outer wall 84 integral with an annular upper end wall 85, the end wall 85 having an aperture 86 fitting around the pipe 77 and soldered or otherwise suitably fastened, water-tight, to the pipe 77. The end wall 85 is here shown as disposed at a level substantially above the lower ends of the tubes 79, the cylindrical wall 84 extending downwardly to a level substantially above the row 82 of holes 83, and the water jacket being closed at its bottom by a conical wall

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87 soldered or otherwise suitably fastened, water-tight, to the lower end of the cylindrical wall 84, and to the pipe 77 at a level below the row 82 of holes 83.

The outer wall 84 has an internally threaded nipple 88 through which water may be admitted to the water jacket 13, from a threaded pipe 89 cooperating with the nipple.

In order to provide a desirably uniform feed of water to the rows 80, 80a, 80b, 82 of holes, the upper, end wall 85 has an auxiliary cylindrical baffle wall 90 depending therefrom, the auxiliary wall 90 being of smaller diameter than the outer wall 84 and extending downwardly to a level leaving a desired short gap 91 (here shown of uniform width) between the lower end of the auxiliary wall 90 and the conical bottom wall 87, whereby water must flow through this gap to reach the hereinbeforementioned rows of holes.

Referring to Figure 1, water is fed to the pipe 89 through a valve 92 which is desirably graduated, so that the amount of flow of water into the water jacket 13 may be adjusted to an amount indicated by a pointer 92a.

Here shown as interposed in the pipe 89 is a T connection 93, the stem 94 of which has connected thereto a pipe 95 in turn connected to a pulsating means 96, diagrammatically shown. The pulsating means comprises a casing 97 closed by a diaphragm 98. The diaphragm 98 is adapted to be vibrated by any suitable means, here diagrammatically shown as a crank disc 99 connected to the diaphragm by a connecting rod 100. The pulsating means may be used, if desired, to produce pulsations in the upwardly flowing hydraulic counter-current in the sorting column 12 and the settling chamber means S. This promotes teetering, and separation of the particles.

The discharge of underage is controlled by a control means 101 connected at the top to a Y pipe-fitting 102 having a branch 103 connected to an elbow 104 in turn connected to the lower end of the pipe 77. The upper end of the trunk 105 of the fitting 102 is closed by a member 106 through which a threaded rod 107 is disposed, water-tight but rotatable, for a purpose which will appear.

Underage is adapted to flow from the pipe 77, through an elbow 104 and Y fitting 102 into a pipe 108 (see Figure 3), and thence into a movable tank or sump 109. The sump 109 is connected to a bellows 110, desirably metallic, the bellows being fastened at its lower end air and water-tight to a cover 111, for the sump 109 and similarly fastened at its upper end to a flange 112 suitably fastened to the lower end of the trunk 105 of the Y fitting 102. The pipe 108 extends freely through the bellows 110 leaving an air space therebetween. Guide rods 113, held by nuts 114 to the flange 112, are provided for guiding the cover 111, and these rods have spaced adjustable nuts 115 at their lower ends for limiting up and down movement of the cover 111, and hence of the sump 109, to a desired amount.

The lower end of the sump is provided with a member 116, which may be guided by suitable guide means 117. The member 116 has screwed thereto or otherwise disposed therein a member 116a and which has an upwardly flaring conical bore 118, providing at its upper end a valve seat 119 for a conical valve body 120 fastened to the rod 107. The valve body 120 is relatively stationary but its position may be adjusted by turning a knurled head 128 on the rod 107. The member 116a is here shown as having a cylindrical bore

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118a extending downwardly from the conical bore 118 and from the lower end of the cylindrical bore 118a underage is dischargeable either directly into a suitable receptacle 121 or into the bore of a spud or nozzle 116b which may be screwed onto the lower end of the member 116a. The spud 116b has a downwardly tapering conical bore 118b. Another spud 116c is here shown as screwed onto the lower end of the spud 116b, the spud 116c having a downwardly tapering conical bore 118c forming a continuation of the bore 118b. By the provision of a plurality of spuds, the size of the ultimate discharge opening for underage may be changed to one not much larger than the maximum flow of underage encountered.

It will be evident that if the sump 109 moves downwardly, the valve opening, between the valve seat 119 and the valve body 120, will be increased, and if it moves upwardly, the valve opening will be reduced. The tendency of the sump 109 to move downwardly is balanced by an adjustable weight 122 on one end of a beam 123 the other end of the beam bearing a knife edge 124 cooperating with a knife edge bearing 125 carried by the cover plate 111. The beam 123 has a fulcrum 126 (suitably supported by the standard 31) having a suitably rounded surface 127, so that if the weight of undischarged underage in the sump 109 increases and the sump moves downwardly, the moment arm from the weight 122 to the point of engagement of the beam 123 with the fulcrum surface 127 will be increased, and if the weight of undischarged underage is decreased and the sump moves upwardly, said moment arm will be decreased. This prevents hunting, and insures that a satisfactory body of undischarged underage will be in the sump 109. The control means 101 and various other combinations and applications thereof are described and claimed in my copending application Serial Number 391,531, now Patent No. 2,369,878, granted February 20, 1945. It will be evident that the control means 101 provides for continuous discharge of underage from the opening 118, at a rate controlled by the weight of undischarged underage in the sump 109, the latter depending on the rate of production of underage. It also will be evident that the control means 101 serves to maintain steady hydrodynamic conditions in the sorting column 12 and the settling chamber means S. This is important both in connection with the upward current in the sorting column and the upwardly progressing vortex current in the settling chamber means S.

The pipe 108 (Figure 3) is here shown as extending downwardly to a level well below the cover 111, so that when the liquid level or underage level rises to the lower end of the pipe 108, air will be trapped in the sump between this level and the level of the cover and, of course, also in the space between the pipe 108 and the inside of the bellows 110.

Referring now to the illustrated means for supporting and adjusting the vanes 32, the pivot 33 is in the form of a laterally projecting stud on a block 135 disposed at the side of the vane 32 opposite from the nut 35. The block has a hole 136 in which the stem 34 fits slidably. To hold the block 135 in any desired adjusted position on the stem 34 a set screw 137, extending into the block 135, is provided. At its other end the stem 34 fits slidably in a hole 138 in a boss 139 projecting laterally from the sleeve 36. A set screw 140, extending into the boss 139, is pro-

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vided for holding the stem in any desired adjusted position in the hole in the boss. The sleeve 36 may be held in any desired adjusted position on the rod 37 by one or more set screws 141. While the same stem 34 may be used for any of the positions of the vane 32, a shorter stem may be used when the vane is adjusted to a position such as 32b, in the event that it is preferred that the lower end of the stem shall not extend into the liquid below the lower margin of the vane.

Thus the vanes 32 may be set so as to be near the surface of the liquid, generally horizontal or corresponding to the general angle of the surface of the liquid, or they may be set so as to be at any desired depth and position below the surface of the liquid, depending on the type of material being treated.

The operation of the apparatus is as follows. It may be assumed that water is being fed to the water jacket 13 through the graduated valve 92 at a selected rate and that particles to be classified are being fed into the funnel 14, and that the vanes 32 are set in a desired position and are being rotated at a selected speed. It is of course apparent that the speed of the vanes and the rate of water feed may be separately adjusted to give the best combination for classifying a given feed of particles. When the body of liquid is caused to rotate by the vanes 32, the outer peripheral portion will rise in level and the inner peripheral portion will sink in level, so that the surface of the liquid is of downwardly dished form. It may be further assumed that the speed of rotation, and the position of the margin 20 of the ring 18 have been so selected that overage will flow over the margin 20 only, and no overage will flow over the margin 67, the latter being, under assumed conditions, higher than the level of the inner periphery of the surface of the liquid.

Some of the particles discharged from the openings 16 will descend in the conical chamber 10 and reach the sorting column 12, and these particles will be here subjected to hindered settling, especially in and just above the tubes 79, where the so-called teeter zone exists. Particles having a higher settling rate (the underage) fall through the teeter zone into the elbow 104 and thence into the sump 109 from which they are discharged in the manner hereinbefore described. The particles of lower settling rate (the overage) are carried upwardly by the hydraulic counter-current and discharged, under the assumed conditions, over the margin 20 of the ring 18 into the launder 24 and thence from the spout 26. It will be understood by those skilled in the art that the settling rate of particles is a function of several factors, including specific gravity and also size and shape and surface condition.

By rotation of the vanes 32 the resultant vortex provides a preliminary separation of the heavier from the lighter material inasmuch as the heavier material will tend to work relatively outwardly in the vortex and thence downwardly to the sorting column 12. On the other hand, the lighter material will tend to work relatively inwardly in the vortex and progress upwardly with the rotating body of liquid until it is discharged over the margin 20. This increases the accuracy of the separation in the sorting column. It will, furthermore, be noted that the stream lines of water flow in the sorting column 12 must be vertically upward, for the most accurate results, and that the provision of the tubes 79 insures such

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vertical upward flow. This construction is of value even if the apparatus is used without a vortex rotation in the chamber 10, but is of special value in combination with such vortex rotation because this rotation cannot produce rotation of the liquid and material in the sorting column 12.

Another mode of operation of the apparatus, which is especially advantageous, is to adjust the position of the ring 18 and the position of the central discharge wall means 66 so that with a given speed of rotation of the vanes 32, and a given rate of water feed to the jacket 13, no overage will be discharged over the margin 20, all the overage being discharged substantially radially inwardly over the margin 67 of the central discharge wall means. As hereinbefore pointed out the heavier material works relatively outwardly and downwardly in the vortex, and hence the lighter material, which works relatively toward the center of the vortex, is directly discharged over the margin 67 of the central discharge wall means and from there into the inside of the auxiliary conical wall 56 thence through the tubes 58 into the launder 60 and out of the spout 63.

Still another especially advantageous mode of operation of the apparatus is to so adjust the position of the ring 18, and the position of the central discharge wall means 66 that, with a given speed of rotation of the vanes 32, and a given rate of water feed to the jacket 13, overage will be discharged outwardly over the margin 20 of the ring 18 into the launder 24, and other overage will be discharged inwardly over the margin 67 of the central discharge wall means. Thus the apparatus will produce three different products: underage, and two kinds of overage. Speaking in relative terms, the underage will contain the larger, heavy particles, the overage discharged over the margin 20 of the ring 18 will contain the larger, lighter particles, and intermediate heavier particles, and the overage discharged over the margin 67 of the central discharge wall means will contain the intermediate light and only the very smallest heavy particles.

The present apparatus enables the hydraulic classification of particles of fine mesh size, for example, 200 or 300 mesh to 400 mesh or finer, though it is not restricted to that purpose. The more complex minerals, for example, require finer grinding to release the values, but when ground to a sufficient fineness for that purpose, prior means of classifying the resultant particles are too inefficient. The present apparatus is not only of great efficacy in classifying finely ground materials, but, in general, it gives very accurate classification, upon a gravity basis with only a reasonably close pre-sizing. It is also capable of quite accurately classifying and sub-classifying by size, relatively fine particles of material of the same specific gravity.

From the foregoing it will be apparent to those skilled in the art that the illustrated embodiment of the invention provides new and improved apparatus for classifying material particles and accordingly, accomplishes the principal object of the invention. On the other hand, it also will be obvious to those skilled in the art that the illustrated embodiment of the invention may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those illustrated, without departing from the spirit of the invention, or sacrificing all of the advantages thereof, and that accordingly,

the disclosure herein is illustrative only, and the invention is not limited thereto.

I claim:

1. Apparatus for classifying material particles, comprising: hydraulic settling chamber means having outlet means for discharging underage and outlet means for discharging overage; means, including a vane, constructed and arranged to cause rotation of liquid in said chamber means; and means supporting said vane so constructed and arranged that said vane is bodily approximately vertically adjustable to selected positions, said supporting means comprising an approximately vertical rod, a block slidably adjustable on said rod, and means for fastening said vane to said block.

2. Apparatus for classifying material particles, comprising: hydraulic settling chamber means having outlet means for discharging underage and outlet means for discharging overage; means, including a vane, constructed and arranged to cause rotation of liquid in said chamber means; and means supporting said vane so constructed and arranged that said vane is bodily approximately horizontally adjustable to selected positions, said supporting means comprising an approximately horizontal first rod, a block slidably adjustable on said first rod, a second rod, means so constructed and arranged that said second rod is supported at an angle to said first rod, and means for holding said vane on said second rod.

3. Apparatus for classifying material particles, comprising: hydraulic settling chamber means having outlet means for discharging underage and outlet means for discharging overage; means, including a vane, constructed and arranged to cause rotation of liquid in said chamber means; and means supporting said vane so constructed and arranged that said vane is bodily approximately horizontally adjustable to selected positions, and vertically adjustable to selected positions, and rotatably adjustable to selected positions in a plane at an angle to the path of rotation of said vane, said supporting means comprising an approximately horizontal first rod, a first block slidably adjustable on said first rod, a second rod, means so constructed and arranged that said second rod is supported by said first block at an angle thereto and slidably adjustable with respect thereto, a second block slidably adjustable on said second rod, a pivot for said vane projecting laterally from said second block, and means for holding said vane to said second block in a selected rotative position about said pivot.

4. Apparatus for classifying material particles, comprising: hydraulic settling chamber means of circular section having outlet means for discharge of underage, and having an uppermost, circular peripheral margin; means for feeding liquid to said chamber means, so constructed and arranged that particles fed to said chamber means are subjected to hydraulic counter-current settling; overage receiving means, having a circular entrance opening co-axial with and disposed within said chamber means, so constructed and arranged that overage may flow inwardly over the margin of said opening; means, including an elongated vane, constructed and arranged to cause rotation of the liquid in the upper portion of said chamber means, about the vertical axis of said chamber means; and means, adjustably supporting said vane, so constructed and arranged that said vane may be positioned approximately horizontally at the general level of said margins and may be positioned approximately vertically at a lower level,

between said overage receiving means and said chamber means.

5. Apparatus for multiple classification of material particles, comprising hydraulic chamber means formed to receive classifying liquid and particles to be classified, including means to effect hydraulic counter-current settling in a lower portion thereof, and provided with an underage exit for the settling particles and with an inner overage exit and an outer overage exit, said outer overage exit being disposed substantially higher than said inner overage exit, and means constructed and arranged to swirl the overage from said counter-current separation in an upper portion of said chamber means to cause particles of said overage more susceptible to centrifugal action to move to and discharge at said higher overage exit, while particles less susceptible to said action move to and discharge at said lower inner overage exit.

6. Apparatus for multiple classification of material particles, comprising hydraulic chamber means formed to receive classifying liquid and particles to be classified, including means to effect hydraulic counter-current settling in a lower portion thereof, and provided with an underage exit for the settling particles and with an inner overage exit and an outer overage exit, said outer overage exit being disposed substantially higher than said inner overage exit, and at least one of said overage exits being adjustable to vary the difference in height between said overage exits, and means constructed and arranged to swirl the overage from said counter-current separation in an upper portion of said chamber means to cause particles of said overage more susceptible to centrifugal action to move to and discharge at said higher overage exit, while particles less susceptible to said action move to and discharge at said lower inner overage exit.

7. The process of effecting multiple classification of material particles which comprises subjecting the mineral particles to a hydraulic counter-current separation, removing settled particles, effecting upward movement of the liquid and particles rising from the counter-current separation, swirling said liquid and particles at a speed to cause a segregation of said particles on the basis of centrifugal action, and removing particles less susceptible to such action at a relatively inward location and particles more susceptible to such action at a substantially higher relatively outward location.

EDWIN L. WIEGAND.

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