

Aug. 3, 1954

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2,685,369

COAGULATION OF FINELY DIVIDED SUSPENDED SOLIDS

Filed June 27, 1951

2 Sheets-Sheet 2

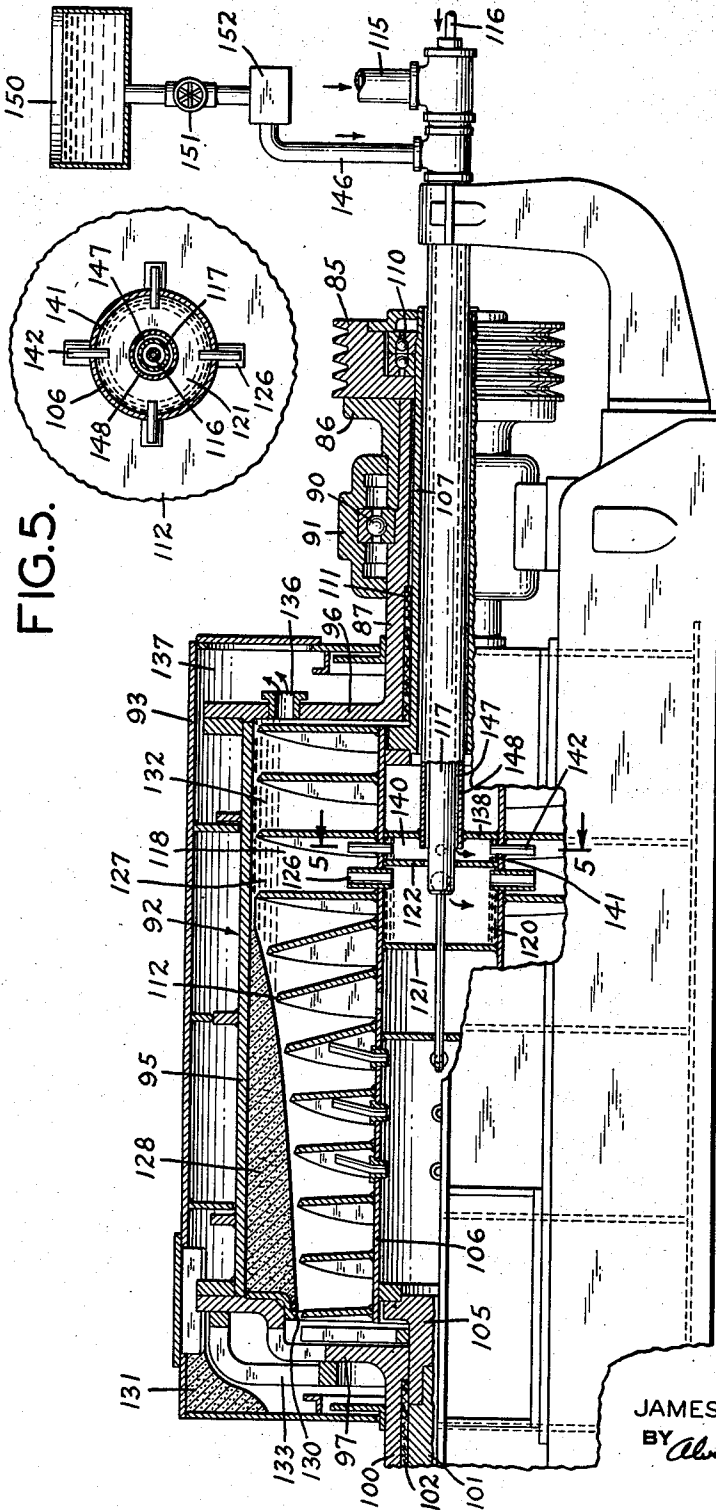


FIG. 5.

FIG. 4.

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2,685,369

COAGULATION OF FINELY DIVIDED
SUSPENDED SOLIDSJames E. Crossley, Collinsville, Ill., assignor to
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Application June 27, 1951, Serial No. 233,757

3 Claims. (Cl. 210—42.5)

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This invention is directed to improved method and means for separation and recovery of liquids from finely divided material suspended therein. More particularly, it is concerned with such separation procedures in which a flocculating agent is employed to assist the removal of finely divided insoluble material from suspensions in liquid or solutions.

In separating suspended material and recovery of clear solutions from e. g. slurries or muds, it has been the practice to store the liquid suspension in large vats to permit settling, whereupon clear liquor is withdrawn by decantation. The solid particles are frequently in such a fine state of subdivision that use of prolonged periods of settling prior to decantation and consequent large volume of settling-decantation vessels are required. It will be appreciated that from the standpoint of keeping plant investment at a minimum, affording maximum output of product from a given installation and providing flexibility of operation, the long settling time and resulting large volume of tanks are serious disadvantages. Various methods, such as diluting the slurry with greater amounts of water in order to increase the difference in density between solution and mud particles and thereby effect an increase in rate of mud settling, have been proposed. However, when it is desired to recover the solution components in concentrated form, resorting to dilution of the mud with water causes a decrease in economy of operation by reason of increased steam costs in evaporating said water in subsequent operating steps.

One object of the present invention is to develop improved method and means for separating finely divided and slow-separating suspended foreign material from liquid containing the same, particularly such method and means for separating digest mud from mixtures with aluminum sulfate liquors obtained in the sulfuric acid-clay digestion method for manufacturing alum.

The invention and the manner in which the objects stated above are accomplished may be understood by considering the drawings in which like reference numbers designate equivalent parts on the various figures.

Figure 1 represents an elevation view of one type of machine of the present invention with part of the machine broken away and shown in section. Figures 2 and 3 are vertical and horizontal sections, respectively, of the central element of the rotor of the Figure 1 machine, illustrating certain variations of the invention. Figure 4 is an elevation view of another type of ma-

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chine built according to the present invention with certain portions thereof broken away and shown in section. Figure 5 is a vertical section taken at plane 5—5 of Figure 4.

The invention will first be described in connection with Figure 1, which represents one embodiment. The stationary housing of the machine is indicated generally at 10 and is securely mounted on supporting brackets not shown. Spider 11 supports bearing 12, within which turns shaft 15 driven by belt and pulley 16. Shaft 15 extends through stationary collar 17 and is attached at the bottom end to head piece 20. Head piece 20 has a radially disposed apron or skirt 21 having ribs 22 which interlock with ribs 25 on basket or bowl 26, thereby transmitting motion from shaft 15 to basket 26. Lock ring 27 is provided to permit dismantling of the centrifuge basket 26 when desired. Sleeve 37 which surrounds shaft 15 and the upper part of head 20 is supported on skirt 21 and spaced therefrom by knobs 40. Sleeve 37 supports, in turn, conical discs 46 which are spaced from each other by knobs or detents 48. The weight of basket 26 and its contents are carried by skirt 21 and shaft 15. The outermost periphery of basket 26 is provided with multiple spaced nozzles 42, communicating with discharge manifold 51, leading in turn to recirculating line 52—56 via ports 53 in the manifold. The rotor, or rotating portion of the centrifuge machine comprises shaft 15, head 20, basket or bowl 26, sleeve 37 and discs 46.

According to the present invention, feed material containing liquid and solid material to be separated, preferably after preliminary settling or classification to remove the largest of the insoluble particles (primarily to reduce attrition on metallic parts) and to prevent plugging nozzles 42, is introduced through pipe 30 and enters the annular space 31 between stationary collars 17 and 32. It will be understood that up until the time the feed material reaches approximately the point 35 at the outlet of annular passage 31, the liquid is still flowing in a straight line, as distinguished from rotational, flow, i. e. it has not yet been subjected to the shearing action which inevitably accompanies introduction of the straight line flow liquid into a body of rapidly rotating liquid in the centrifuge machine. The feed enters annular inlet zone 36 formed between sleeve 37 and head 20, said zone having an appreciable radial component of direction and in which the liquid is first subjected to rapid rotation and resultant

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shearing. The liquid feed passes underneath the bottom edge of sleeve 37 (supported on head 29 by multiple knobs 40) and enters separating zone 41 of enlarged radial dimension. The present invention provides for supplying flocculating agent to the feed slurry at such a point in the system that the material within separating zone 41 is subjected to flocculation and the effect of enhanced separation of solid particles from liquid produced by reason of the presence of said agents. High centrifugal force in separating zone 41 produced by the high rotational speed of basket 26, coupled with the enhanced flocculating effect of the agent produce the advantageous separation of fines from liquid according to the present invention whereby solid material is induced to pass through multiple nozzles 42 while substantially clear solution or liquid passes through passageways 45 between inclined discs 46. Discs 46 assist clarification of the liquor by providing surface on which the solid particles can settle and inducing by friction outward movement of particles of insolubles that come into contact with the discs. The liquid, under the hydrostatic head of the feed introduced at 30, passes upwardly through the annular discharge passage between sleeve 37 and basket 26 and over discharge lip 47 at the top of the basket and into discharge conduit 50. Part of the "underflow" discharged through nozzles 42 and entering manifold 51 and recirculating pipe 52 is normally discharged through valve and pipe 55 and part is normally recirculated via pipe 56 and port 57 in the bottom of basket 26 as indicated by the flow arrows. The recirculated liquid passes through apertures between skirt 21 and bowl 26 into separating zone 41 as shown. Wash liquid may be introduced through valve and piping 66 if needed.

A particular feature of the discovery of the present invention is that by introducing flocculating agent into the feed stream in such a manner and at such a point in the stream as to effect dispersion of the flocculating agent through the liquid downstream from the point at which said feed is first subjected to shear, remarkably improved separation of solid from liquid is realized. Pursuant to this feature of the discovery inlet pipe 61, communicating with the annular passage between rotating shaft 15 and stationary collar 17, is provided. Through this pipe the flow of flocculating agent, supplied from vessel 62 controlled by valve 65 and metered at 66, is supplied. This stream of flocculating agent is added to the main flow of feed material from pipe 30 at the point at which said feed flow is first subjected to the shearing action aforesaid. Since an appreciable interval of time is required to effect dissemination of the flocculating agent through the feed material, it is apparent that dispersion of the flocculating agent through the liquid is effected downstream from the point at which the feed is first subjected to shear. The stream of liquid, now comprising feed plus flocculating agent, passes downwardly through inlet zone 36, under the bottom of sleeve 37 and into separating zone 41 where enhanced effect of the flocculating agent in separating solid from liquid is utilized as described above. Broadly considered, the invention comprises adding flocculating agent at any point between 35 (where the feed is first subjected to shear) and the discharge of separating zone 41, preferably sufficiently adjacent to the point of first shear to permit adequate centrifuging of the feed to effect dispersion

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of the flocculating agent in zone 36 and separation of solid in zone 41 before discharge of liquid and solid from separating zone 41. A particular embodiment of the invention comprises adding flocculating agent prior to the point at which the stream enters separating zone 41, i. e. between points 35 and 40 which define the radially directed inlet zone.

Modifications of the invention are illustrated in Figures 2 and 3 which provide for introduction of flocculating agent through axially disposed passageway 67 in shaft 15 and subsequent flow of the agent through multiple radial passages 70 in head 20. The feed material is first subjected to shear above the outlet of passage 70 and hence the flocculating agent and feed are mixed in inlet zone 36 after the point at which the feed is first subjected to shear.

A further embodiment of the invention provides for removing threaded plugs 72, inserting similar plugs in passageway 7 and provide for flow of flocculating agent only through radial passageways 72. The latter arrangement also contemplates introducing the flocculating agent within inlet zone 36 after the feed is first subjected to shear and before the feed enters separating zone 41.

Figure 4 represents a different, i. e. horizontal type centrifugal machine constructed according to the present invention. Pulley 85, driven by belts and motor not shown, is connected via flange 86 to cylindrical sleeve 87 rotating on bearing 90 within pillow block 91. Sleeve 87 is connected to centrifugal basket indicated generally at 92, housed in stationary casing 93, said basket comprising cylindrical section 95 and end wall sections 96 and 97, all of which are adapted to rotate at high speed about their horizontal axes. Wall section 97 is connected to sleeve 100 which engages a gear unit not shown on the drawing. The motion of pulley 85 and bowl or basket 92 is transmitted through said gear unit to internal shaft 101 (separated from shaft 100 by packing 102), trunnion 105 and conveyor hub 106. At its opposite end, hub 106 is connected to internal sleeve 107, which rides on bearings 110 and is separated from shaft 37 by packing 111. Hub 106 is provided with helical conveyor blades 112 which, by reason of the slight relative rotation between bowl 92 and hub 106, are adapted to move material within the bowl to the end of the machine represented by the left end of the Figure 4 drawing.

Feed slurry (preferably after preliminary settling or classification to remove the largest particles of solid) enters the machine through pipe 115 and passes through the annular space between inner wash pipe 116 and pipe 117. The feed emerges from said annular space and enters inlet zone 118 formed between the outlet of pipe 117 and separating zone 127. The feed first falls into pool 120 on the inside of hub 106 and between partitions 121 and 122, said pool being in the form of a cylinder by reason of centrifugal force. Feed liquid overflows from pool 120 into multiple overflow pipes 126 and enters separating zone 127 internally of bowl 92. Pipes 126, which facilitate rotational flow of liquid thereby minimizing disturbance of the liquid as it enters pool 132 in separating zone 127 may be short as shown in Figure 4, or may extend into pool 132. Due to high centrifugal force, the denser solid particles of the mud tend to concentrate on the inner surface of cylinder 95 and are pushed to the left forming bed 128 which is dis-

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charged over a weir 130 into the underflow connecting manifold 131 in stationary casing 93. Underflow is forced from manifold 131 by means of plow 133 attached to end wall 97 and discharged from manifold 131 through a port not shown, near the bottom of the casing.

The overflow from bowl 92 builds up in pool 132 in separating zone 127 and the clear liquid near the axis of bowl 92 overflows through discharge ports 136 into overflow collecting manifold 137 in casing 93. The overflow is likewise withdrawn from the casing through a port near the bottom of the casing which is not shown in the drawing.

In the manner indicated above, the present invention provides for supplying an agent having flocculating properties in separating zone 127 and subjecting the feed while in said zone to the combined action of said agent and centrifugal force thereby markedly to increase the effectiveness of the centrifugal force in separating the materials of different densities, i. e. the less dense liquid and the relatively more dense dispersed solid. The liquid flowing through the annular space between pipes 116 and 117 is non-rotating as distinguished from rotational flow, i. e. the flow of a body of rapidly rotating liquid in a centrifuge machine. The stream is first subjected to the shearing action as it enters pool 129. Accordingly, the invention broadly comprises adding flocculating agent in the region from pool 120, to discharge ports 136 preferably in inlet zone 118.

A particular embodiment of the invention comprises supplying an additional partition 138 to the right of partition 122 forming a zone 140 containing flocculating agent in pool 141 which overflows through multiple radially disposed distributing pipes 142 into separating zone 127. Pipes 142 which may be short as shown or may extend into pool 132 facilitate rotational flow of flocculating agent entering pool 132, thereby minimizing disturbance of the liquid. Flocculating agent is supplied to zone 127 through feed pipe 146 which communicates with annular passage 147 between external pipe 148 and pipe 117, said annular passage discharging into pool 141. A flow of flocculating agent from pipe 146 is established from storage vessel 150 via flow control valve 151 and meter 152. According to the latter embodiment of the invention, flocculating agent and feed are first mixed substantially at the end of inlet zone 118, i. e. after the feed is first subjected to shear so as to permit dispersion of agent through the feed after first shearing the feed liquid.

A further embodiment comprises omitting partition 122 so that flocculating agent from annular space 147 enters pool 120 directly, thereby effecting dispersion of flocculating agent through the feed liquid after the point at which the feed is first subjected to shear, i. e. pool 120. The mixture thereafter flows through pipes 126 (preferably elongated to reach pool 132) into the pool. If desired, pool 120 and distribution pipes 126 also may be dispensed with and feed and flocculating agent permitted to fall directly into pool 132 in separating zone 127. It will further be noted that, in accordance with the principles stated above, introducing flocculating agent into pool 120 or directly into pool 132 provides for addition of agent in the region from the point at which the feed is first subjected to shear (pool 120 or pool 132, as the case may be) to overflow pipe 136 at the discharge end of separating zone 127.

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As exemplifying the size of machine suitable for the purpose of the present invention, in the Figure 1 apparatus, the inside diameter of the basket 26 may be 9 inches. The distance from port 57 to discharge lip 47 may be $9\frac{3}{4}$ inches. The outside diameter of apron 21 may be $6\frac{3}{4}$ inches. The approximate length of inlet zone 36, i. e. between points 35 and 40 may be 5 inches. Separating zone 41 may have capacity of 2 gallons. Discs 46 may be 28 in number, disposed at 45° from the horizontal and $1\frac{1}{8}$ inches long in section. With respect to the Figure 4 apparatus, cylinder 95 may be 13 inches in diameter and the distance between end walls 96 and 97 may be 28 inches. Separating zone 127 may have capacity of 5 gallons. The Figure 1 apparatus may suitably operate at about 6600 to 9000 r. p. m., thereby producing centrifugal force of 5400 to 10,000 times gravity; and the Figure 4 apparatus operated at 2000 to 2500 r. p. m. thereby producing a force equal to 1000 to 1500 times gravity. The principle of this invention applies when operating with any elevated degree of centrifugal force, but lower forces generally require longer retention time in the separating zone, as described below. Hence it is preferred to operate with centrifugal force not less than about 1000 times gravity. The use of this invention is not limited to machines of the above dimensions since such dimensions vary in accordance with type and size of equipment.

The foregoing method and apparatus have general application where it is desired to separate finely divided insoluble material from liquid containing the same. Specific instances for using the present invention include recovery of sulfuric acid from sludge obtained via scrubbing impure sulfuric acid synthesis gases; removal of gypsum from phosphoric acid in the manufacture thereof by treatment of phosphate rock with sulfuric acid; removal of solids from mixtures resulting from the treatment of aluminous materials with acids and alkalis; and recovery of oxide of titanium from ilmenite ore.

The flocculating agent employed in each instance may depend largely on the particular foreign material to be removed and the particular solution to be clarified. Suitable flocculating agents which may be mentioned include prosein (a protein material derived from soya bean) glue-sulfide (equal parts of animal glue and 60% sodium sulfide) and animal glue alone. In each case the flocculating agent is first dispersed in a suitable solvent such as water to facilitate distribution thereof through the material to be treated.

It has been found that the method and apparatus outlined above may be advantageously applied to separation of aqueous aluminum sulfate solutions from insolubles in the manufacture of aluminum sulfate by the sulfuric acid-clay digestion process. In the commercial process for making aluminum sulfate from clay or other aluminous material, the starting material, either in the raw state or after calcination to remove water and render the clay more susceptible to subsequent attack by sulfuric acid, is digested with strong sulfuric acid to convert the combined aluminous materials in the clay to aluminum sulfate. The product of digestion is diluted with water or weak aluminum sulfate solution to dissolve out sought-for aluminum sulfate. The slurry so formed is introduced into large settling tanks to permit undissolved and insoluble portions of the clay (referred to as digest mud) to settle until the height of the mud level drops to about

35% or less of the total column of diluted reaction mixture. Clear supernatant liquor is withdrawn through stand pipes and concentrated in steam heated evaporators to alum, cake strength. The mud may be reslurried in water and subjected to resettling to recover aluminum sulfate present in mud liquor. The solid particles of the digest mud are generally in such a fine state of subdivision that use of prolonged periods of settling prior to decantation, e. g. up to 24 hours or more in some cases and consequent large volumes of settling-decantation vessels are necessitated. According to the present invention, more effective and efficient recovery of clear aluminum sulfate solution from aluminum sulfate slurries may be realized without incurring the disadvantages of increased steam costs for evaporation or excessive investment in unduly large settling tanks which were inherent in previously proposed method and means (i. e. dilution of slurry to increase density differences and thereby speed settling) for improving recovery of aluminum sulfate.

It has been found that in the case of aluminum sulfate recovery, animal glue is a particularly effective flocculating agent, said glue being used according to the method and means described generally and in detail above. Hence, one specific embodiment comprises supplying means for and utilizing glue as flocculating agent in recovery of aluminum sulfate from slurries according to the invention described above. For example a rapidly rotating body of liquid is maintained in a centrifuge machine and a non-rotating stream of slurry to be centrifuged is added to the rotating body thereby to create a zone of shear between the feed of non-rotating slurry and the rotating liquid. Centrifuged clear liquid is withdrawn from the rotating body. An aqueous glue solution is introduced to the rotating body of liquid substantially in the region but after the point at which the slurry feed stream is first subjected to shear upon introduction into the rotating body of liquid undergoing centrifuging.

The flocculating agent, e. g. glue is used in amount sufficient to effect the degree of removal of insolubles desired. Excessive amounts of glue do not appreciably increase the efficiency of clarification. A suitable concentration range of glue in the aluminum sulfate solution affording usual efficient operation without undue waste of glue is 0.50 to 1.12 grams of dry glue per gallon of solution to be clarified.

A further significant variable is the concentration of glue in the glue solution to be added to the slurry. In concentrations below about 0.1 lb. of dry glue per gallon of water appreciable decrease in effectiveness of the flocculating agent may be noted and hence concentration is preferably maintained not less than about 0.1 lb. of dry glue per gallon of water. To facilitate dispersion of the flocculating agent into and through the process material and efficient utilization of glue, concentration of glue in the solution is preferably maintained not greater than about 0.2 lb. per gallon of water although higher concentration may be used if desired. By maintaining glue solution concentration in the range approximately 0.1 to 0.2 lb. per gallon of water, adding such solution at the rate of about 30 cc. or more per gallon of aluminum sulfate slurry to be clarified, according to the technique outlined above, effective clarification of the aluminum sulfate digest mud may be obtained.

The slurry being treated is retained in the cen-

trifuge machine under the influence of flocculating agent and centrifugal force for time sufficient to effect the degree of clarification desired. As previously indicated, the effect of centrifugal force in producing separation of insolubles is aided by the presence of discs in the separating zone, and hence the retention time required for effective clarification will be determined by the presence of the discs as well as the centrifugal force. The retention time, of course, will be controlled by the rate of flow of feed material and influenced by the volume of the centrifuge bowl or basket. It will be understood that generally, large volume machines will accommodate larger flow rates while still affording the required retention time and, conversely, small volume machines will normally accommodate only smaller flow rates. Using a machine of the type described in Figure 1, having dimensions and operating according to the procedure described above, retention time of the order of 0.66 to 0.25 minute (corresponding with rates of flow of feed of 3 to 8 G. P. M., respectively) may be found to produce suitable clarification. Operating with the type of machine described in Figure 4 having dimensions indicated above and operating according to previously described procedure, retention times in the range approximately 5 to 1 minutes (corresponding with feed rates of 1 to 5 G. P. M., respectively) may be suitable. For any given installation and set of conditions, retention time and rate of flow of feed may best be determined by making test runs and noting results.

Requirements of product quality may vary, but in manufacture of high grade alum, it is preferred to reduce content of insoluble in the clarified solution to below about 0.1% (corresponding with about .25% based on the final 17.2% Al_2O_3 solid product). Efficiency of clarification may be measured by the volume ratio of overflow having acceptable clarity to underflow (containing the majority of the insolubles). In the interest of high capacity and efficient operation, and to realize advantages of the invention, conditions are preferably maintained so as to produce volume ratio of overflow (having not more than about 0.1% insolubles) to underflow not less than about 3.

The apparatus and procedure of this invention were found to be effective in clarifying aluminum sulfate solutions of substantially any $Al_2(SO_4)_3$ strength, e. g. in the range 1° Bé. to 40° Bé. Within the limits of operativeness of the flocculating agent, the procedure may be carried out at any temperature, i. e. temperatures as low as 70° F. and as high as 200° F. have been found to be suitable in clarifying aluminum sulfate digest muds with glue as flocculating agent.

The clarification procedure of the invention has been described chiefly as being carried out continuously, but batchwise operation is not thereby excluded. For example, a batch of feed material may be introduced to the centrifuge basket, a proportionate amount of flocculating agent added thereto, the mixture centrifuged, sediment removed from the basket and the clarified solution subsequently recovered.

Although this invention is not limited to any specific theory, I believe that the flocculating agent in some fashion probably causes agglomeration or flocculation of the finely divided and slow settling particles into relatively larger, more rapidly settling agglomerates or flocks, thereby facilitating separation of insolubles from the body of the solution. When the feed stream passes

through the zone of shear upon entering the rotating basket of the centrifuge, any such flocks or agglomerates previously formed are somewhat disintegrated, thereby diminishing the previous beneficial result of flock formation. Hence, according to a particular embodiment of the invention, by adding flocculating agent in the region from the point where the feed stream is first subjected to shear to the separating zone, the flocks or agglomerates after once being formed are not subjected to further shearing or other violent agitation which might result in breaking up of the agglomerates. Hence, the effect of flock formation in improving settling characteristics is preserved until the suspension reaches the separating zone wherein insolubles and solution are separated from each other.

The following example illustrates practice of the present invention carried out with apparatus described in Figure 1, the parts and percentages being by weight.

Example

The aluminum sulfate slurry chosen for test was produced by sulfuric acid treatment of calcined clay. Prior to centrifuging, the slurry was permitted to settle for a short time to remove the largest particles of insolubles. This slurry, having 3.8% solids, aluminum sulfate content equivalent to 8.48% Al_2O_3 and specific gravity of 37.1° Bé. at 60° F., was introduced at the rate of 5.4 G. P. M. through feed pipe 30 of the Figure 1 apparatus. The feed temperature was 190° F. (34.6° Bé.). The machine speed (no load) was 6,510 R. P. M. Nozzles 42 were .052 inch in diameter. An aqueous glue solution containing 1.5% glue on a dry basis was introduced through pipe 51 at the rate of 30 cc. per minute per gallon aluminum sulfate slurry (corresponding with 0.001 lb. per minute of dry glue per gallon aluminum sulfate slurry). No wash water was introduced through pipe and valve 66. Underflow was withdrawn from pipe and valve 55 at the rate of 1.3 G. P. M. and overflow through pipe 53 at the rate of 4.1 G. P. M. With these conditions the overflow contained 0.06% solids (which corresponded with 0.13% solids based on the 17.2% Al_2O_3 aluminum sulfate produced after evaporation of the solution) and was 35.5° Bé. at 60° F. The underflow contained 17.3% solids and was 37.8° Bé. at 60° F. The percentage of feed solution recovered in the overflow was 80% and the recovery of solids in the underflow was 99%.

The foregoing example illustrates single pass operation. If desired, the underflow, containing substantially all of the solids and a certain amount of the aluminum sulfate present in the original feed, may be reslurried with additional water, then treated again in a separate centrifuge machine with additional flocculating agent to effect recovery of residual amounts of aluminum sulfate. By such treatment of digest muds in a series of centrifuging operations, any desired proportion, e. g. preferably 98 to 99%, of the original aluminum sulfate may be recovered as clear aluminum sulfate solution.

I claim:

1. A two zone continuous method for separating finely divided suspended solid material from liquid containing the same which comprises in a first dispersing zone rotating a body of said liquid containing finely divided suspended solid material without substantial turbulence about an axis in a dispersing zone disposed near said axis at a linear velocity sufficient to effect dispersion

of added flocculating agent to the rotating body of liquid in the dispersing zone without effecting substantial separation of suspended material from the liquid in said dispersing zone, continuously introducing a non-rotating stream of liquid containing finely divided suspended material to the dispersing zone through conduit means located near said axis thereby to create a zone of shear between said feed of non-rotating liquid and said rotating liquid in said dispersing zone, continuously introducing through axially disposed conduit means a flocculating agent to said rotating body of liquid in the dispersing zone after the point at which said feed liquid is first subjected to shear, continuously flowing the liquid containing finely divided suspended solid material and dispersed flocculating agent from the first rotating body of liquid in the dispersing zone without subjecting said liquid to shearing and violent agitation which would result in breaking up of flocs to a second separating zone containing a body of liquid rotating about the axis at a higher linear velocity than the rotating body of liquid in the first dispersing zone and with sufficient velocity to effect separation of finely divided suspended solid material from the liquid by centrifugal force, continuously removing said separated solid material from the second zone, and continuously discharging clarified liquid from the second zone.

2. A two zone continuous method for recovery of aluminum sulfate solution from liquid containing the same and insoluble material produced in the sulfuric acid-clay digestion process for manufacture of aluminum sulfate, which comprises in a first dispersing zone rotating a body of aluminum sulfate solution containing insoluble material without substantial turbulence about an axis in a dispersing zone disposed near said axis at a linear velocity sufficient to effect dispersion of added flocculating agent to the rotating body of liquid in the dispersing zone without effecting substantial separation of suspended material from the liquid in said dispersing zone, continuously introducing a non-rotating stream of aluminum sulfate liquid containing insoluble material to the dispersing zone through conduit means located near said axis thereby to create a zone of shear between said feed of non-rotating liquid and said rotating liquid in said dispersing zone, continuously introducing through axially disposed conduit means a flocculating agent to said rotating body of liquid in the dispersing zone after the point at which said feed liquid is first subjected to shear, continuously flowing the aluminum sulfate liquid containing insoluble material and dispersed flocculating agent from the rotating body of liquid in the first dispersing zone without subjecting said liquid to shearing and violent agitation which would result in breaking up of flocs to a second separating zone containing a body of aluminum sulfate liquid rotating about the axis at a higher linear velocity than the rotating body of liquid in the first dispersing zone and with sufficient velocity to effect separation of suspended material from the liquid by centrifugal force, continuously removing said separated solid material from the second zone, and continuously discharging clarified aluminum sulfate liquid from said second zone.

3. A two zone continuous method for recovery of aluminum sulfate solution from liquid containing the same and insoluble material produced in the sulfuric acid-clay digestion process

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for manufacture of aluminum sulfate, which comprises in a first dispersing zone rotating a body of aluminum sulfate solution containing insoluble material without substantial turbulence about an axis in a dispersing zone disposed near said axis at a linear velocity sufficient to effect dispersion of added flocculating agent to the rotating body of liquid in the dispersing zone without effecting substantial separation of suspended material from the liquid in said dispersing zone, continuously introducing a non-rotating stream of aluminum sulfate liquid containing insoluble material to the dispersing zone through conduit means located near said axis thereby to create a zone of shear between said feed of non-rotating liquid and said rotating liquid in said dispersing zone, continuously introducing through axially disposed conduit means a flocculating agent comprising an aqueous glue solution of concentration in the range of 0.1 to 0.2 lb. dry glue per gallon of water and in amount corresponding with 0.50 to 1.12 grams of dry glue per gallon of aluminum sulfate liquid feed to said rotating body of liquid in the dispersing zone after the point at which said feed liquid is first subjected to shear, continuously flowing the aluminum sulfate liquid containing insoluble material and dispersed flocculating agent from the rotating body of liquid

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in the first dispersing zone without subjecting said liquid to shearing and violent agitation which would result in breaking up of flocs to a second separating zone containing a body of aluminum sulfate liquid rotating about the axis at a higher linear velocity than the rotating body of liquid in the first dispersing zone and with sufficient velocity to effect separation of suspended material from the liquid by centrifugal force, continuously removing said separated solid material from the second zone, and continuously discharging clarified aluminum sulfate liquid from said second zone.

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