

[54] **METHOD AND APPARATUS FOR CLASSIFYING FINE PARTICLE MATERIALS**

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[51] Int. Cl. **B04b 1/00**

[58] Field of Search **233/18, 7, 3, 27, 233/28, 1 R, 17**

[56] **References Cited**

UNITED STATES PATENTS

1,952,788	3/1934	Berlin.....	233/3 X
2,622,794	12/1952	Smith.....	233/7
3,285,507	11/1966	Shapiro.....	233/7
3,447,742	6/1969	Eriksson et al.	233/7

2,097,420	10/1937	Lyons.....	233/18
2,528,974	11/1950	Ritsch.....	233/18 X

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[57] **ABSTRACT**

Methods and apparatus are provided for classifying fine particles by the steps of feeding a slurry or slip to be classified into a rotating bowl centrifuge divided into two pool areas, one pool providing a relatively high speed helical path for said slip wherein coarse particles are thrown to the periphery of the bowl and carried outwardly and a second pool providing a relatively low speed path over a ribbon type conveyor wherein intermediate size particles are thrown into the ribbon conveyor and returned along the bowl periphery to the first pool where they are intermingled with the coarse particles there thrown out of suspension and discharged and an effluent port for the remaining slurry.

10 Claims, 4 Drawing Figures

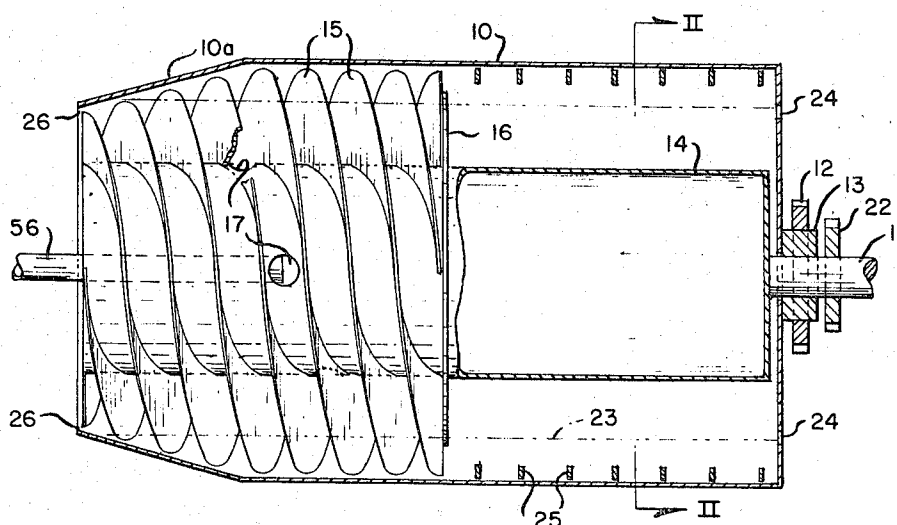


Fig. 1.

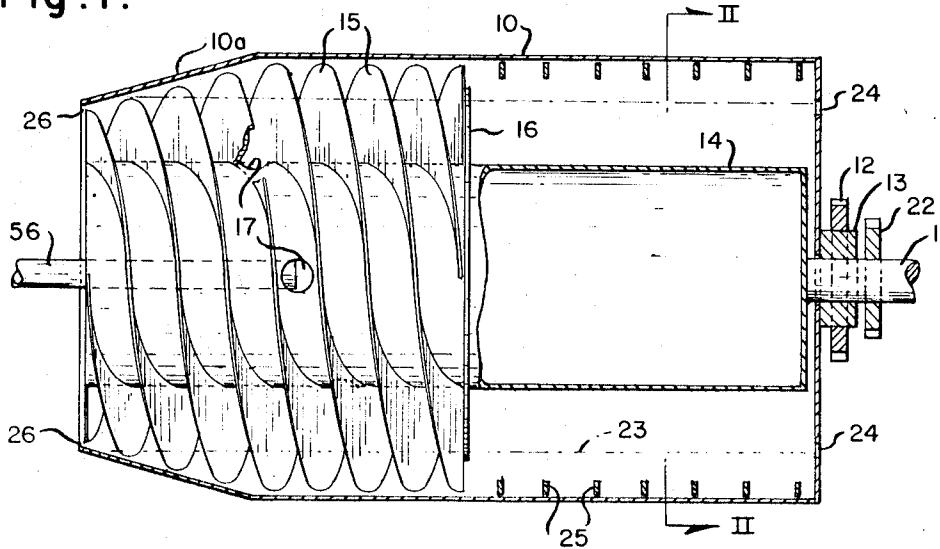


Fig. 2.

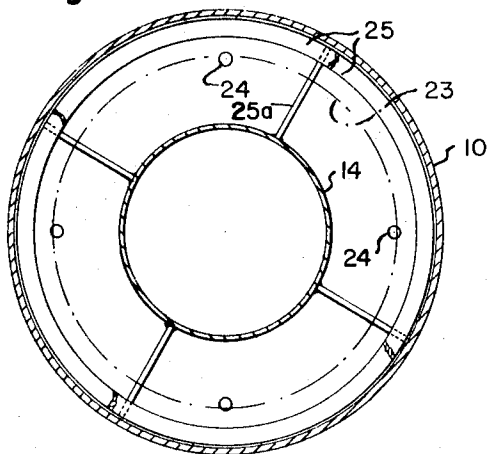


Fig. 4.

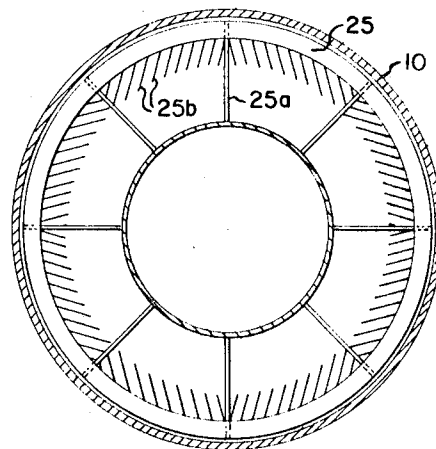
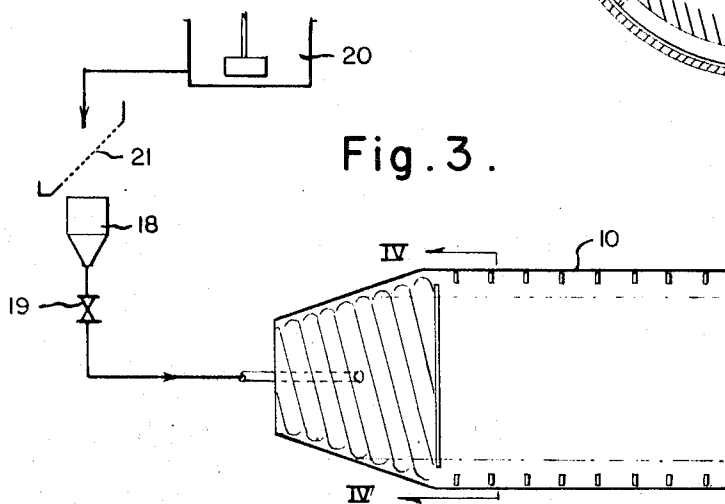


Fig. 3.



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METHOD AND APPARATUS FOR CLASSIFYING FINE PARTICLE MATERIALS

This invention relates to methods and apparatus for classifying fine particle materials such as kaolin and the like and particularly to a method and apparatus for centrifugally classifying and/or dewatering kaolin and other products which have a substantial proportion of subsieve particles which are so slow in consolidating as a centrifuge sediment that a conventional solid bowl scroll type centrifuge cannot effectively reject them from the sphere of centrifugation.

The use of continuous centrifugal machines for the classification of fine particle materials such as kaolin is not new. It is, in fact, probably the most widely used method of classification used in the kaolin industry to date. Accordingly the present invention will be hereafter described in the context of the kaolin industry and the classification of kaolin although it may be used equally advantageously in classifying other fine particle materials. The use of the centrifuge for classification of kaolins has been particularly prevalent since the issue of U. S. Pat. Nos. 2,085,538 and 2,097,420.

The concept of continuous centrifuges with spiral conveyors for use in classifying fine particle materials is likewise old, dating back at least to Van Kirk U.S. Pat. No. 775,320 and Berrigan U.S. Pat. No. 1,005,800. Machines of the type disclosed in those patents included sediment conveyors which were not fully submerged. These early centrifuges were not successfully commercially applied to the kaolin industry until about 1930, when the disclosures regarding the criticality of the rate of flow of the slurry through the centrifuge as well as its rotational speed, stability of volume of zone of sedimentation etc., were recognized and practical methods for their control disclosed in U.S. Pat. No. 2,097,420, mentioned above.

Although these continuous centrifuge techniques mentioned above were very satisfactory for processing kaolin and other similar fine products down to a certain range of fineness, it has been found that, beyond a certain limit of particle size, the capacity of a given centrifuge to produce yet finer products diminished far faster than would have been expected by consideration of the calculated lower sedimentation rates of the finer clay particles in the zone of centrifugation. As newer types of kaolin products have been introduced into industry, the need for centrifuges which can classify and/or dewater kaolin having substantial amounts of intermediate size particles, e.g. slightly $> 3 \mu$ e.s.d. and which do not respond to conventional centrifugal sedimentation to a degree sufficient to permit them to be conveyed and evacuated from the sphere of centrifugation has become increasingly apparent. Newer methods of delamination and newer fields of clay having different aspect ratios from the older mined fields has increased this problem. As a result the productive capacity of conventional centrifuges has drastically dropped. These newer types of kaolin products will often reduce the product capacity of a given conventional centrifuge from one half to as little as one fifth its normal output.

This problem makes it evident that something more than mere "Stokesian factors" are involved, and that more than the simple rate of individual particle sedimentation must be involved.

As has been pointed out above, the comparative "conveyability" of the sedimented particles on the bowl-wall plays a decisive role in the functioning of the centrifuge as a classifier — yet very little has been done to insure maximum effective removal of this sediment.

A " 3μ ," e.s.d. particle from one crude should by definition, settle at the same rate as a " 3μ ," e.s.d. particle of another clay.

However, if a " 3μ ," e.s.d. particle of one clay settles more firmly against the bowl than does the other, or if a " 3μ ," e.s.d. particle from one forms a dilatantly conveyable sediment more readily than does the other, — then it will be removed from the sphere of centrifugation more promptly than the other will, and this will permit additional particles to sediment into the space thus made available within the sphere of centrifugation, and the capacity of the centrifugal machine will be increased.

At least two properties of the sedimented particles appear to be involved. One of these is the minimum-size of particle which would settle to a firm, conveyable sediment in the helical flow-path of the conveyor, under the operating conditions of hydraulic friction, turbulence, etc. being developed therein. Another — and perhaps more important one — is the shape of the particle, in reference to the speed with which it will form a dilatantly conveyable sediment under the above conditions.

If the particles are relatively isometric or not platelike, they will pack to a dense sediment and/or one which will become dilatant easily.

On the other hand, I have found that if they are platelike, they are prone to form "heavy liquids" which are not dilatant enough to be propelled readily and which seriously retard the necessary subsidence of new particles through them.

Requisites For Conveyability of Sediment Out of the Bowl

It is still generally assumed that, in order to be propelled by the helical-conveyor of the centrifuge to the solids-discharge ports of the centrifuge-bowl, the oversize and/or heavier particles must be deposited upon the wall of the bowl in a sufficiently high degree of concentration or compaction so that they will be stiff enough to be wedged along the discharge path by the conveyor-flight even against the component of the centrifugal force at the discharge "beach." In many cases, this is the fact. However, in the case of the coarser-particle fractions of kaolin, a special condition exists, which is slightly different from that mentioned above.

I have found that these clay particles, when thus concentrated from aqueous, dispersed, suspensions to a range of from about 60 to about 70 percent solids, will instantly assume a dilatant rigidity if subjected to hydraulic-shearing, such as occurs due to the relative differential movement at the point of confrontation between the periphery of the helical conveyor-blade and the bowl-wall.

The vital role which is played by this dilatancy of the kaolin in its efficient centrifugal classification was overlooked for several years, until it was finally noticed that the centrifugal "cake" from these kaolin classifications would flow, by gravity, away from its point of discharge from the centrifuge — unless it were physically pushed

or sheared, in which case, it became rigid, like "quick-sand."

I also found that the coarser particle kaolin slurries became dilatant at lower concentration than those of finer particle kaolin.

Extensive commercial operation of continuous, solid-bowl, centrifuges of the "Bird" type in the classification of kaolins (while in aqueous suspension) has shown that, while the so-called "Stokesian principle" is an important factor in their functioning, it is by no means, the sole determinant of the particle-size of a fraction produced by these machines, as they are now commercially operated. As a result it is practically impossible to calculate the rate at which a given kaolin slurry could be fed to a given centrifuge rotating at a given speed in order to produce an effluent product of specified fineness content. The only known and practical way has been to start feeding the original kaolin (slurry) "slip" to the centrifuge at some chosen feed-rate and then check the fineness of the effluent ("fine-fraction") product. If the product be too fine, the feed-rate is increased slightly, until the desired product is obtained.

In practice, processing crude kaolins from a certain source, which tend to be of reasonably uniform quality, it has usually been possible to soon accumulate a background of operating experience which permits an acceptable control of the operation.

However, during regular commercial operations, there appear relatively minor, unexpected and unexplained, variations which still require fairly frequent rechecks of fineness and readjustments of feed-rate.

I have found that there are two significant reasons why sedimentation evacuation problems occur and a practical method for correcting them and their effects. First, as mentioned above, in order to be successfully and progressively exhausted from the centrifugal machine, the particles must become sedimented in a sufficiently compact and/or rigid form so that they will be propelled by the spiral blades, not only axially, along the bowl-wall, but also inwardly toward their point of exit — meanwhile, against the strong centrifugal effect. I have found that this necessary degree of rigidity can be — and, with kaolins, usually is — provided by the tendency of such sediments to become dilatantly rigid when subjected to hydraulic-shearing, — as between the centrifugal-bowl wall and the confronting conveyor — spiral blade.

Secondly, I have discovered further that the major reason why these intermediate sized particles fail to attain the necessary rigidity is,

1. Their particle-mass is so small that they cannot "push their way through the heavy liquid" which has already formed before they arrive at the centrifuge-wall;
2. The development of dilatant-rigidity in such intermediate-fine clay slurries occurs only at higher ranges of concentration than it does with coarser particles.

To illustrate the correlation between kaolin particles coarseness and its ability to be propelled by the helical conveyor of the centrifuge, two specimens of relatively different coarse-particle kaolin were selected, made into deflocculated, aqueous suspensions and their respective viscosities measured at different percent Solids concentration and at different rates-of-shear.

One specimen, labeled "B-2," contained 88.6 percent of particles coarser than 2μ , e.s.d. while the other "V-Flo" contained 30.5 percent of particles coarser than 2μ , e.s.d.

Each specimen was carefully made into a deflocculated, homogeneous, aqueous suspension at 65 percent solids, and its viscosity measured at 10 RPM, and again at 100 RPM, by means of the Brookfield viscometer.

Each specimen was then carefully diluted to 60 percent solids and the measurements repeated.

This was done again, at 50 percent solids.

The resulting test data is seen in the tabulation below.

TABLE I

Specimen	> 2μ , e.s.d.	Solids Conc.	Viscosity (Centipoises) Rate of Shear	
			10 RPM	100 RPM
"B-2"	88.6%	65%	144.	505
"	"	60%	40.	96
"	"	55%	8.	42.4
"V-Flo"	30.5%	65%	40.	94.
"	"	60%	20.	60.
"	"	55%	8.	32.

Note that slurry of the coarser-particle clay shows nearly the same viscosity values at 50 percent Solids and at low (10 RPM) rate of shear and even at the higher shear rate as does the finer-particle slurry.

However, when the concentration of both slurries is increased to 65 percent Solids, the viscosity of the coarse-particle slurry increases very much faster than does that of the finer material.

If the percent Solids content of the coarser slurry were increased by one or two percent more, its viscosity would have increased so fast as to go "off-scale" — and it would become dilatantly rigid and — incidentally, propellable by the centrifuge-conveyor.

To a lower degree, the viscosity of the finer slurry would increase, too — though not as rapidly.

It can be thus seen why it is so vital to efficient centrifugal classification that the finer particles be settled out from a less turbulent or fast-moving flow-stream, so as to permit these particles to be sedimented to a more compact and/or conveyable concentrate on the wall of the centrifuge bowl.

It has been recognized for some considerable time that in order to be propelled by the centrifuge conveyor along the wall of the centrifuge bowl to the reject ports, the intermediate-fine particles were very slow in settling out through the accumulated concentration of fine-particles in the outer zones to form the sediment on the bowl-wall, sufficiently rigid to be propelled by the conveyor.

In order to overcome this difficulty, spiral "sedimentation-accelerator" vanes were installed between the blades of the conveyor for the purpose of collecting and concentrating the fine-particles on the inner-faces of the vanes for rapid drainage toward the outer zones and simultaneously providing on the underside of these vanes a relatively unhindered path toward the center of the bowl for the fluid displaced by the sedimented particles on their way outward.

This method was disclosed in U.S. Pat. No. 2,625,320 and provided some relief from this operational handicap. However, the results were not as completely favorable as had been hoped for.

However, the structural features inherent in this type of unit had exerted one serious and adverse effect. Since the rate of slip through the helical channel was very high, it was necessary to install these spiral sedimentation vanes so that they approached very closely to the wall of the centrifuge bowl in order to deliver the sediment onto the wall and not to have it swept along by the fast-flowing fluid. This would probably have been acceptable, except that the peripheral tips of the sedimentation vanes then approached the centrifuge bowl wall so closely that the differential rotary movements of the bowl wall with respect to the conveyor and/or sedimentation vanes caused the vanes to stir the sediment as it approached the bowl wall, thereby forming a "heavy liquid" whose specific gravity was not sufficient to endow it with enough dilatant rigidity to cause it to be propelled forward by the conveyor.

I have discovered a novel process and apparatus for centrifugally classifying and/or dewatering kaolin and other products which contain a substantial proportion of subsieve particles which are characteristically so slow in consolidating as a centrifugal sediment that conventional solid-bowl scroll-type centrifuges cannot effectively reject them from the sphere of centrifugation.

My process consists essentially in feeding a fluid suspension (e.g. kaolin, H_2O , and a deflocculating agent) of fine-particle material through a constant-feed controller (which may consist of a constant-head tank with efflux-control valve) into a novel, continuous-operating, solid-bowl centrifugal of unique functional design.

At point of entrance of the feed-slurry, it is forced to follow a conical, helical flow-path formed by the centrifuge conveyor-flights which extend from the conveyor hub to the inner-face of the bowl wall.

After the feed-slip has passed through this helical path, it flows (preferably, around a slightly immersed circular baffle-plate) into an annular pool, extending toward the base of the centrifuge-bowl, assuming an axial flow-path to — and through — the effluent ports, at the pool level in the end of the bowl. (See FIG. 1).

Submerged in this effluent-pool is a ribbon-type conveyor, driven by the centrifuge-conveyor hub at an appropriate differential speed, and designed to deliver any sediment which falls between its blades into the conical, helical path preceeding it.

During its passage through the conical, helical path, the coarser particles are deposited on the inner wall of the centrifuge bowl, in spite of the rapid flow of the slip and are forced backward (against the direction of flow) and inward against the centrifugal effect to a point inward from the slip level in the effluent pool, whence they are ejected through the reject ports.

As the now partially depleted slip emerges from the conical, helical path into the annular, cylindrical pool — preferably, passing under a circular disc baffle-plate, slightly immersed in the pool (to reduce streaming flow, eddy-currents, etc.) — it will spread out into a stream about fifteen times wider than before and its speed of flow will be many times slower.

Then, intermediate-size particles which were too fine to remain sedimented to the bowl-wall in the previous channel, in view of the rapid flow in the conical, helical path, can settle out into the channel between the blades of the submerged ribbon-type conveyor.

Since these finer and less densely-sedimented, particles are not now subjected to the former rapid flow of supernatant slip, they can consolidate themselves sufficiently to be propelled by the ribbon-conveyor back toward the conical-helical flow-path where they are buried under — and blended with — the coarser particles there being sedimented out and, together, they will be forced toward the reject-ports, and ejected — thus maintaining the effluent pool more nearly free of "heavy-liquid" suspensions of these intermediate-size particles, so that more of them can be similarly separated from the effluent product slip.

This matter of consolidation of the partially sedimented particles is more vital to the effective operation of continuous centrifuges when classifying fine-particle products, like kaolins, than is generally realized.

There is still a common misapprehension that, if a particle has been centrifugally thrown part way out of the main supernatant slip-stream that "it is on its way out toward the reject-ports."

While this may be true, to a minor degree in the case of some products, and may be true of kaolins, it is a much more important fact that, if these particles are not rapidly consolidated into a propellable cake, they will not be promptly forced out of the sphere of centrifugation and will form a "heavy-liquid" suspension which effectively prevents any more particles from being settled out until this high-density slurry has been removed.

One of the basic advantages of this new design is to effect a necessary consolidation of the intermediate-size particles in the effluent pool which heretofore have tended to form a "heavy liquid" — type suspension while in the conventional helical flow-path. This did not suffice for propulsion and evacuation of these intermediate-size particles from the zone of centrifugation, — with result that they accumulated in the bowl and flowed over with the "fines" into the effluent product from present centrifuges.

It should be clear that with my "dual-pool" principle, the coarse particles are settled out almost immediately between the conveyor blades from a slurry flowing so fast as to carry the fines on until the stream becomes spread out about 15 times as wide, in the effluent-pool, whereupon it is ready to flow axially at rates which are so drastically reduced that the next finer particles can now settle out.

In my dual-pool construction, the somewhat finer particles settled from the effluent pool into the submerged helical-path on the ribbon-conveyor are not "attacked" by any significant spiral-flow current and can easily be propelled toward the reject end of the bowl where they will become "buried" under the rapidly advancing pool of coarse-particles sediment.

Since this new-type centrifuge embodies certain features, hitherto, not found in such machines it may be helpful to point out certain basic features of design.

As in any centrifuge of this general type, the sediment conveying capacity of the helical conveyor must be such that — at the end where the sediment leaves

the centrifuge bowl, its design — in respect to blade spacing, lead, and pitch must be of physical dimension somewhat larger than would be adequate to permit passage of the maximum load of sediment which could be centrifugally sedimented from the chosen type of clay, at the desired rate of feed. Moreover, this conveyor must be rotated at a different speed than the bowl so as to provide adequate propulsive effect and/or hydraulic-shearing effect between the periphery of the conveyor blades and the inner face of the bowl-wall so as to develop the necessary dilatant rigidity in the sediment, yet, without actually producing so much shearing as to induce resuspension of the sediment.

There is no known way to calculate these speeds, but extensive operational experience has shown that ratios in the range of 20:1 to 80:1 will usually produce usable results.

My new-type dual-pool centrifuge possesses one novel functional feature of particular advantage in the treatment of products within a relatively specific range.

Whereas, in the conventional helical-conveyor flow-path, it is practically impossible to reduce the rate of flow (and/or turbulence) except by cutting back on the rate of feed — which reduces the tonnage capacity of the machine — there are two changes in design which can be made in my dual-pool machine which will promote the rapid consolidation of sediment.

First, a reduction in the proportion of the pool which is helical can extend the effluent-pool, with its gentle axial-flow and, thereby, an increase in the sedimentation consolidation of the intermediate-size particles between the submerged, ribbon-conveyor blades. Some consideration, in this case, must be given to the proportion of coarse particles present in the feed, so that the spiral path is not made so short that they do not have an opportunity to settle out there, where they are needed to help push the reject inward, along the inclined "beach," against the centrifugal effect.

However, if the machine is being designed especially to classify clays containing only a relatively small proportion of coarse-particles, the helical section can advantageously be somewhat shorter than it would for clays with higher percent of coarse particles.

Secondly, it is comparatively simple to install sedimentation accelerator planes, axially, in the effluent-pool, inward from the inner edge of the ribbon-conveyor.

If the radial spokes, or arms, which project from the conveyor-hub toward the bowl-wall, to support the submerged ribbon-type conveyor, are laid-out in straight lines, parallel to the axis of rotational, they will demarcate a series of open parallel channels embracing space, bounded on the outside by the inner edge of the ribbon-conveyors and on the inside by the conveyor hub.

While these are somewhat wedge-shaped in the radial direction, they can provide an excellent location for mounting and supporting assemblies of sediment accelerator planes which will be partly immersed in the effluent pool (between the pool surface and the inner edge of the ribbon-conveyor flights).

While my new dual-pool type centrifuge probably could be used to good effect in the centrifugal classification and/or dewatering of many different types of finely divided materials, it is particularly useful when

classifying or dewatering fine-particle materials, like certain kaolins whose coarser particles are effectively sedimented out of suspension by the centrifugal force, even in the conventional rapid-flowing stream of the helical zone, but whose somewhat finer particles form a fluid, "heavy-liquid" type of sediment in this narrow, high rate-of-flow zone, but which can be sedimented out to a propellable concentration in the more placid flow of the "effluent-pool" zone, whence they can be propelled by a submerged, ribbon-type conveyor into the discharge end of the helical zone, where they will be blended with the coarser sediment already formed.

In the foregoing general description I have outlined the problems which the present invention overcomes, together with certain objects, purposes and advantages of the invention. Other objects, purposes and advantages of this invention will be apparent from a consideration of the following description and the accompanying drawings in which:

FIG. 1 is a longitudinal section of a dual pool centrifuge according to my invention;

FIG. 2 is a section on the line II—II of FIG. 1;

FIG. 3 is a typical flow diagram for the process using my new centrifuge for clay treatment; and

FIG. 4 is a section on the line IV—IV of FIG. 3 through the dual pool.

Referring to the drawings I have illustrated a centrifuge bowl housing 10 of cylindrical form having a truncated conical end 10a mounted on a generally horizontal shaft 11 and driven for rotation through a gear 12 fixed to the journal 13. Within the housing 10 and mounted on the shaft 11 is a conveyor hub 14 which carries a helical centrifugal conveyor 15 at one end and an intermediate baffle 16. The slip which is to be centrifuged is delivered through a pipe 56 into the axis of the conveyor hub and discharged through ports 17 in the hub into the area within the helical conveyor. The slip or slurry delivered by pipe 16 is preferably fed from a constant head tank 18 through a efflux control valve 19 into pipe 56. The constant head tank preferably receives slip from a blunger 20, the slip passing a screen 21 which removes oversize particles.

The slip entering ports 17 is forced to follow a conical helical flow path formed by the helical conveyor flights 15 which extend from the conveyor hub 14 to a point adjacent the inner face of the bowl housing 10. The conveyor hub 14 and the flights 15 are rotated by gear 22 on shaft 11. After the slip or slurry has passed through this helical path, it flows around intermediate circular baffle 16 into an annular pool 23 which extends toward the base of the centrifuge bowl and thence to and through the effluent ports 24.

Submerged in this annular effluent pool 23 is a ribbon type conveyor 25 adjacent to the inner wall of the bowl and fixed to and driven by the hub through radial arms 25a which extend from the hub 14 to the conveyor 25 as shown in FIGS. 2 and 3. Disc stacks or vanes 25b are provided between the ribbon conveyor convolutions as is common in ribbon conveyors at an appropriate differential speed with respect to bowl 10 and designed to deliver any sediment which falls between its blades into the conical helical path preceding it.

During its conical helical passage, the slip deposits its coarser particles on the inner wall of the centrifuge

bowl and these coarser particles are carried toward the conical head end 10a of the bowl where they are ejected through the reject ports 26. The partially depleted slip passes around the circular baffle 16 into the annular pool 23. It spreads out into a stream about 15 times wider than in the helical path and its speed of flow is reduced accordingly. At this point the intermediate size particles which were too fine to be sedimented in the helical path in view of the rapid slip flow in the conical helical path can settle out between the blades 25b of the submerged ribbon conveyor 25. These intermediate size particles can, since they are at this point free of the rapidly flowing slip, consolidate themselves sufficiently to be propelled by the ribbon conveyor back toward the helical conical flow path where they are buried under and blended with the coarser particles which are being sedimented out there and together they are forced toward the reject ports 26 and ejected.

While I have illustrated and described certain presently preferred embodiments and practices of my invention in the foregoing specification, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A method for classifying fine particle materials from a fluid slip comprising the steps of feeding a fluid slip containing coarse, intermediate, and fine particles into a rotary bowl centrifuge, dividing the slip within said bowl into two pools, passing the slip in one pool along a helical path at comparatively high speed to discharge coarse particles onto the bowl wall, then passing the slip through the second pool at slow speed across a rotating ribbon conveyor adjacent the bowl periphery to discharge intermediate size particles into the ribbon conveyor, discharging the remaining slip, conveying the intermediate particles into the first pool on the bowl periphery and intermingling them with the coarse particles and discharging the intermingled coarse and intermediate particles.

2. A method as claimed in claim 1 wherein the helical path is created by relatively rotating the centrifuge bowl and a helical conveyor which extends to the periphery of the bowl forming therewith a continuous helical path.

3. A method as claimed in claim 2 wherein the slip is divided into two pools by a circular baffle intermediate the bowl ends and spaced from the bowl periphery to provide a passageway along the bowl periphery from one pool to the other.

4. The method of classifying fine particle materials

from a liquid slip comprising the steps of

- a. feeding a liquid suspension to be classified having coarse, intermediate and fine particles into a rotating bowl centrifuge adjacent one end,
- b. subjecting said slip in one portion of said bowl to a conical helical flow path against the bowl interior whereby coarse particles are thrown onto the bowl wall,
- c. transferring the slip to an annular slower moving pool in a second portion of said bowl wherein intermediate particles are thrown onto the bowl wall,
- d. carrying the intermediate size particles counter to the slip flow to the said one portion where the coarse particles are thrown onto them,
- e. discharging the mixed coarse and intermediate particles from the said one end and,
- f. discharging the slip and suspended fine particles from the other end.

5. A method as claimed in claim 4 wherein the slip is fed at the axis of the helical flow path.

6. A method as claimed in claim 4 wherein the conical helical flow path is formed by relatively rotating a helical conveyor within one end of the rotating bowl.

7. A method as claimed in claim 4 wherein the bowl interior is divided into two portions by a rotating circular baffle intermediate the bowl ends and spaced from the periphery of the bowl to form a passage for said slip.

8. A centrifuge for classifying fluid suspensions having coarse, intermediate and fine particles comprising a rotatable cylindrical bowl, a rotatable shaft on which said bowl is rotated, means for independently rotating each of said bowl and shaft at appropriate differential speeds, a circular baffle on said shaft within said bowl intermediate the ends of said bowl defining two separate pools, a helical conveyor on said shaft on one side of said baffle, said conveyor extending to a point adjacent the periphery of the bowl, a ribbon conveyor means on said shaft whose outer periphery closely approaches the inner periphery of the bowl at the end opposite the helical conveyor and on the side of the baffle opposite the helical conveyor, an input port delivering slip to be centrifuged to the helical conveyor at one end of the bowl, a particle reject port at the same end of the bowl as the input port and a slip discharge port at the opposite end of said bowl spaced from its periphery.

9. A centrifuge as claimed in claim 8 wherein the input port is located at the axis of the bowl.

10. A centrifuge as claimed in claim 8 wherein the input end of the bowl is frusto conical in shape.

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