Jan. 10, 1961 R. D. EVANS ET AL 2,967,617

HYDRAULIC CLASSIFIER

Filed March 14, 1958

FIG. 1

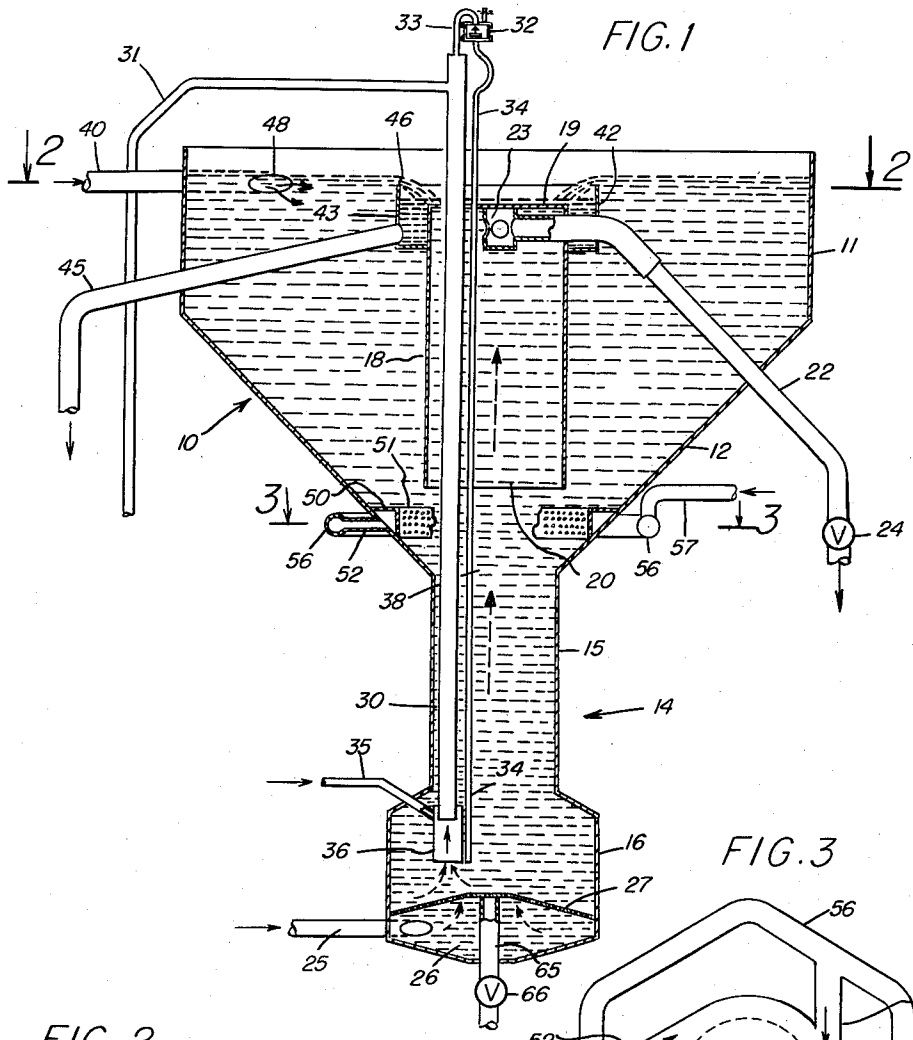


FIG. 2

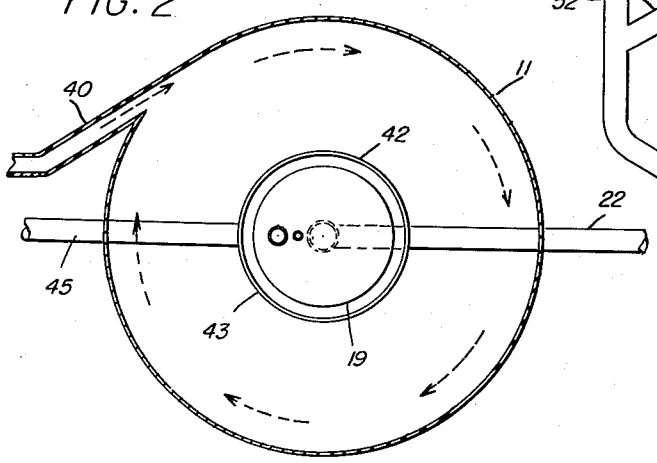
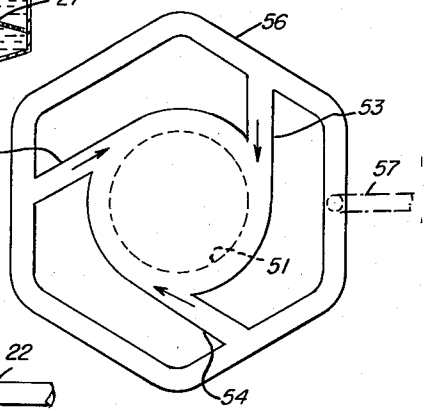


FIG. 3



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HYDRAULIC CLASSIFIER

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This invention relates to hydraulic classifying or sizing apparatus, i.e. for classifying solid particles, which may be supplied in an aqueous pulp to separate them according to settling rate, such apparatus conventionally involving means for effectuating settling of particles in the supplied solids, with the addition of supplemental liquid, usually called hydraulic water, flowing in a direction opposite to the direction of settling.

In a more particular sense, the invention is concerned with improvement in hydraulic classifying apparatus of the character disclosed in United States Patent No. 2,708,517, granted May 17, 1955, on application of Robert D. Evans, a further embodiment of such classifiers being disclosed in United States Patent No. 2,784,841, granted March 12, 1957, on application of Robert D. Evans.

As explained in more detail hereinbelow, the classifiers of the Evans patents, especially as in the basic form of the first-cited patent, involve a pair of vertically spaced column means, viz. a column defining structure providing a lower, hindered-settling column and an upper, free-settling column, the two columns opening toward each other at a central region of the apparatus, with means at the foot of the hindered-settling column for removing the accumulating faster-settling particles in water and means at the closed head of the upper column for withdrawing liquid which carries the slower-settling particles. The upper column and the region around the space between the columns are surrounded by a relatively large, upright cylindrical tank structure, which is filled with liquid and into which the feed pulp to be classified is supplied. The solids of the feed travel downwardly in the tank to the space between the columns, where they have access to the latter and come into the influence of the liquid rising through the columns, i.e. from appropriate means at the foot of the hindered-settling column for introducing such liquid, e.g. hydraulic water, through a suitable constriction plate or the like.

Although the described apparatus and the improvements of the present invention are applicable to hydraulic classification of a wide variety of particulate solids, such as various minerals, sands, and the like, an important example of their use is in the classification of mineral phosphate, e.g. phosphate ore or fractions of phosphate ore, which consist of particles of various sizes both of phosphate material, and impurity, chiefly or entirely siliceous gangue conveniently identified as silica.

Important objects of the invention are to provide improved classifying and sizing apparatus of the character described, as to achieve cleaner or sharper fractionation of the feed into products or portions having different particle sizes, or more accurately into portions having different characteristics of settling rate. A special object is to provide such apparatus which includes improved arrangements for separating slimes, extremely fine particles and other substantially non-settling material from the tank, e.g. at an upper part, while permitting or promoting the progress of the solids to be classified, toward

the region between the upper and lower columns. Another, specific object, is to enhance the removal of slimes and other undesired material by diluting action, without substantially impairing the desired travel of feed to the locality of classifying function.

To these and other ends, the improved apparatus comprises a hydraulic classifier or sizer, for example of the type of the cited patents, including a submerged upper column and a lower column extending beneath the tank, with supplemental and coacting features for removal of slimes and the like. Specifically, such structure includes overflow means disposed centrally of the tank at the upper part so as to afford an annular space, e.g. of considerable width, between such overflow means and the surrounding tank wall, in contrast to the conventional provision of an overflow means at the periphery of the tank, extending around it. In cooperation with the central overflow means, means are provided for introducing the feed pulp at about the same level and through the tank wall in a more or less tangential relation to the latter. Such introduction of the feed pulp, preferably projected with considerable force, causes a circular, or indeed at least somewhat vortical movement of the liquid in the tank around the central overflow means. By such circular travel, the separation of fines and the like at the overflow is enhanced because of the centrifugal action of the circularly traveling liquid. The solid particles to be classified accumulate toward the periphery of the annular path, for the desired fall or advance to the space between the upper and lower columns, while the extreme fine material, slimes and various foreign substances of non-settling character, travel inwardly to the overflow means, for removal. Thus a highly effective classification is achieved in the double-column structure, by reason of the improved separation of fines, otherwise deleterious to the desired classifying action by settling rate.

For coaction with the described structure, the apparatus also preferably includes, as a further feature of invention, means for introducing supplemental liquid, i.e. water, at a locality of the tank substantially below the overflow level. It is found that such addditional water aids considerably in the separation of slimes or fines, presumably by auxiliary dilution of the solids-containing liquid in the tank and by action which in effect washes or rinses the slimes and other undesirable material from the particles descending in the tank. In a particular sense, the added water dilutes the slimes or other material, for more effective removal at the overflow means, so that the pulp reaching the space between the upper and lower columns is in excellent condition for the ensuing sizing or classifying operations of such columns. Special advantage is achieved by introducing the auxiliary water supply at, or more specifically, around the base of the upper or free-settling column, preferably by dispersing the dilution water around the region between the upper and lower columns. It is understood that the effect of the addition of water, as described, is to provide a considerably greater volume of liquid entering the central overflow and thus promoting the desired removal of slimes and the like, the circular flow of water around the inside of the tank wall being simultaneously effective to segregate the solids of desired particle size for the classifying operation and thus to prevent their loss, to any appreciable extent, in the relatively considerable volume of overflow.

The improved apparatus is of special advantage where it is desired that there be not only a classifying action but also a rinsing or cleaning action. For instance, in certain phosphate-concentrating procedure, hydraulic classification may be desired with respect to a mineral pulp which has been subjected to previous treatment in-

volving concentrating reagents or other chemicals or the like, including supplemental chemical treatment to promote removal of previously applied reagents. In such operation it is further desirable that the hydraulic classifier perform a rinsing function as well, i.e. to remove or clean away such reagent or chemical material. For instance, it may be important that either or both of the fractions resulting from the classifying action be uncontaminated by the previously introduced or occurring substances, as in cases where such fraction or fractions may be subjected to subsequent treatment, for concentration or otherwise, where the reagent would be deleterious or where a reagent of different character must be employed. Instances of such undesired materials are various oils, fatty acids, bases and acids as may be used in treatments of phosphate or other minerals or for cleaning such mineral with respect to previously applied substances of this sort. In the improved apparatus of the present invention, the removal of these materials is greatly facilitated, i.e. in carrying them away by the overflow, with the aided rinsing action of the auxiliary water supply, such reagents or chemicals thus coming within the category of substantially non-settling material which the improved pulp feed and overflow arrangement functions to separate, at least in considerable part.

An embodiment of the invention is illustrated in the accompanying drawings, wherein:

Fig. 1 is an essentially schematic or simplified view, as if in central vertical section, of one form of hydraulic classifier according to the invention;

Fig. 2 is a similarly simplified view, taken as if in horizontal section on line 2—2 of Fig. 1; and

Fig. 3 is a similar view, as if in horizontal section, on line 3—3 of Fig. 1.

The classifier shown in the drawings is basically of the Evans type identified above, in simplified illustration with some details, structural parts and the like omitted for clarity. The device comprises a main or outer tank **10** having an upper cylindrical section **11** and a conical portion **12** which tapers to an opening considerably narrower than the wide section **11**, to meet the upper end of the lower or hindered-settling column **14** which consists of an upright cylindrical portion **15** having a somewhat enlarged, cylindrical pocket **16** at its lower end.

Centrally within the wide tank structure **10** there is mounted (by suitable means not shown) an inverted cylindrical tank **18** closed at its top **19** and having a lower, open mouth **20** spaced directly above the top of the lower tank section **15**. The upper section **18**, conveniently having a horizontal diameter at least as great and preferably greater than the lower section **15**, constitutes the upper or free-settling column. Liquid rising in this upper column **18** is continuously withdrawn through a siphon-type discharge pipe **22** opening at one side of a collecting head **23**, which is a short length of pipe closed at its ends and having a plurality of side openings into which liquid may flow, just below the top **19** of the upper column. The siphon pipe **22** has a control and shut-off valve **24**, which may be a pinch-type valve, and conducts the discharged pulp of slower-settling solids to a desired locality for further handling or use, not shown.

To effectuate hindered-settling in the lower column **14** a considerable supply of water is continuously introduced through a pipe **25** opening into a lower part **26** of the pocket **16**, for example substantially tangentially thereof. The lower section **26** is separated from the column above it by a constriction plate **27**, i.e. a metal plate having suitable perforations, through which the introduced water flows with considerable velocity, to rise in the column **14** and provide hindered-settling conditions. That is to say, as will be readily understood, the solids tending to descend in the column **14** are increasingly impeded at the lower part of the column, creating a so-called condition of teeter and correspondingly preventing the finer or slower-settling particles from reaching the lowermost part of the column.

While other means such as a simple outlet pipe and plug valve can be employed for regulated withdrawal of the accumulating coarser or slower-settling particles in the pocket **16** above the constriction plate, the structure shown includes a siphon discharge arrangement of the character disclosed in United States Patent No. 2,714,958, granted August 9, 1955, on application of Robert D. Evans. Specifically such arrangement consists of an upright siphon tube or pipe **30** extending to a locality well above the top of the tank section **11** and there opening into a horizontal and downwardly extending pipe **31**, constituting the upper turn and other leg of the siphon. Control of the siphon is effected by a float valve **32** adapted to open or close an air vent **33** at the upper turn of the siphon, the float valve being positioned by the water in a static tube **34** which opens near the foot of the hindered-settling column **14**. When the pressure or head at the lower part of the column reaches a desired value representative of a pulp density of the desired particles, the float valve **32** closes so that siphon action may initiate, the density of the pulp at the bottom of the column providing an elevation of liquid greater than hydraulic head alone. Thus a rather concentrated aqueous pulp of the desired coarse or faster-settling particles is removed through the siphon discharge **30–31**. Self-starting and desired flow of the siphon is facilitated by supplemental water introduced through a pipe **35** opening into a narrow bell **36** which constitutes the lower opening of the siphon intake pipe **30**. The function of the described siphon discharge will be more fully understood by reference to the cited Evans Patent No. 2,714,958, including the further feature of adjusting the sizing or fractionating point by elevating or lowering the float valve **32**, i.e. to function only upon greater or less head as transmitted by the static tube **34**.

All of the above-described structure is essentially that of the classifier of the Evans Patent No. 2,708,517, from which it will be understood that the entire structure is kept filled with liquid, feed pulp being introduced into the top of the upper tank section **11** so that the particles to be classified descend in the tank **10**, around the upper column **18** and move into the space **38** between the upper and lower columns, the conical portion **12** of the tank being arranged to surround such space. The particles there tend to settle, but by virtue of the hindered-settling in the column **14**, i.e. the conditions of teeter (particularly in the lower portion of the column), essentially only the larger or faster-settling particles reach the foot or region of the pocket **16**. Slower-settling particles are carried up into the upper column **18**, where free-settling conditions prevail. That is to say, any larger or rapid-settling particles tending to rise in such column will fall back and descend into the lower column, so that the pulp withdrawn through the discharge pipe **22** will consist essentially only or mostly of the slower-settling sizes. Hence the desired fractionation is accomplished with the respective fractions being delivered by the pipes **31** and **22**, the flow through these pipes being produced by the introduction of water into the classifier and the conditions of head and flow within the described columns of the latter as explained. Further details and characteristics of operation will be apparent from the cited Evans patents relating to classifiers of this character, it being further understood that improved or alternative structures may be employed here as for other embodiments of such apparatus.

In accordance with the present invention, the feed of pulp to be treated is introduced near the top of the tank section **11** through a pipe **40** which extends horizontally into the tank wall in a substantially tangent relation thereto as apparent from the drawings, particularly Fig. 2. Thus the feed pulp, being an aqueous suspension of solids consisting chiefly of the particles to be classified by the action of the upper and lower columns **18, 14**, is projected along the inner wall of the tank so

that a circular or rotary flow of liquid is induced around the inside of the tank, e.g. as indicated by the arrows in Fig. 2.

Instead of providing overflow over the top edge of the tank wall **11**, the present apparatus includes a central, conveniently cylindrical overflow box **42** advantageously placed above the upper column structure **18**, for example with the top wall **19** of the latter constituting at least the central portion of the floor of the overflow means **42**. This overflow box, circular in plan, may have a deeper channel portion **43** around the outside of the column **18**, as in the nature of a collecting launder from which a pipe **45** extends outwardly and downwardly to discharge the collected liquid. Conveniently the overflow edge **46** of the box **42** is disposed at approximately the level of the tangential opening **48** of the feed pipe **40**, a presently preferred arrangement being to have the upper edge of the opening **48** a little higher than the edge **46** of the overflow box, so that with a slight vortical action of the liquid surface between the tank wall **11** and the overflow **42** there is nevertheless effective and substantial overflow action, with minimum submergence of the opening **48**. In some cases, such opening can even be slightly above the overflow level.

The improved classifier also includes means for introducing supplemental water at a locality substantially below the overflow level, e.g. as explained above, most conveniently at a locality around the space **38** between the settling columns. Thus the wall **12** of the tank is there provided with an inner, annular box structure **50** having a short, cylindrical, vertical wall **51** with a multiplicity of perforations, facing the space **38**. Water is continuously introduced into the box **50** through a plurality of tangential pipes, such as the three pipes **52**, **53**, **54** (Fig. 3) extending from a hexagonal or other appropriate header or pipe ring **56** having an inlet **57**. While the direction of water inlet effected by the tangential pipe or pipes utilized to introduce this additional water to the classifier is preferably the same as the direction of flow provided by the feed pulp inlet **40**, such similarity of flow direction is not necessary in all cases. Indeed the essential function of the box **50** is to provide a dispersion of the introduced water, through the perforated plate **51**, and to avoid any large, localized jetting action. Thus the tangential entry of water into the box **50** primarily serves to facilitate the dispersion or distribution of the water passing through the perforated plate, rather than to provide any circular or centrifugal flow within the main body of the tank section **12**.

It will now be seen that in operation, the feed pulp consisting of the phosphate or other mineral or like material, in appropriate dilution in water, is introduced continuously through the pipe **40**, causing a relatively strong circular or centrifugal flow around the tank **11** at and for a considerable distance below the surface of the liquid in the tank. At the same time, there is a continuing overflow at the edge **46** of the overflow box **42**. The circular action in the main body of liquid causes all but the very finest particles of the suspended solids to migrate toward or remain near the outer wall **11** of the tank, at least in such fashion that the liquid approaching and reaching the central, circular overflow edge **46** is essentially entirely free of any but extremely fine particles, slimes and the like. Hence the latter material is carried into the overflow means and removed by the pipe **45**. This de-sliming or similar action is enhanced by the additional water supplied to the tank through the perforated ring **51**, which dilutes the liquid throughout the upper part of the apparatus and correspondingly increases the volume of overflow. The greater effectiveness of overflow and of slime or fines removal, by virtue of this added water, is made possible by the centrifugal separating action around the overflow means, such action being effective to keep the great bulk of the supplied particles (having the larger particle sizes desired to be classified in the columns **18**, **14**) from getting into the overflow. Hence with improved removal of fines, the particles descending through the tank **10** to the space **38** are in better condition for the classifying action, so that the latter is performed more efficiently and with a sharper fractionation at the desired point in the range of particle sizes or settling rate properties present. Furthermore the delivered product or coarse fraction through the pipe **31** and similarly the delivered tailings or fine fraction through the pipe **22** are desirably free of slimes or other unwanted material.

It will be appreciated that the described classifier may be built in a wide variety of sizes and proportions adapted for the desired purpose and capacity in any given case, and may in some instances include other known structure, for instance in that for large and varying capacity the upper column means **18** may be of the multiple type such as shown in the Evans Patent No. 2,784,841. Simply by way of example, the following dimensions are suitable for a classifier of moderate capacity, constructed essentially as shown in the present drawing and designed to handle a phosphate mineral feed consisting of phosphate and silica particles of a size distributed throughout the range of 20 mesh to about 100 mesh. The upper tank section **11** has a diameter of 15 feet, this cylindrical portion having a height of 4 feet, with the overflow edge **46** about one foot below the top edge of the tank. The cone portion **12** has an altitude of 6 feet, tapering to a column section **15** which is 3 feet in diameter and has a height of 5 feet, down to the pocket **16**. The overall height of the latter is about 4 feet, with the upper center of the shallow conical plate **27** rising about 1½ feet from the very bottom of the pocket. Conveniently the structure may here include a drain pipe **65**, having a normally closed valve **66**, i.e. to provide a drain from the pocket **16** at desired times of shut-down. The diameter of the bottom pocket **16** is 5 feet.

The upper column **18** has a diameter of 3 feet four inches and a vertical height of about 6 feet 6 inches, its lower mouth being spaced 2 feet above the top of the lower column section **15**. The overflow box **42** conveniently built(as described above) as an integral structure with the upper column **18**, has a horizontal diameter of 4 feet 10 inches, so that the width or radial dimension of the annular body of liquid between the overflow means and the tank wall **11** is about 5 feet.

As indicated, the housing **50** is located so that the dilution water is preferably introduced near the intake of the free-settling column **18**. That is to say, this supplemental water flow is supplied either just above such intake, or most desirably, directly around the intake region, viz. the region between the columns **18** and **14**, as shown.

As an example of unusually effective use of the described apparatus, it is employed for classifying phosphate mineral material which is derived as the concentrate of roughing flotation cells from which the material had been treated with phosphate-selecting reagents, i.e. so-called negative-ion reagents, comprising tall oil, fuel oil and caustic. Since in this particular operation it is desired that a part of the material discharged from the classifier would be subsequently treated to remove silica, by flotation with positive-ion reagents, the feed to the classifier was preliminarily treated with sulfuric acid to de-oil the mineral. Hence as supplied to the apparatus through the feed pipe **40**, the pulp contained not only the defined mineral, but also the described chemicals as well as a proportion of fines and slimes. The particles to be classified consisted of phosphate and silica, with the phosphate particles distributed throughout the range mentioned above and with the silica particles predominantly in the finer sizes.

Utilizing the classifier in the manner stated, with so-called hydraulic water supplied through the pipe **25** to effectuate hindered-settling and with supplemental water supplied through the header **56** and the perforated ring

51 (e.g. in amount equal to about three-fourths of the feed pulp volume), highly effective fractionation was obtained, yielding a product consisting chiefly of the larger phosphate particles through the siphon discharge pipe 30—31, and a tailing, comprising the finer phosphate and silica particles through the pipe 22. Both products were considerably de-slimed and rendered substantially free of extremely fine material, while the classifier, both because of its nature and with the aid of the supplemental water supply, exhibited a remarkably effective rinsing action. That is to say, the chemicals were in considerable measure rinsed away from the mineral material, especially with respect to the tailing product through the pipe 22. Hence with a single further rinse of water, such product was in good condition for subsequent treatment with positive-ion reagent material for concentration by silica flotation. Procedure just described, for concentrating phosphate material by the stated series of steps, is disclosed and claimed in the copending application of Charles M. Goin, Serial Number 723,852, filed March 25, 1958.

It will now be appreciated that the apparatus affords unusually satisfactory results for classifying mineral material, especially in cases where it is desired to separate fines, slimes and other non-settling substances, so as to have a sharp fractionation, yielding effectively cleaned products of respectively different particle size or settling rates.

It is to be understood that the invention is not limited to the specific forms herein shown and described, but may be embodied in other ways without departure from its spirit.

We claim:

1. Hydraulic classifying apparatus comprising upright liquid column-defining structure having liquid-introducing means at the lowest region thereof, for effectuating classification by settling of liquid-carried solids supplied to a predetermined intermediate locality of said structure, to accumulate faster-settling particles at said lowest region of said structure and to carry slower-settling particles to a higher region of the structure above said intermediate locality, removal means respectively connected to said regions for separately withdrawing liquid bodies respectively containing said faster-setting and slower-settling particles, tank means adapted to receive liquid to a predetermined level near the top thereof and opening at a lower part to said predetermined locality of the column-defining structure for movement of liquid-carried solids to be classified, downward through said tank means into said column-defining structure, said tank means having a wall of substantially circular horizontal section around its upper part, means associated with the tank means at its lower part for introducing supplemental liquid into the tank means to dilute the solids-and-liquid mixture therein and thereby to promote separation of substantially non-settling material from solids descending to said predetermined locality, overflow means disposed centrally of the tank means near the top and spaced substantially inward of said circular wall, to receive overflow, at the aforesaid level, of liquid which carries substantially non-settling material, and means for introducing feed pulp of solids to be classified, through said wall and in approximately tangential relation thereto at approximately the level of the overflow means, to provide circulation of liquid in the tank means around the overflow means, for centrifugally impeding the travel, to said overflow means, of solids which are intended to descend to the aforesaid locality for classification.

2. Hydraulic classifying apparatus comprising upright liquid column-defining structure having liquid-introducing means at the lowest region thereof, for effectuating classification by settling of liquid-carried solids supplied to a predetermined intermediate locality of said structure, to accumulate faster-settling particles at said lowest region of said structure and to carry slower-settling particles to an upper region of the structure above the intermediate locality, removal means at said regions for separately withdrawing liquid bodies respectively containing said faster-settling and slower-settling particles, tank means surrounding part of said column-defining structure and enclosing the said predetermined locality, to be filled with liquid for travel, downward into said locality, of solids to be classified, overflow means disposed centrally of the tank means adjacent the top thereof and spaced substantially inward of the wall of the tank means, and means for introducing feed pulp of solids to be classified, into the tank means at approximately the level of the overflow means, in a direction to effect circular flow of liquid in the tank means around the overflow means, said pulp-introducing means and said overflow means being constructed and arranged to promote centrifugal segregation of solids to be classified, toward the wall of the tank means, and to effectuate overflow of liquid which carries substantially non-settling material, into the central overflow means.

3. Hydraulic classifying apparatus as defined in claim 2, which includes means for introducing supplemental liquid through the wall of the tank means at a region substantially below the level of the overflow means, for promoting liquid overflow and removal of substantially non-settling material into the aforesaid central overflow means.

4. Hydraulic classifying apparatus comprising upwardly opening lower column means having liquid-introducing means and pulp removing means at the foot thereof, for effectuating hindered settling in liquid-carried solids contained in said column means, to accumulate faster-settling particles for discharge through said removing means, upwardly closed upper column means having removal means at the top thereof and opening downwardly at a locality spaced above the lower column means, for effectuating free settling of particles in solids-carrying liquid moving upwardly in said upper column means, to separate and discharge slower-settling particles in liquid through said last-mentioned removal means, tank means surrounding said upper column means and the space between the upper and lower column means, to be filled with liquid for travel, downward into said space, of solids to be classified, overflow means disposed centrally of the tank means above the upper column means and spaced substantially inward of the wall of the tank means, and means for introducing feed pulp of solids to be classified, into the tank means at approximately the level of the overflow means, in a direction to effect circular flow of liquid in the tank means around the overflow means, said pulp-introducing means and said overflow means being constructed and arranged to promote centrifugal segregation of solids to be classified, toward the wall of the tank means, and to effectuate overflow of liquid which carries substantially non-settling material, into the central overflow means.

5. Hydraulic classifying apparatus as defined in claim 4, which includes means for introducing supplemental liquid through the wall of the tank means adjacent the space between the upper and lower column means, for promoting liquid overflow and removal of substantially non-settling material into the aforesaid central overflow means.

6. Hydraulic classifying apparatus comprising upright tank means having a wide upper section of circular transverse shape and a narrow lower column section opening upwardly into the bottom of the upper section, means introducing a flow of liquid at the foot of said lower column, to effectuate hindered settling of particles in liquid in said lower column, for accumulating faster-settling particles at said foot of the lower column, upper column means comprising upwardly closed enclosure means spaced within the upper section and opening downwardly at a locality spaced above the open top of

the lower column and means for removal of liquid carrying slower-settling particles from the head of said upper column means, to effectuate free settling in said upper column means among particles in liquid moving upwardly to the removal means, means for introducing a feed pulp of liquid carrying solid particles to be classified into the aforesaid upper tank section at the upper periphery thereof, said introducing means comprising means projecting said feed pulp substantially tangentially of the curved wall of said upper section, substantially horizontally along the inner surface thereof, to provide circular flow of liquid in the upper part of said upper section, overflow means spaced centrally within said upper section at the top thereof at substantially the level of said projecting means and including overflow-collecting and removing structure submerged in the liquid in the tank above said upper column means, and means for removing pulp of said faster-settling particles from the foot of the lower column means, said tangential feed projecting means and said central overflow means serving to promote centrifugal segregation of solids to be classified, for downward movement of said solids to the space between the upper and lower column means, while removing substantially non-settling material in said central overflow means.

7. Hydraulic classifying apparatus as defined in claim 6, wherein the enclosure means of the upper column means includes a substantially horizontal top wall therefor and wherein the overflow-collecting and removing structure comprises an upright, shallow, vessel circular in plan and built integrally with said enclosure means and having a floor which comprises said top wall.

8. Hydraulic classifying apparatus comprising upright tank means adapted at the top thereof to receive feed pulp of liquid which carries solid particles to be classified and having a wide upper section of circular transverse shape and a narrow lower column section opening upwardly into the bottom of the upper section, means introducing a flow of liquid at the foot of said lower column, to effectuate hindered settling of particles in liquid in said lower column, for accumulating faster-settling particles at said foot of the lower column, upper column means comprising upwardly closed enclosure means spaced within the upper section and opening downwardly at a locality spaced above the open top of the lower column and means for removal of liquid carrying slower-settling particles from the head of said upper column means, to effectuate free settling in said upper column means among particles in liquid moving upwardly to the removal means, means near the downward opening of said enclosure means of the upper column means, for introducing supplemental liquid into the tank means, to dilute the mixture of liquid and of solids descending to said downward opening, in said tank means around said enclosure means, and thereby to promote separation of substantially non-settling material from solids advancing to the space between the upper and lower columns, means for introducing the aforesaid feed pulp into the aforesaid upper tank section at the upper periphery thereof, said introducing means comprising means projecting said feed pulp substantially tangentially of the curved wall of said upper section, substantially horizontally along the inner surface thereof, to provide circular flow of liquid in the upper part of said upper section, overflow means spaced centrally within said upper section at the top thereof of substantially the level of said projecting means and including overflow-collecting and removing structure submerged in the liquid in the tank above said upper column means, and means for removing pulp of said faster-settling particles from the foot of the lower column means, said tangential feed projecting means and said central overflow means serving to promote centrifugal segregation of solids to be classified, for downward movement of said solids to the space between the upper and lower column means, while removing substantially non-settling material in said central overflow means.

9. Hydraulic classifying apparatus as defined in claim 8, wherein the upper tank section comprises a conical portion tapering to join the narrow lower column section and surrounding the space between the upper and lower columns in spaced relation therefrom, and wherein the means for introducing supplemental liquid comprises a housing associated with said conical tank portion extending horizontally around said tank portion and having a perforated wall surrounding the said space between the columns for dispersing liquid from the housing into the tank around the said space, and means for supplying liquid to said housing.

10. Hydraulic classifying apparatus as defined in claim 9, wherein the last-mentioned liquid-supplying means comprises a plurality of pipes substantially tangentially entering the housing at mutually horizontally spaced localities, for directing the liquid along the housing to promote uniformity of liquid dispersion through the perforated wall.

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