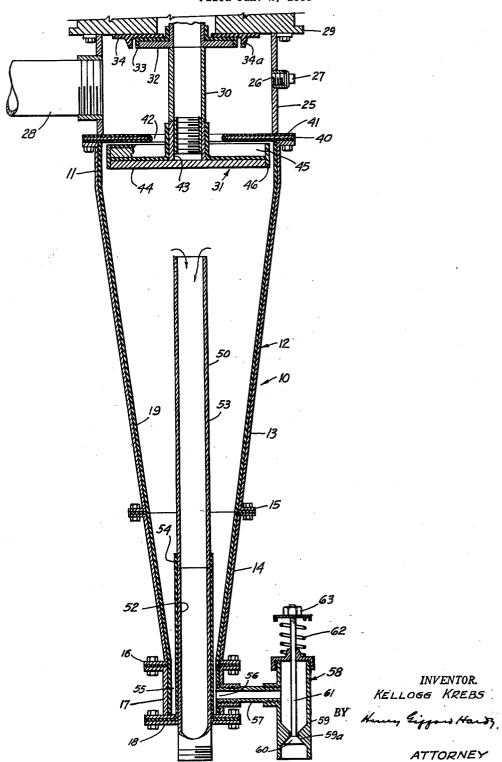
CENTRIFUGAL CLASSIFIER

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1

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CENTRIFUGAL CLASSIFIER

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This invention relates to centrifugal classifiers. More particularly, it relates to a continuous centrifugal classifier for wet operation in the sharp classification of finely divided materials suspended in a fluid. Such suspended materials may consist of solids or semisolids such as rubber, elastomers, discrete gels or wastes or organic substances.

It is particularly effective to sharply classify at 200 mesh with feeds of from 48% to 68% solids and have as little as 5% of the minus-200 in the underflow and no plus-200 in the overflow.

The present invention finds particular use in the cement and other industries where the slurry to be separated comes directly from a ball mill or the like. Further, this invention makes possible the creation of a feasible and simple attained closed circuit in cement manufacture with water content results which are comparable to open circuit wet grinding and with an increase in production of 30% to 50%. When used with the long tube mills, the increase in flow rate of the high density pulp made possible for the first time, greatly reduces overgrinding of the fines and eliminates the undesired tramp oversize.

The flexibility of operation of the present apparatus is one of its remarkable advantages. It may be used to make precision cuts of micron sizes with dilute slurries. As 40 the pulp density and viscosity increase, the need for the flexibility in the time and force relationship becomes more necessary.

One of the objects is to provide a device which will bring finely divided particles into the overflow at high 45 density.

Another object is to provide equipment capable of separating particles of different sizes without upsetting the water balance, or abating it positively, maintaining the water balance in the underflow and overflow. This provides maximum density in the overflow.

A further and important object is the provision of a centrifugal separator which is a full pressure device during operation, eliminating the vacuum which is required and is common to all other cyclonic separators.

In a co-pending application, Serial No. 220,434 entitled "Continuous Centrifugal Separator," filed April 11, 1951, by Norris Goodwin, now patent No. 2,701,642, there is described and claimed a continuous centrifugal separator of the cyclone type in which, however, the fluid mixture to be separated, instead of being introduced tangentially through a restricted orifice into the separating chamber, is introduced initially into a feed chamber and then to a rotating solid impeller having radial vanes. By this means any desired angular velocity can be imparted to the fluid mixture and so delivered to the separating chamber, dependent only upon the speed of the motor and the mechanical design of the apparatus. The rapidly moving fluid to be treated is delivered peripherally to the separating chamber, free of eddies and turbulence. with the creation of a free vortex within the separatory The heavier or larger particles of suspended

2

material are separated by centrifugal force and move downwardly along the wall to the bottom of the conical chamber where it is axially removed; the lighter and smaller particles together with the liquid medium move upwardly through an axial outlet at the top of the conical chamber into a collecting chamber where it is removed.

It is an object of the present invention to provide an improved type of centrifugal separator, employing the principles of free vortex centrifugal separation, in which a sharper separation of suspended particles can be achieved.

Another object of the invention is to provide a centrifugal separator wherein difficulties in the overflow of the fluid medium are obviated.

Yet another object of the invention is to provide a means of removing the separated fluid medium and smaller or lighter particles without carrying over an appreciable amount of oversized material.

materials may consist of solids or semisolids such as rubber, elastomers, discrete gels or wastes or organic substances.

These and other objects of the invention will be apparent from the ensuing description and the appended claims.

One form of the invention is shown by way of example in the accompanying drawing, in which,

The single figure is a view in longitudinal midsection 25 of the apparatus of the invention.

Referring now to the single figure of the drawing, the apparatus of the invention is generally indicated as 10 and it comprises a cylindrical chamber 11 which is integral with a frustoconical vessel 12 which, for convenience, is constructed in two sections consisting of an upper section 13 integral with the cylindrical chamber 11 and a lower section 14. The vessel 12 is referred to hereinafter, for convenience, as the cone. The two sections of the cone 12 may be bolted together at 15, as by means of a conventional flange, bolts and nuts or in any other suitable manner, or may be made integral. At its lowermost end the cone 12 is connected, as by means of flanges 16, to a cylindrical outlet collar 17, which, in turn, is provided with flanges 18 for bolting the device to a platform or any other rigid supporting structure if desired. It will be noted that a protective covering or armor 19 is provided for the interior of the cone, such armor being of hard, abrasion-resistant rubber or other material. The rubber armor 19 is employed not only in connection with the cone 12 and the cylindrical section 11 but also for other parts of the apparatus which are subjected to strong abrasive action by suspended solids.

Joined to the upper end of the cylinder 11 is an inlet chamber 25 having an opening at 26 which is normally closed by means of a plug 27. The purpose of this opening is to permit inspection and cleaning of the inlet chamber 25. The inlet chamber 25 is also provided with an inlet port at 28 for introducing a slurry or suspension to be separated. At its upper end the inlet chamber 25 is closed by any suitable means indicated at 29, which may form part of the bearing housing for the drive shaft 30. The drive shaft 30 is, of course, driven directly or indirectly by any suitable means such as an electric motor (not shown), and the entire assembly is firmly and rigidly supported.

An impeller 31 is affixed to the lower end of the drive shaft 30, and somewhat above the impeller, adjacent the top of the inlet chamber 25, an expeller 32 is fixed to the drive shaft. The expeller 32 is protected at 33 along its edge and inner surface with a hard rubber armor and a disc 34 of similar material having a downwardly extending annular rib 34a is also provided above and adjacent the expeller. The plate 32 rotates with the shaft 30 and serves to counteract any tendency of the inflowing slurry or suspension to flow upwardly, as by suction or foul the bearings. The armor at 33, 34 and 34a resists the abrasive action of suspended particles.

Fixed to the lower end of the inlet chamber 25 is a circular baffle plate 40 which is covered with rubber armor 41 and which forms the top cover of the cylinder 11. The baffle 41 is formed with an axial opening which, in conjunction with the drive shaft 30, forms an annular opening 42 coaxial with the impeller 31 for delivery of fluid from the inlet chamber 25 to the rotating solid baffle impeller 31 in the cylinder 11.

The impeller 31 comprises a hub 43 and a solid plate or disc 44 which is circular and has a diameter slightly 10 less than the inside diameter of the cylinder 11 so as to provide a slight clearance between the inner wall of the cylinder 11 and the impeller. Fixed to the upper surface of the plate 44 are a number of radial vanes 45, preferably eight in number although a greater or lesser number 15 of vanes may be employed. These vanes are preferably vertical and extend radially outwardly from the hub 43 to the outer edge of the plate 44. However, these vanes may be curved, e. g., to form the arms of a spiral, or they may be slanted. As will be seen, the entire impeller assembly, with the exception of the under surface of the plate 44, is covered with a pure gum rubber lining 46, including the hub 43, the upper surface of the plate 44, the edges and sides of the vanes 45, and the outer edge of the plate 44.

In accordance with the present invention an overflow pipe or riser is provided at 50 which, for convenience, may be constructed in two sections shown at 52 and 53 and which may be joined together by any suitable means such as by welding or by means of a threaded coupling (not shown). The riser 50 is disposed coaxially of the cone 12 and it extends well into the separatory chamber of the cone, down through the open lower end of the collar 17 and, as shown, it is threaded at its lower end so that a suitable outlet connection can be attached thereto. The lower end of the riser 50 within the lower collar 17 is spaced somewhat from the inner walls of such cylinder 17 to provide an annular space 55. An opening 56 is formed in the wall of the lower cylinder 17 to provide an outlet for separated solids which pass through a pipe 57 to a proportioning valve which is generally indicated as The proportioning valve 58 comprises a chamber 59 having a frusto-conical opening 59a at its lower end which is normally closed by a tapered valve 60. A rod 61 is connected to the valve 60 and extends upwardly through the upper end of the chamber 59, a suitable gland being provided, if necessary, to prevent leakage. An expansion spring 62 is provided which is compressed between and a nut 63 and the upper end of the chamber The expansive force of the spring 62 urges the valve 60 to closed position. This force can be varied and adjusted by means of the nut 63.

In operation the apparatus thus described and illustrated functions as follows:

The impeller 31 is rotated continuously and preferably at high speed, e. g., 100 feet per second. Meanwhile, a slurry or other fluid mixture containing suspended particles is introduced through the inlet pipe 28 into the inlet chamber 25. Any tendency of the fluid to flow upwardly or remain in the inlet chamber is counteracted by the expeller plate 32 which rotates with the shaft 30 and directs the flow with positive action toward the feed aperture 42. The fluid mixture passes down through the annular opening 42 and is immediately subjected to rotating force by the vanes 45 of the impeller 31. This, of course, results in flinging the fluid radially outwardly into the relatively narrow annular space between the impeller and the cylinder 11 which is the only entrance into the separatory chamber within cone 12.

separatory zone free of eddies and turbulence and that there is nothing within the cone to interfere with the establishment of free vortex separation. It is, therefore, to be understood that the present invention deals with avoids, to a great extent, the inherent limitations of other types of separators and classifiers.

The free vortex differs from the forced vortex in that the fluid does not revolve as a solid. In the free vortex a fluid system is established in which (internal friction being ignored) the actual R. P. M. of a given particle increases from the periphery to the point near the axis. To establish such a system, fluid under head pressure and at a high velocity is introduced at the outer periphery of a preferably conical vessel and is forced to travel inwardly in a tightening spiral to a point adjacent the axis of rotation. The path of travel may be likened to a watch spring wherein travel starts at the outer free end and moves inwardly. One may further visualize a free vortex as a system composed of a series of concentric stream cylinders. A point on any one cylinder may be traveling the same number of feet per minute as a point on any other cylinder, but as the radius of all cylinders decreases inwardly, each inner cylinder is traveling at a greater 20 R. P. M. than its outer neighbors.

In the apparatus of the present invention the effluent fluid medium and the smaller or lighter particles which are not moved outwardly to the walls of the separating chamber flow generally inwardly and upwardly along the walls of riser 50, overflow into the riser and pass downwardly through the riser and out of the apparatus.

At the same time the larger or heavier particles mixed, of course, with some of the fluid medium, pass downwardly along the inner face of cone toward the apex, thence into the space between the collar 17 and the riser 50 and thence out through the pipe 57 to the proportioning valve 58 which controls the rate of flow of the underflow material. The nut 63 will have been adjusted, in relation to the rate of input of fluid mixture through the inlet pipe 28 and to the degree of separation effected by the apparatus, so as to remove the separated heavier particles and attendant liquid at a proper rate. It will be apparent that the pressure of the effluent underflow will tend to open the valve 60, such opening being opposed by the expansion spring 62. By suitable adjustment of the nut 67 the proper rate of underflow can be maintained under any given set of operating conditions.

By means of the apparatus of the present invention, and in particular by reason of the provision of an axial overflow pipe in the form of the riser 50, certain marked advantages are obtained. By way of example, a slurry whose particles all passed a 28 mesh sieve, was subjected to separaiton by the apparatus of the present invention employing a riser of one inch inside diameter and rising to a height of three inches below the impeller. impeller was driven at 2,000 R. P. M. The overflow consisted entirely of liquid containing solid particles all of which were less than 20 microns in diameter. By substituitng a one and one-half inch diameter riser extending to approximately three inches below the impeller, the characteristics of the device were changed so that the overflow consisted of liquid containing solids of up to minus 325 mesh. By using a two inch diameter riser the overflow consisted of liquid containing solids up to 200 60 mesh.

It is thus apparent that a sharp and controlled separation can be obtained by suitable selection of an overflow riser having a height and diameter such as to overflow a liquid containing solids up to any desired maxi-65 mum size. Alternatively, a riser of fixed diameter and height may be employed and the speed of the impeller may be varied. The overflow is free from any substantial quantity of oversize particles, and difficulties due to turbulence at the point of efflux of the fluid medium (i. e., It will be observed that the material is delivered to the 70 the top of the riser) are obviated. These features, among others, provide a great range of control and flexibility not possible with other types of equipment.

It will be observed that in the conventional types of cyclonic separators and classifiers, two situations inevithe type of separation known as "free vortex" and thus 75 tably occur. The first of these is the development of a

vacuum which appears as a column at the axis of rotation. This produces a negative pressure, permitting takeoff of the overflow upwardly; the second is, that the mass containing the larger particles which moves to the perimeter of the vortex, is more and more compacted and dewatered as it goes to and is delivered to the underflow outlet. Accordingly, the water balance between the overflow is greatly increased in density and difficult to handle. while the overflow is greatly reduced in density.

With the present invention it will be observed that the 10 central riser 50 substantially fills the space usually occupied by the vacuum. This has several beneficial and unexpected results and completely converts this type of free vortex centrifugal classifier into a full pressure device. taking off the overflow at a positive pressure which gives a much higher overflow density for the same feed and at any sizing cut. The operation of the device at full pressure, both in the overflow and in the underflow, elimibring about the maintenance of the water valance between the overflow and the underflow which is greatly desired.

1. In a centrifugal separator for free vortex wet separations, the combination of a cylindrical chamber for re- 25 ceiving a slurry, a frusto conical separating chamber joined at its larger end to said cylindrical chamber to form an extension thereof, a solid dividing wall separating said chambers having a central opening for delivery of said slurry, a solid baffle impeller with upstanding 30 vanes on its upper surface and a smooth under surface. mounted for rotation within said separating chamber just below said dividing wall and having a diameter great enough to permit only a narrow clearance with the wall of said separating chamber, said rotating baffle feeding said slurry to the separating chamber through said clearance at a predetermined linear speed, an axial outflow pipe extending upwardly from the bottom within said separating chamber and occupying the space normally defining the vacuum of a free vortex system, and an annular underflow outlet at the bottom of said separating chamber.

2. In a centrifugal separator for free vortex wet separations, the combination of a cylindrical chamber adapted to receive a continuous flow of slurry containing suspended solids at varying rates of flow and pressure, a frusto conical separating chamber joined at its larger end to said cylindrical chamber to form an extension thereof, a solid dividing wall separating said chambers having a central opening for delivery of said slurry, a solid horizontal baffle impeller with upstanding vanes on its upper surface and a smooth under surface, mounted for rotation within said separating chamber just below said dividing wall and having a diameter great enough to permit only a narrow clearance with the wall of said separating chamber, said rotating baffle feeding said slurry to the separating chamber through said clearance at a predetermined linear speed, an axial outflow pipe extending upwardly from the bottom adjacent the under surface of said rotating baffle within said separating chamber and occupying the space normally defining the vacuum of a

free vortex system, and an underflow outlet at the bottom of said separating chamber.

3. In a free vortex centrifugal classifier for wet separation of liquid mixtures comprising a separate inlet chamber continuous with the separating chamber and having an outlet feeding to the rotating means in the separation chamber, a conical separating chamber and rotating means at the top of said separating chamber for introducing a wet mixture into said separating chamber adjacent the inner face of the wall thereof with an established constant angular velocity independent of the inlet pressure or rate of flow, the improvement which comprises an outlet riser arranged coaxially and extending upwardly from the apex within said separating chamber for re-The elimination of the vacuum at the center results in 15 moving the lighter cuts of said wet mixture, said riser occupying the space normally defining the vacuum of a free vortex system, and an annular outlet at said apex for the heavier cut.

4. In a free vortex wet centrifugal classifier for the nates the drying up of the underflow. These circumstances 20 separation of liquids containing suspended solids comprising a separate vertical inlet chamber having an outlet therefrom feeding to the separating chamber and the rotating means therein, a separating chamber of an inverted conical shape, and rotating means for introducing a fluid mixture containing suspended solids into the upper end of said separating chamber with an established constant angular velocity independent of the inlet pressure or rate of flow, the improvement which comprises an outlet riser arranged coaxially within and extending from the apex upwardly into said separating chamber for removing the lighter cuts of said fluid mixture, said riser occupying the space normally defining the vacuum of the free vortex, and an annular underflow outlet at said apex for the heavier cut.

5. In a free vortex centrifugal classifier for separating liquid slurries, the combination comprising a separate inlet chamber continuous with the separating chamber having an annular axial outlet communicating with the separating chamber and to the rotating means, a conical separating chamber, rotating means for introducing liquid slurries fed axially thereto into said separating chamber adjacent the inner face of the wall at the top thereof with a substantially constant rotational velocity independent of the inlet velocity or pressure, an outlet riser of substantially uniform diameter extending upwardly from the apex within the said separating chamber, for removing the lighter cut, said riser occupying the space normally defining the vacuum of the free vortex system, and an annular outlet at the apex of said separating chamber for removing the heavier cut.

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