Aug. 11, 1959 R. D. EVANS 2,899,056

HYDRAULIC CLASSIFICATION OF SOLIDS

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FIG. 1-A

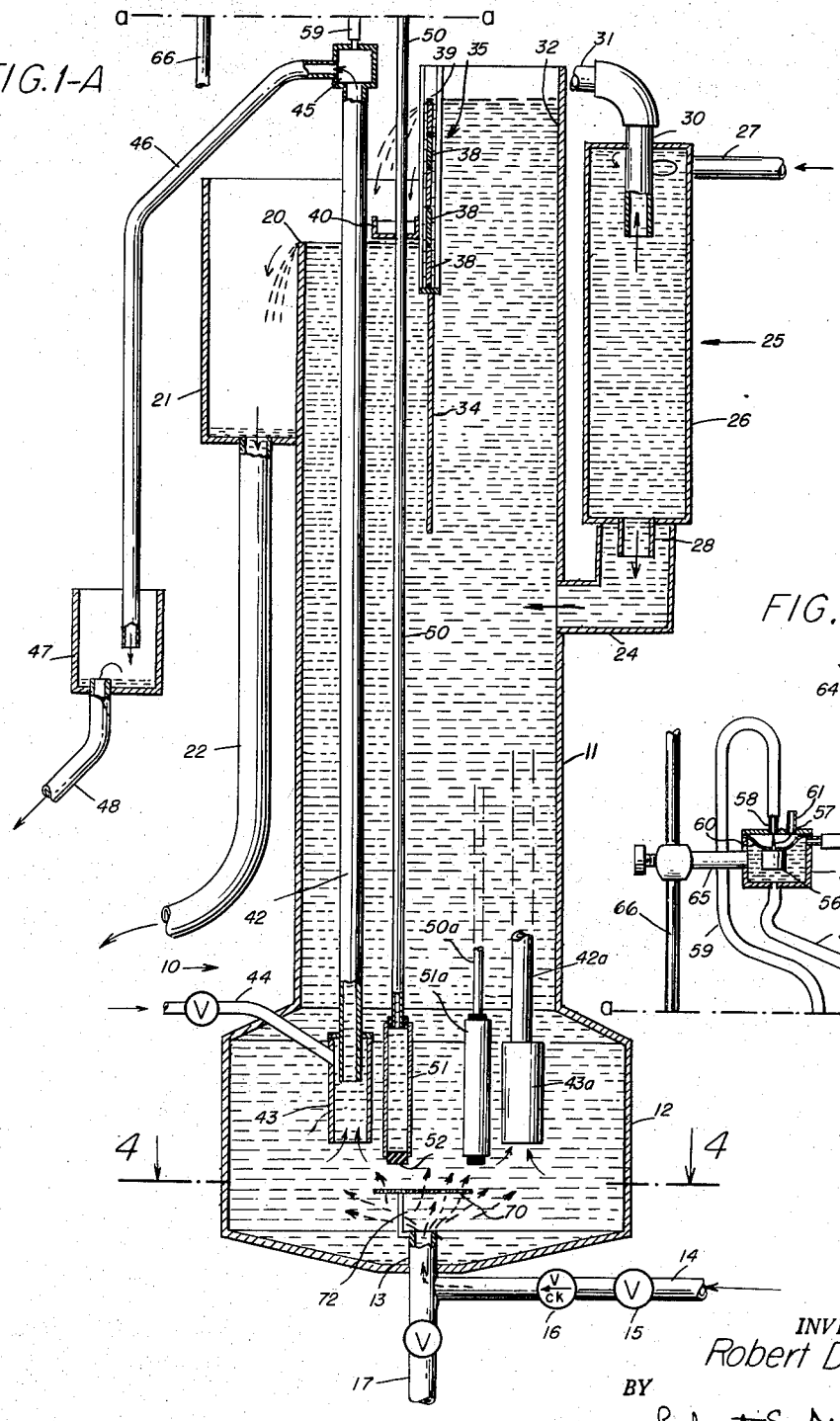


FIG. 1-B

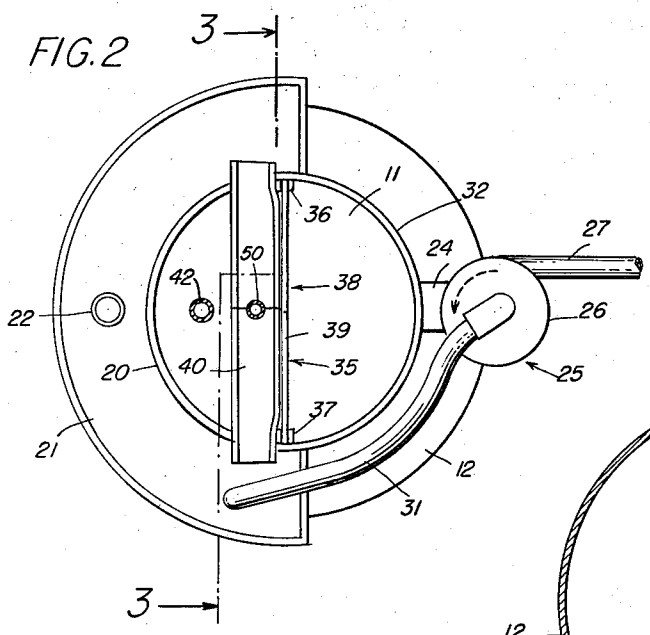
INVENTOR.
Robert D. Evans
BY
Robert S. Dunham
Attorney

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FIG. 2



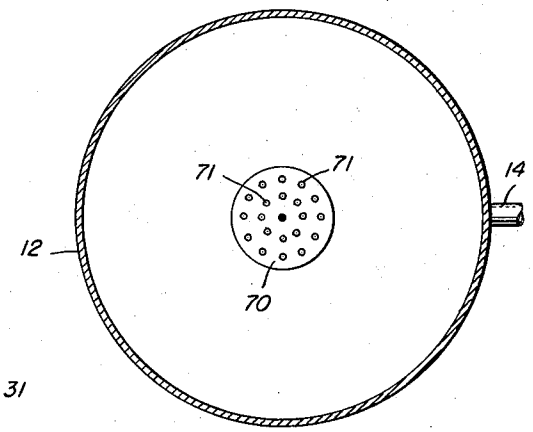


FIG. 4

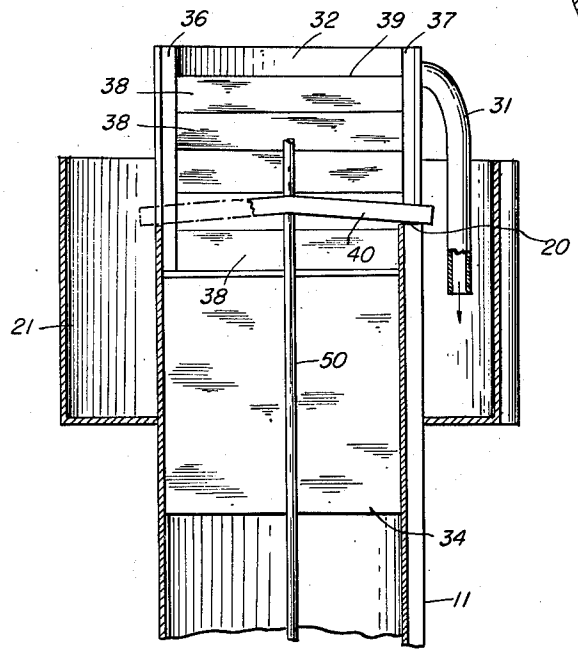


FIG. 3

INVENTOR.
Robert D. Evans

BY
Robert S. Dunham
Attorney

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2,899,056

HYDRAULIC CLASSIFICATION OF SOLIDS

Robert D. Evans, Pierce, Fla., assignor to The American Agricultural Chemical Company, New York, N.Y., a corporation of Delaware

Application March 11, 1957, Serial No. 645,214

11 Claims. (Cl. 209—158)

This invention relates to hydraulic sizing or classification of solids, particularly solid material in divided form, which may be supplied as a liquid pulp, e.g. in aqueous suspension, and which is to be classified or separated into fractions having different characteristics of particle size or settling rate. The invention is especially applicable to classification of ores or other mineral substances, as mined or as may have been subjected to preceding stages of classification, concentration, grinding, or the like. Important examples of such material are phosphate ores, such as the finer fractions of phosphate rock, or phosphatic sands, but the improved apparatus and procedure are also useful for classifying operation with respect to a variety of other materials as indicated above.

In a more specific sense, the invention relates to apparatus and procedure involving so-called hindered settling, for instance by way of improvement of apparatus such as shown in my Patent No. 2,714,958, issued August 9, 1955. In general, classification by hindered settling involves the establishment of an upright column of liquid to which the feed pulp is supplied at an upper locality and which is also supplied with water at the foot, so as to afford an upward flow of liquid against which the particles of material from the feed pulp (usually introduced at the top of the column) tend to settle. Preferably with the aid of local acceleration of the incoming water (at the bottom), which is usually called hydraulic or "teeter" water, the solids reaching the bottom tend to accumulate in a mobile suspension, raising the effective density of the fluid mass, and indeed building up the suspension through a substantial vertical height in the column. The mass is sometimes described as being in teeter, and the effect of the hindered settling and particularly of the increase in fluid density thus produced is that only the heavier or larger particles (i.e. the faster settling particles) will reach the foot of the upright tank. Slower settling particles are hindered from traveling downward, and in consequence tend to be carried up, for example to the overflow at the very top of the vessel. By appropriately removing pulp from the foot of the column, e.g. just above the locality of introduction of the so-called hydraulic water, a fraction is obtained which consists essentially of higher settling rate solids, usually the coarser fraction, while the fine or slow-settling material is carried away in the overflow.

The present invention is designed to provide improvement in classifying apparatus and procedure, such as described above, for more convenient and efficient operation, for greater simplicity and durability of construction, and for adaptability or adjustability to various conditions and requirements. In particular, the invention is designed to provide apparatus that will be compact and efficient and yet will handle feed pulp having a degree of dilution which might otherwise be troublesome for the operation of hindered settling or might require unusually large equipment. In another respect, the apparatus is designed to provide adjustability as to the degree of classification, for example with respect to the size or

settling rate of particles withdrawn at the overflow. In cooperation with these and other features, the apparatus is designed to afford improved structure and function of the teeter column, particularly for efficient classifying action and removal of a coarse or high settling rate product, as in a pulp of high solids content. Improved control structure for the product removal means is also included, to cooperate in controlling the life and reliability of the apparatus.

In the drawings, which illustrate one example of apparatus embodying the invention:

Figs. 1–A and 1–B together represent a view, chiefly in vertical section but with certain parts in elevation, of a complete hydraulic classifier, Fig. 1–A representing the main part of the apparatus and Fig. 1–B certain upper instrumentalities continued above the line *a—a*;

Fig. 2 is a plan view of the device but with certain parts, particularly those above the main tank, omitted;

Fig. 3 is a vertical section on line 3—3 of Fig. 2, of the upper part of the apparatus of Fig. 1–A; and

Fig. 4 is a horizontal section on line 4—4 of Fig. 1–A.

Referring to the drawings, which represent a somewhat simplified and diagrammatic illustration of the equipment, the main sizer tank **10** comprises an upright cylindrical tank section **11** opening downward into a wider cylindrical pocket or tank section **12** into the bottom of which the hydraulic or teeter water is continuously introduced through a central pipe **13** fed by a pipe **14** having a control valve **15** and a check valve **16**, this pipe system also having a normally-closed valve branch **17** for drain purposes. At the upper part of the tank section **11**, the edge **20**, occupying about one-half of the circumference, provides normal overflow means whereby liquid carrying the finer or slower settling particles of solid overflows into a surrounding launder **21**, likewise semi-circular, having a discharge pipe **22**. Feed of pulp to be classified, for example consisting of mineral particles carried in water, is introduced into a vertically central portion of the tank section **11** via the inlet passage **24**, after traversing a preliminary classifying or dewatering device **25**, of so-called cyclone type.

Although in many cases a plurality of such cyclone devices may be used, and indeed preferably at least two with apparatus such as illustrated, being arranged in parallel for simultaneously handling divided portions of the feed, a single such means is shown in the drawings for the sake of clarity. The device **25** comprises an upright tank or vessel **26** to which, at the upper end, the feed of pulp (which may have a relatively low solids content) is introduced tangentially through a supply pipe **27**. The vessel **26** being filled with liquid at all times, the thus introduced pulp tends to follow a circular path around the cylindrical wall of the vessel whereby solid particles, and particularly all but the very smallest or slime-type particles tend to move outward, as by centrifugal force. From the bottom of the tank **26**, the discharge conduit **28** carries the pulp into the inlet passage **24** of the main tank **10**. A water outlet pipe **30** projects downwardly into the center of the upper part of the vessel **26**, as shown, to withdraw continuously a substantial part of the water of the feed pulp, possibly together with very fine particles, such pipe **30** being connected by a further conduit or hose **31** to an appropriate discharge locality, for instance into the launder **21** (Figs. 2 and 3).

At the uppermost part of the tank section **11**, an upper tank extension **32** is provided, having a horizontal area representing a substantial part of the total tank horizontal area, say one-half. A considerable part of the tank section **11** below the upper portion **32** is divided by a partition **34**, extending, for instance, across a diameter of the tank, this partition **34** being conveniently disposed so as

to constitute a lower continuation of upper, adjustable wall or partitioning means generally designated **35** which, with the semi-cylindrical wall, bounds the tank section **32** and extends directly above and alongside the tank portion that is surrounded by the semi-circular overflow **20**. The lower edge of the partition plate **34** is conveniently at a locality between one-half and three-fourths of the height of the overflow **20** above the general region of the inlet of hydraulic water at the bottom of the tank **10**, preferably at a point two-thirds of the distance from the hydraulic water inlet to the overflow.

The adjustable wall or partitioning means **35**, which together with the plate **34** provides an adjustable partition for the upper part of the tank dividing it into two upper levels, comprises a pair of flanged channels or slots **36, 37** extending vertically at opposite sides of the uppermost tank wall **32**, i.e. at the vertical edges of the latter, and arranged to receive a plurality of slats or narrow plates **38** with their long edges in successively abutting position so as to build up a wall or partition. It will be understood that these plates fit in the channels **36, 37** and abut each other with sufficient closeness as to provide essentially water-tight contact to contain the liquid in the upper section **32** to the level, represented by the uppermost slat edge, e.g. as shown at **39**. It will be seen that by inserting or removing slats, the height of the wall **35** is adjustable, from a level substantially below the normal overflow edge **20**, to levels at various heights above such edge.

A separate launder or channel **40** extends across the tank portion having the edge **20** and may slope down slightly at each side (as shown) to receive overflow from the adjustable wall edge **39**, i.e. the upper overflow, and discharge same into an appropriate locality, which may be the same collecting launder **21**.

For withdrawal of a product of high settling rate solids from the foot of the teeter column constituted in the tank **10**, suitable means are provided. Although simple cone or plug valve devices extending down from a lower part of the pocket **12** can be used, the apparatus very preferably includes siphon discharge means of the character disclosed in my Patent No. 2,714,958, granted August 9, 1955, to which reference may be had for further details of structure and function. Essentially such siphon discharge comprises a long upright pipe **42** having an enlarged lower section **43** into which siphon-assisting water is continuously supplied through a valved inlet pipe **44**, to flow up into the pipe **42**, the lower part **43** opening downwardly at a region near the bottom of the hindered settling column, viz. in a vertical central or lower region of the pocket **12**. At its upper end, spaced substantially above the normal overflow, the pipe **42** has a connecting chamber **45** from which a discharge pipe **46** extends laterally and downwardly to a locality below and preferably well below the overflow level **20**. For instance, the pipe **46** may there open into discharge pocket **47** from which the product pulp is withdrawn by an outlet pipe **48**.

Although hydrostatic control means of the type shown in the illustrated examples of my Patent No. 2,714,958, with hydrostatic conduits opening directly into the liquid of the tank **10**, may be effectively employed for controlling the operation of the siphon discharge **42—46**, the drawings illustrate an improved embodiment of such means. For instance, a long vertical hydrostatic pipe **50** extends to the lower pocket **12** of the apparatus, being there closed by a flexible diaphragm structure which is exposed to the liquid at the bottom of the teeter column. Specifically the flexible diaphragm may consist of a long flexible, thin wall, somewhat resilient tube **51**, of rubber or the like, having a rigid top connected to the rigid conduit **50** and a rigid bottom closure **52**, with supporting rods (not shown) between top and bottom if desired. At an adjustable locality above the connecting chamber **45** the conduit **50**, through a flexible tube **54**, opens into the bottom of a control chamber **55** which preferably has a transparent wall for observation and which encloses a float **56** having an upper needle-shaped or cone-like projection **57**. The projection **57** constitutes a needle valve with an upper conduit **58** into which it projects, so that when the float **56** rises the needle or cone valve **57—58** is closed. The conduit or nipple **58** is connected by a flexible tube **59** into the top of the chamber **45**. A thin highly flexible diaphragm **60** seals the space within the housing **55** between the top of the housing side wall and the top of the float, so that the region above this diaphragm is filled with air, by reason of communication with the atmopshere through the passage **61**, while liquid in the chamber is maintained below the diaphragm.

From one side of the housing or chamber **55**, a flexible conduit **63** extends to a small, open-type reservoir **64** supported (as by means not shown) at a predetermined high locality. The control chamber **55** is carried by a bracket **65** adjustably mounted on a suitable, fixed supporting rod **66**. The system comprising the lower diaphragm chamber **51**, rigid hydrostatic tube **50**, tube **54**, the main portion of chamber **55**, tube **63** and reservoir **64** is supplied with an appropriate liquid, which is preferably of non-corrosive character and may be water, or in some cases other liquids, for example having a density not appreciably greater than the density of water where aqueous pulps are, as usually, to be handled in the classifying apparatus.

The discharge control means functions on the basic principles explained in my cited Patent No. 2,714,958, to effectuate operation of the siphon when hindered settling action is occurring for desired accumulation of coarser or higher settling rate solids at the foot of the column, e.g. in the pocket **12**. When hindered settling is thus occurring as desired, the presence of the solids in teeter near the bottom and throughout a considerable upper part of the column increases the fluid density of the liquid and correspondingly the fluid pressure at the bottom, i.e. in the pocket **12**. Hence a column of water, such as the liquid in the hydrostatic conduit **50**, containing no solids, will be displaced by compression of the diaphragm **51** and will rise above the normal overflow **20** to a substantially higher level, e.g. to or beyond the top of the chamber **55**. The vertical position of the chamber **55** is adjusted so that when the desired pressure is reached at the foot of the teeter column, as represented by the desired accumulating of solids to be separated, the corresponding liquid displacement causes the float **56** to rise and close the cone valve **57—58**. The uppermost bend of the siphon **42—46** (at **45**) having been previously vented to the atmosphere through the tube **59**, is now closed. Aided by the continuing flow of supplemental water from the pipe **44**, the hydrostatic pressure carries water promptly to fill the pipe **45** starting siphon action, whereupon pulp including the desired, separated solid particles is continuously carried up the pipe **42** and through the siphon to discharge as product via the means **47, 48**. Should the classifying action be inadequate, the fluid pressure in the pocket **12** falls, correspondingly reducing the pressure on the diaphragm **51** and causing the float **56** to drop. The cone valve **57—58** then vents the siphon to the atmosphere, interrupting siphon flow of pulp. Thus the described means automatically controls the siphon operation to effectuate it only when desired settling conditions are occurring, i.e. for separation of the feed solids into the desired high settling rate fraction.

Whereas in previous devices it has been conventional to introduce the hydraulic or teeter water at the foot of the column through a so-called constriction plate, which would in the apparatus shown be a plate extending entirely across a lower region of the pocket **12**, having a large multiplicity of perforations (the water being supplied under pressure to the space below such plate), and although such constriction plate can be used with other features of the improved device shown, the draw-

ings illustrate a simplified arrangement for supplying such water. Specifically this arrangement comprises the slightly upwardly projecting pipe **13**, with a deflection plate **70**, having an area much smaller than the horizontal area of the pocket **12**, spaced a short distance above the upward pipe opening. This plate may have a number of small perforations **71**, e.g. as shown, the plate being carried on a suitable bracket **72** from the side of the pipe **13**. It is found that by directing the water, at substantial velocity into the bottom of the teeter column in this fashion, with the aid of distribution of a major part of it outwardly and upwardly around and beyond the edges of the plate **70**, and with some upward jets directly through the perforations **71**, effective upper flow of liquid is provided for the hindered settling action. The incoming water thus enters at a considerable velocity, for cooperation in establishing teeter conditions, it being found that such instrumentalities afford effectively constricted water supply and satisfactory distribution of upwardly introduced water, for the stated purpose.

It will be understood that a plurality, e.g. two, three or more, of the siphon discharge means may be employed, each with its separate hydrostatic control. For simplicity of illustration, the drawings merely show the lower portion of another siphon discharge system, as by the siphon sections **42***a*, **43***a* and the hydrostatic diaphragm **51***a* and conduit **50***a*.

The operation of the apparatus and the advantages of various novel features are now to be further described. For efficient operation of a hindered settling column of the simple vertical type shown in the drawings, a pulp feed which is substantially steady in rate of flow and which is reasonably constant in solids content or dilution, is relatively important; if there are large amounts of water with the feed or if there are sudden large surges of feed, the tank overflows very heavily, the teeter effect is substantially lost and there is insufficient separation of solids by settling rate, either under hindered or free-settling action. In general, the solids feed, e.g. as determined in the case of particles of phosphate rock, should be such that the pulp supplied to the column (preferably at a locality at least about one-third of the distance below the normal overflow, to avoid too much loss of desired coarse particles) contains at least about 40% solids by weight, and preferably 60% to 70%. It will be remembered that in the operation of a hindered settling column, the dilution effected by the hydraulic water rising from the bottom is considerable. The device **25** cooperates to insure or maintain desired pulp feed in the hindered settling system, even where the solids content of the pulp actually received may be considerably lower than desired or where there may be changes in the flow of feed occasioned by variations in dilution. Thus by the cyclone action, involving the circular flow initiated at the top of the tank **26**, the greater part of the particles are carried to the wall of the device **25** and travel downwardly to the bottom for discharge through the passage **28**. Under the pressure of the supplied liquid, the pipe **30** thus removes a considerable amount of water which is freed from the desired solid particles or which contains only a small proportion of fine particles, slimes or the like. In consequence, a substantial steady flow of pulp with the desired, moderate or high solids content is introduced into the main tank section **11** through the passage **24**. In other words, the device **25** adapts the hydraulic classifier to situations where the feed pulp consists of a reasonably steady flow of solids accompanied by wide fluctuations in water content. The excess water is removed by the cyclone overflow **30**, **31**, leaving a steady flow of relatively dewatered solids to the hindered settling column by way of the cyclone underflow **28**.

It will be understood that the cyclone device **25** is conveniently located, as shown, alongside of the main tank **10** and is preferably situated so that a substantial part of its extent rises above the normal overflow **20**, i.e. to avoid undue loss of pulp through the siphon overflow by upward pressure from the teeter column. Although in practice it is thus preferred that at least about one-half of the vertical height of the cyclone **25** extends above the overflow level of the hindered settling column, the drawing diagrammatically shows a somewhat lessened relation, for the sake of compactness of illustration.

The adjustable partition and wall structure constituted by the means **34**, **35** affords flexibility in predetermining the classifying action of the apparatus. For example, if all of the slats **38** are removed, the device functions as if there were no partition **34** or upper section **32**. The overflow level is wholly determined by the edge **20**, and the liquid rise velocity through the upper part of the column, e.g. above the inlet **24**, is nearly constant over the entire cross-sectional area. In such case (since the upper edge of the partition **34** is several inches below the level **20**) the rise velocity has a minimum value for the apparatus, and the solids overflowing at the top represent only a relatively fine fraction. If some slats **38** are inserted, for example to raise the level in the section **32**, several inches above the edge **20**, the upper portion of the tank is then divided into two sections, with a larger rise velocity of liquid in the section terminated by the edge **20**, i.e. the normal overflow region, than in the region to the right of the plate **34** as seen in Fig. 1–A. Where, for example, all of the illustrated slats are inserted, this disparity in rise velocities in the two sections increases, essentially to the point where the rise velocity in the left-hand or normal overflow section may be doubled and where it may fall to a very low or even zero value in the section **32**. By so adjusting the effective rise velocity in the upper part of the tank, larger proportions of coarser or faster-settling particles may be removed with the overflow, i.e. the principal overflow at the edge **20**. In consequence, the nature and extent of solids classification for removal of highest settling rate product (at the foot of the column) is adjusted with the adjustment of the wall constituted by the slats **38**. When the slats are inserted to provide a normal overflow section of increased rise velocity, the proportion of solids less than the finest which travel to the overflow is increased, and in consequence the inclusion of such solids, along with the coarsest or fastest-settling in the siphon discharge product, is reduced.

Thus by the adjustable partition means the rise velocity in the upper part of the hindered settling column can be varied, e.g. to various predetermined values, and the nature of fractionation, and particularly the particle size characteristics of the siphon discharge product and overflow product respectively, can be modified.

As explained, there may be some overflow from the uppermost column section **32**, largely consisting of water with only the very finest solids. Although in some cases it may be desired to conduct this overflow to a separate locality (as where the tailings from the normal overflow **20** are recovered for a special use), the drawing for simplicity shows the launder **40** as carrying such overflow simply into the main tailings launder **21**.

It will finally be noted that the enlarged pocket **12**, which may have a horizontal dimension or diameter from 25% to preferably 50% (or more) larger than that of the upper tank section **11**, affords certain special advantage. It provides a region of low rise velocity, at the foot of the teeter or hindered settling column, in which the sized particles may settle and compact prior to their discharge through the siphon conduit system **43**—**42**. As a consequence less teeter water is lost through the siphon discharge means and a siphon product of relatively high solids content, for example 55% or substantially higher (by weight) can be obtained. This settling pocket also provides space for the enlarged portions of devices that are disposed within the tank **10**, e.g.

the large pipes or bells **43** constituting the intakes for the siphons.

As will be understood, various features of the complete device shown in Figs. 1–A and 1–B may be omitted in various cases, for example where their special cooperative effects are not needed. Likewise other forms of instrumentalities, for example as previously provided for the introduction of teeter water or for the control of siphon discharge, may be employed.

The general operation of the apparatus is believed implicit in the foregoing description. Feed pulp is supplied continuously to the cyclone device **25**, which in effect dewaters it as necessary, and the resulting continuous feed to the column in the tank **11** maintains the desired supply of solids to be classified. Hindered settling conditions are continuously maintained by the upward flow of water from the bottom of the pocket **12**, and when maintained, the siphon discharge, under control of the device including the float **56**, removes the desired fraction of high-settling rate material. From the overflow at the upper edge **20**, the finer or lower settling sizes are removed, with considerable volume of water. Where the adjustable wall is included and set for establishment of a relatively quiet upper section of liquid, the effective rise velocity of the upper portion of the teeter column, i.e. to the left of the partition **34** in Fig. 1–A is correspondingly increased with a desired predetermined effect on the separating action as explained. The entire apparatus is desirably continuous in function, permitting considerable variation in feed characteristics and affording a greater flexibility of presetting, by the adjustable partition as well as by the siphon discharge control, to obtain a specific result. While dimensions and proportions may vary widely, one useful example involved a steel tank **10** having an upper section about 12 feet high from the lower pocket **12** to the overflow **20** and a diameter of about 4 feet. The total height of the pocket **12** was about 4 feet, with a diameter of approximately 6 feet. As stated, the size and arrangement of the apparatus will depend, in a given case, upon the requirements of use, including the volume of material to be handled.

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

I claim:

1. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means opening into the tank means at a position therein which is spaced below the top thereof for introducing feed pulp of particles to be sized, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column, for accumulating faster-settling particles at the foot of the tank means, and siphon discharge means opening at its lower end into the tank means at said foot thereof and extending upward therefrom for removal of pulp of particles accumulated by hindered settling, said tank means including a horizontally enlarged tank portion at the foot thereof and surrounding said lower end of the siphon discharge means and said liquid introducing means, to provide a lower rise velocity of liquid in said portion than in tank regions above the same.

2. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means opening into the tank means at a position therein which is spaced below the top thereof for introducing feed pulp of particles to be sized, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column, for accumulating faster-settling particles at the foot of the tank means, and siphon discharge means opening at its lower end into the tank means at said foot thereof and extending upward therefrom for removal of pulp of particles accumulated by hindered settling, said tank means including a horizontally enlarged tank portion at the foot thereof and surrounding said lower end of the siphon discharge means and said liquid introducing means, to provide a lower rise velocity of liquid in said portion than in tank regions above the same, and said liquid introducing means comprising conduit structure opening through the bottom of said enlarged tank portion and plate means having a diameter equal to a minor fraction of the diameter of the said tank portion, disposed over said conduit structure for deflecting the introduced liquid to disperse it upwardly in the tank.

3. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at the top, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column, and means for introducing a feed pulp of solid particles to be classified, including supplemental upright vessel means having a tangential inlet at the top for establishing a circular current of feed pulp in said supplemental tank means, to urge solid particles in the feed toward the wall of said tank means, means extending into the center of the upper part of said supplemental vessel means for withdrawing a portion of liquid therefrom, which is reduced in solids content by said circular current, means at the foot of said supplemental vessel means and opening into the upright hindered settling tank means at a locality spaced below the top thereof, for conducting feed pulp of reduced water content into said hindered settling tank means, for classifying action thereon, and siphon discharge means opening at its lower end into the tank means at said foot thereof and extending upward therefrom for removal of pulp of particles accumulated by hindered settling, said tank means including a horizontally enlarged tank portion at the foot thereof and surrounding said lower end of the siphon discharge means and said liquid introducing means, to provide a lower rise velocity of liquid in said portion than in tank regions above the same.

4. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at the top, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column, siphon discharge means comprising a conduit having an inlet opening near the foot of said tank means and extending upwardly to an upper locality above said overflow means and from said locality downwardly to a discharge locality below said overflow means and outside the tank means, said conduit being adapted to withdraw accumulated pulp of faster settling particles from the foot of the tank means while slower settling particles are discharged at the overflow means, said conduit having a control opening therein at its said upper locality and valve means shiftable selectively to close said control opening for effectuation of siphon discharge action and to open said control opening to the atmosphere for interrupting siphon discharge action, pressure responsive means, including structure extending into said tank means to a position near the aforesaid inlet opening of the conduit to sense pressure in the fluid material near said inlet opening, for operating said valve means to keep said valve means closed for siphon discharge when the accumulated faster settling solids maintain the aforesaid fluid pressure at greater than a predetermined value and to open the valve means for interrupting siphon discharge when there is insufficient accumulation of faster settling solids to provide said greater pressure, and means for introducing into the tank means a feed pulp of solid particles to be classified into the aforesaid faster settling and slower settling particles, including supplemental up-

right vessel means having a tangential inlet at the top for establishing a circular current of feed pulp in said suplemental vessel means, to urge solid particles in the feed toward the wall of said vessel means, means extending into the center of the upper part of said supplemental vessel means for withdrawing a portion of liquid therefrom, which is reduced in solids content by said circular current, and means at the foot of said supplemental vessel means and opening into the upright hindered settling tank means at a locality spaced below the top thereof, for conducting feed pulp of reduced liquid content into said hindered settling tank means, for classifying action thereon, said supplemental vessel means and its said tangential inlet and its said liquid withdrawing means and pulp conducting means being constructed and arranged for effectuating said reduction of liquid content of the feed pulp to prevent excess liquid in the feed from impairing the hindered settling action in the tank means and the desired accumulation of faster settling particles at the foot of the tank means.

5. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column and to maintain continuous rise of liquid in the tank means to said overflow means, means including upper tank wall structure and cooperating adjustable partition wall means across the tank means for providing an upper extension of the tank means above the aforesaid level, partitioned from the overflow means, said partition wall means cooperating with the tank means to provide a narrowed upper portion in the tank means below said overflow means, said upper extension and said narrowed portion cooperating to maintain a higher rise velocity of liquid rising in the narrowed portion to said overflow means than in liquid below said narrowed portion, said partition wall means being adjustable in height for adjusting said last-mentioned rise velocity to vary the sizing action of the apparatus, means for introducing into the tank means a feed pulp of solid particles to be classified, including supplemental upright vessel means having a tangential inlet at the top for establishing a circular current of feed pulp in said supplemental tank means, to urge solid particles in the feed toward the wall of said tank means, means extending into the center of the upper part of said supplemental vessel means for withdrawing a portion of liquid therefrom, which is reduced in solids content by said circular current, and means at the foot of said supplemental vessel means and opening into the upright hindered settling tank means at a locality below the partition wall means, for conducting feed pulp of reduced water content into said hindered settling tank means, means extending into the center of the upper part discharge of solid particles from the foot of the tank means, as accumulating by hindered settling.

6. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column and to maintain continuous rise of liquid in the tank means to said overflow means, means including upper tank wall structure and cooperating adjustable partition wall means across the tank means for providing an upper extension of the tank means above the aforesaid level, partitioned from the overflow means, said partition wall means cooperating with the tank means to provide a narrowed upper portion in the tank means below said overflow means, said upper extension and said narrowed portion cooperating to maintain a higher rise velocity of liquid rising in the narrowed portion to said overflow means than in liquid below said narrowed portion, said partition wall means being adjustable in height for adjusting said last-mentioned rise velocity to vary the sizing action of the apparatus, means for introducing liquid pulp of solids to be sized into the tank means below the partition wall means, and means for discharge of solid particles from the foot of the tank means, as accumulating by hindered settling.

7. Apparatus as defined in claim 6 wherein the adjustable partition wall means comprises a permanent partition wall across the tank means below the aforesaid overflow means, partition section-receiving means extending upwardly from said permanent wall along said upper tank wall structure, and a plurality of mutually abutting, vertically aligned, removable partition sections received in said section-receiving means.

8. Apparatus as defined in claim 7 wherein the section-receiving means comprises a pair of channel structures at opposite sides of the upper tank wall structure, the partition sections being slats each having its ends disposed in said channel structures.

9. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at the top, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column, means for introducing a feed pulp of solid particles to be classified, into the tank means, and siphon discharge means opening at its lower end into the tank means at said foot thereof and extending upward therefrom for removal of pulp of particles accumulated by hindered settling, said liquid introducing means being disposed below the siphon discharge means and said liquid introducing means comprising conduit structure opening through the bottom of the tank means and plate means within the tank means, having a diameter equal to a minor fraction of the diameter of said tank means around it, disposed over said conduit structure for deflecting the introduced liquid to disperse it upwardly in the tank.

10. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column and to maintain continuous rise of liquid in the tank means to said overflow means, means including upper tank wall structure and cooperating adjustable partition wall means across the tank means for providing an upper extension of the tank means above the aforesaid level, partitioned from the overflow means, said partition wall means cooperating with the tank means to provide a narrowed upper portion in the tank means below said overflow means, said upper extension and said narrowed portion cooperating to maintain a higher rise velocity of liquid rising in the narrowed portion to said overflow means than in liquid below said narrowed portion, said partition wall means being adjustable in height for adjusting said last-mentioned rise velocity to vary the sizing action of the apparatus, means for introducing into the tank means a feed pulp of solid particles to be classified, including supplemental upright vessel means having a tangential inlet at the top for establishing a circular current of feed pulp in said supplemental tank means, to urge solid particles in the feed toward the wall of said tank means, means extending into the center of the upper part of said supplemental vessel means for withdrawing a portion of liquid therefrom, which is reduced in solids content by said circular current, and means at the foot of said supplemental vessel means and opening into the upright hindered settling tank means at a locality below the partition wall means, for conducting feed pulp of reduced water content into said hindered settling tank means, for classifying action thereon, and siphon discharge means opening at its lower end into the tank means at the foot

thereof and extending upward therefrom for removal of particles accumulated by hindered settling, said tank means including a horizontally enlarged tank portion at the foot thereof and surrounding said lower end of the siphon discharge means and said liquid introducing means, to provide a lower rise velocity of liquid in said portion than in tank regions above the same, and the aforesaid liquid introducing means being disposed below the siphon discharge means and comprising conduit structure opening through the bottom of said enlarged tank portion and plate means having a diameter equal to a minor fraction of the diameter of the said tank portion, disposed over said conduit structure for deflecting the introduced liquid to disperse it upwardly in the tank.

11. Hydraulic sizing apparatus comprising, in combination, upright tank means adapted to contain a column of liquid and having overflow means at a predetermined upper level thereof, means at the foot of said tank means for introducing a flow of liquid to effectuate hindered settling of solid particles within the liquid of said column and to maintain continuous rise of liquid in the tank means to said overflow means, means including upper tank wall structure and cooperating adjustable partition wall means across the tank means for providing an upper extension of the tank means above the aforesaid level, partitioned from the overflow means, said partition wall means

including a vertical partition member cooperating with the tank means to provide a narrowed upper portion in the tank means below said overflow means, said upper extension and said narrowed portion cooperating to maintain a higher rise velocity of liquid rising in the narrowed portion to said overflow means than in liquid below said narrowed portion, said partition wall means being adjustable in height for adjusting said last-mentioned rise velocity to vary the sizing action of the apparatus, means for introducing liquid pulp of solids to be sized into the tank means at a locality spaced from said narrowed portion, and means for discharge of solid particles from the foot of the tank means, as accumulating by hindered settling.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,899,056

August 11, 1959

Robert D. Evans

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 55, for "means extending into the center of the upper part" read -- for classifying action thereon, and means for --.

Signed and sealed this 3rd day of May 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents