Feb. 8, 1955 N. GOODWIN 2,701,642

CONTINUOUS CENTRIFUGAL SEPARATOR

Filed April 11, 1951

FIG. 1.

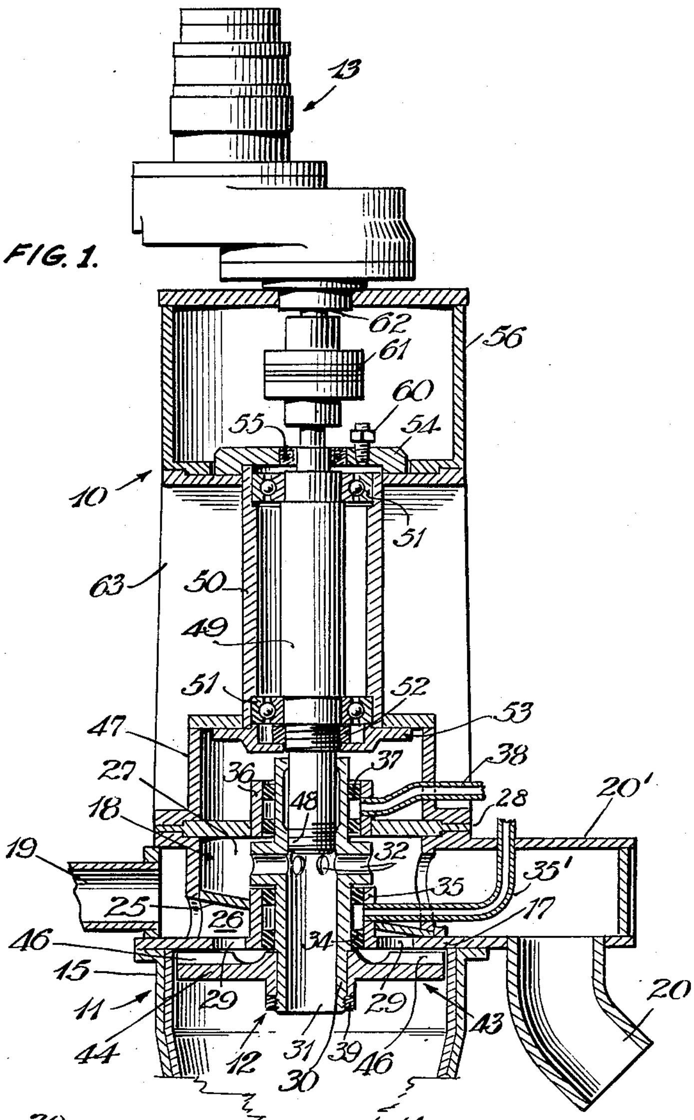
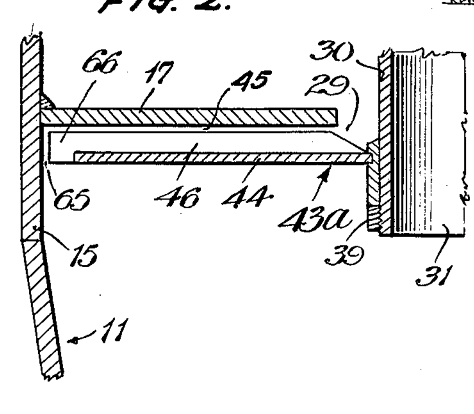


FIG. 2.



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CONTINUOUS CENTRIFUGAL SEPARATOR

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11 Claims. (Cl. 209—211)

This invention relates to centrifugal separators. More particularly, it relates to a continuous centrifugal separator for wet operation in separating finely divided suspended materials from a liquid. Such suspended materials may consist of solids or semisolids such as rubber, elastomers, discrete gels or wastes or organic substances.

For example, the separator may be used to separate colloidal particles of clay or the like from a liquid in order to clarify the liquid or achieve a separation or classification of the clay particles themselves.

In the application of centrifugal force to classification, two general types of classifiers are established for wet separation and classification. The first of these is the forced vortex which is probably best illustrated by the centrifuge. A forced vortex system is characterized by the fact that all parts of the mixture undergoing treatment revolve as a unit, that is as if the mixture were a solid body. If the centrifuge is being rotated at a given R. P. M., all parts of the mixture rotate at the same R. P. M. although the portion of the mixture closest to the axis will not travel as many feet per minute as the portion near the periphery where the radius is larger. Classification by forced vortex differs from ordinary gravity classification only by the time required for the separation and is therefore subject to the same limitations and deficiencies as found in ordinary gravity classification.

The present invention, however, deals with the type known as free vortex, and avoids, to a very great extent, the inherent limitations of other types of separators and classifiers.

The free vortex differs from the forced vortex in that the liquid does not revolve as a solid. In the free vortex a liquid 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, liquid 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 R. P. M. than its outer neighbors.

It is an object of the present invention to provide an improved type of centrifugal separator, which to a very large degree overcomes the objections and limitations of earlier devices.

It is a further object of the invention to provide a centrifugal separator wherein the peripheral speed of the liquid in the separator can be controlled independently of the throughput of the liquid and hence independently of the time of residence.

It is likewise an object of the present invention to provide such a centrifugal separator where the time of residence may be varied independently and controlled at any given peripheral speed.

It is a still further object of the invention to provide a centrifugal separator capable of handling liquid containing abrasive materials suspended therein, wherein abrasive effects are reduced and where the operating effects due to narrow or constricted channels carrying the abrasive suspension at high velocity, are eliminated.

A still further object is to provide a machine which by proper regulation of the intensity of centrifugal force and time of residence, may serve to fractionate suspended materials of varying particle size, such as, for example, the separation of clay suspensions into fractions of predetermined particle size. This result may be accomplished by repeated passage through the same machine with a step-wise variation of the intensity of the centrifugal force or by variation of the time of residence or both. In addition, this result may be accomplished by a multiplicity of machines, each one in the series being controlled to produce a fraction of a particular particle size.

It is another object to provide a device which is capable of accomplishing a complete removal of suspended material in a liquid by applying maximum centrifugal force and a suitable time of residence and which by varying the operating procedure, is capable of accomplishing a separation or fractionation of suspended material of common specific gravity but varying in particle size or two materials of common particle size but with varying specific gravity.

It is likewise an object of the present invention to provide a separator which is useful in the field of heavy media separation wherein heavy minerals such as galena, magnetite, ferrosilicon in finely divided or colloidal condition are suspended in a liquid to increase its effective density and where said artificially weighted liquid is used to separate relatively coarse mixtures of other minerals. The ability to vary both the intensity of the peripheral speed and the time of residence at the will of the operator enhances the usefulness of the present device to accomplish such separation.

It is also an object to provide a device which will accomplish sharp, effective separations in a continuous manner.

These and other objects of the invention which are inherent in the device and which will readily be recognized by those skilled in the art, will be apparent from the ensuing description and the appended claims.

The invention as exemplified in the following description is illustrated by way of example only in the accompanying drawings, in which the figures show the centrifugal separating device of the present invention.

Referring now to the drawings:

Figure 1 is a vertical longitudinal section of the separator of the present invention with a portion of the cone member broken away.

Figure 2 is a fragmentary vertical section showing another form of impeller.

The separating apparatus of the present invention, which is generally designated as **10**, comprises a cyclone body or housing **11** and an impeller assembly **12** which is driven by a motor **13**. The cyclone body or housing **11** includes the characteristic cone **14**, the larger base of which at the top joins the cylinder **15**. The cone may have an included angle of 20°, although this is subject to variation depending upon the type of use to which the device is to be put. The smaller base or lower end of the cone is formed with an outlet orifice **14a** which may be flanged or otherwise adapted for suitable connection with an adjustable orifice, delivery pipe, duct, or other receptacle (not shown). In general, the diameter of the outlet **14a** should be somewhat less than the diameter of the liquid outlet passage **31**.

Immediately above the cylinder **15** and separated therefrom is a cylindrical chamber **18** which is provided with an inlet **19** of substantially uniform size.

In the preferred form of the invention illustrated in Figure 1 of the drawing, the inlet **19** is neither constricted nor tangential, but on the contrary is of relatively large uniform size to minimize abrasion effects and is placed radially or axially with respect to the vertical axis of the device **10**. The placement of the inlet **19** to the chamber **18** may be tangential but is shown in a radial or axial position to indicate that its positioning is not essential in the present invention to the production or establishment of peripheral speed or the whirling cyclonic-like motion. The circular chamber **18** is also provided with an outlet box **20'** which communicates with outlet conduit **20**. The inlet conduit **19** will ordinarily be connected to abut an elevated tank or other means (not shown) for supplying liquid to the device and for controlling the throughput of material. The outlet conduit **20** may be connected to any suitable reservoir or receiver (not shown). The chamber **18** is provided with a slanting partition **25** which divides the chamber into a lower feed compartment **26** and an upper outlet compartment **27**. The compartment **26** is in direct communication with outlet **29** and there is no direct communication between these two compartments. The feed compartment **26** communicates with the interior of the cylinder **15** through a plurality of apertures or openings **29** which are spaced about the central longitudinal axis of the cylinder **15** in the bottom member **17** of the chamber **18** and are preferably placed as near to the axis of the device as possible. It will be observed that the feed of untreated material through the wall or baffle **17** is directly onto the solid impeller disc **44** provided with vanes **46**, which forms a rotating baffle, and provides a pumping zone **45** all as later described in connection with Figure 2.

The impeller assembly **12** comprises a hollow rotating shaft **30** which provides an axial outlet passage **31** as illustrated. The outlet passage **31** is open at its lower end to the interior of the chamber, which is here termed as the separatory zone, formed by cylinder **15** and cone **14**. Radial outlet passages **32** are formed in the hollow rotating shaft **30** near its upper end and within the upper or outlet compartment **27**. These radial outlet passages **32** intersect the main axial passage **31** for establishing communication through outlet passage **31** to the outlet chamber or compartment **27**. As will be seen from the drawings, the rotating hollow shaft **30** passes through the chamber **18**, but is sealed from communication therewith by means of sleeve **35** nonrotatably fixed to the bottom plate of chamber **18** and spaced annular rings **34** of any suitable type which seal against liquid pressure. Conduit **35'** provides for introducing liquid under pressure into the space between the seals **34** to maintain an effective seal. Likewise, adjacent the upper end of the hollow shaft **30**, sleeve **36** is nonrotatably fixed to the upper plate **28** of the chamber **18** and is provided with spaced annular sealing rings **37** for sealing against liquid pressure. A conduit **38** is likewise provided for introducing liquid under pressure into the space between the seals **37** to maintain effective sealing.

At the lower end of the hollow rotating shaft **30** and removably affixed thereto as by retaining rings **39** is an impeller **43** comprising a solid disc body portion **44** with radially extending blades or vanes **46** at spaced intervals. It is to be understood, of course, that the impeller **43** is keyed or otherwise secured to the hollow rotating shaft for rotation therewith. The blades **46** are shown as being vertical but they may, if desired, be pitched at any angle to the vertical, or curved or made into any other design or form to accomplish the combined pumping action, development of momentum (angular velocity) to the incoming feed material, and other functions as described with respect to Figure 2.

The upper end of the rotating hollow shaft **30** is received within a housnig **47** and is threaded as at **48** to shaft **49**. The shaft **49** is received within a bearing housing **50** which is provided with axially spaced bearings **51**. The shaft **49** is clamped against axial displacement by means of a lock nut **52** and a bearing cap **53** at its lower end, and by bearing cap **54** at its upper end. A suitable seal **55** is provided at the upper end of the shaft **49** and a lubricant fitting **60** is also provided for lubricating the bearing.

A flexible coupling **61** for connecting the motor **13** and driving shaft **62** to the shaft **49** is provided and located within the motor adapter housing **56**. If necessary or desirable, vertical reinforcing webs **63** may be provided and extend between the housing **56** and the chambers **47** and **18**.

In Figure 2 there is shown a slightly different form of impeller *43a* which also performs four fundamental functions:

(1) It performs a pumping action which frees the device of the present invention from the need of externally applied head whether by pump or otherwise.

(2) As stated before, it imparts a maximum and uni-

form peripheral velocity to all portions of the incoming feed.

(3) It distributes the feed in a uniformly thin layer to the separatory zone of the cone as far from the axial center of the cone as is possible to do in the structure.

(4) It functions as a baffle between the pumping zone above, where energy is imparted to the liquid and the separatory zone immediately below the impeller.

The impeller *43a* shown in Figure 2 comprises the same web or disc **44** and vanes **46** on the upper surface thereof, only in this instance they extend from the point of inlet **29** to the periphery of the impeller disc **44** and are provided with integral wings **66** which extend beyond the impeller disc and downwardly so as to be substantially flush with the under surface. The outer ends of these wings **66** provide the clearance for the space or passage **65** rather than the periphery of the disc **44**. It is also to be noted that the inlet passage or feed passage **29** is moved closer to the axis of the cone and as near thereto as can be done with the structure involved.

For the purposes herein, a forced vortex will be considered as a rotating liquid system wherein angular velocities are constant throughout or increase from axis to periphery; a free vortex is a rotating liquid system in which angular velocities increase from periphery toward the axis of rotation. We recognize that this is a broader definition than usual in texts on hydraulics, but is adapted here to simplify description.

In the operation of the device, a suspension of finely divided materials in a liquid, for example, a suspension of colloidal clay in water, is introduced to the device through the inlet conduit **19** at any desired rate of flow. The liquid thus introduced is delivered into the feed compartment **26**, will pass downwardly through the apertures **29** directly onto the disc of the impeller **43**, the feed holes **29** being disposed inwardly from the wall of cylinder **15** as near to the axis of the device **10** as possible, and thence to the periphery of impeller **43**. During the feed of the material to be treated, the motor **13** is rotating the hollow shaft **30** and with it the impeller **43**. Thus, the impeller **43** not only acts as a baffle to separate the feed of untreated material from the treated material in the chamber formed by the cylinder **15** and cones **14** which is the separatory zone, but it imparts to the liquid entering through the feed apertures **29** a definite peripheral speed directly proportionate to the rate of rotation and the diameter of the impeller. It will thus be observed that the velocity, or the peripheral speed, developed by the unit of the present invention is the result of independent mechanical means and is applied to the liquid internally, that is to say, within the body of the vessel itself. Since the means used herein to impart peripheral speed to the liquid is the rotatable impeller which may be rotated at any desired speed, the only limiting function in the operation is imposed by the centrifugal stresses set up in the body of the impeller itself and the safe operating stresses allowable for the material of which it is constructed. In obtaining the peripheral speed in this manner, all material is forced directly to the wall of the cylinder **15** and passes downwardly in an arc of 360°, in the space or passage **65** represented by the clearance between the outer edge of the impeller vane **46** and the inner surface of the wall of cylinder **15**. Beyond a certain critical velocity, the centrifugal forces generated will be greater than the force of gravity and the liquid will rotate within the treating chamber or separatory zone. Simultaneously, an open air passage will be established on the central axis of the treating chamber. The continuous circulation and recirculation of the liquid medium will cause the suspended material to be thrown radially outward to the inner surface of cylinder **15**. Any unseparated suspended materials will also be recirculated with the liquid and be ultimately thrown out of suspension. Although solids alone and for purposes of simplicity of exposition, are raferred to, it is intended that all of the forms of the separated suspended material as hereinbefore described and defined, are included.

Gravity and the sheering action of the rapidly moving liquid will move the deposited, separated material down the walls of the cylinder **15** and cone **14** to the outlet *14a*. The innermost portion of the liquid undergoing treatment will pass upwardly through the axial passage **31**, then outwardly through radial passages **32** into the outlet compartment **27** and the outlet box **20'** to conduit **20**.

With further reference to Figure 2 of the drawings and particularly with reference to its operation, the pumping action or function is provided by the rapid rotation of the impeller assembly **43a** and the clearance between the blades **46a** and the wall **17** directly above. In accordance with standard pump design, it is this clearance which determines the efficiency of the structure as a pump, but it is also to be observed that the clearance must be greater than the greatest particle size in the incoming feed. In moving the incoming feed aperture **29** as closely as possible to the axis of the device it will be observed that the feed is introduced at a point of lowest peripheral speed in terms of feet per second. It is entirely practical in the operation of machines constructed in accordance with Figure 2 to operate with suction heads of ten feet or more, entirely free from the need of external pumps or gravity heads.

It is apparent that the rotation of the impeller **43** or **43a** will impart a maximum and uniform peripheral velocity to all portions of the incoming feed, all of which must pass to the outer edge of the impeller disc **44** before mingling or being fed into the cone proper through the passage **65**. Thus, no short circuiting is possible. It is likewise to be observed that the feed introduced to the separatory zone and cylinder **15** through the passage **65** at high peripheral velocity has only one way to get out which is through the inner vortek. To arrive at the inner vortex a given particle must travel in a spiral path of constantly diminishing radius. Since the initial momentum is mainly conserved, it may be assumed that the actual R. P. M. increases as the spiral diminishes in radius. The true R. P. M. will approach a linear function of the ratio of the cone radius to that of the inner vortex radius. It has been observed that liquid may make from three to five times as many R. P. M.'s at the vortex than it does at the wall **15** of the cone. Any blades on the under surface of the impeller disc **44** of the impeller assembly **43a** would interfere with this action.

As indicated above, the disc **44** of the impeller assemblies **43** and **43a** act as a baffle between the pumping zone (where energy is imparted to the liquid and momentum is increased to a maximum value at the periphery by the rotation and the vanes **46** and **46a**) and the separatory zone immediately below the impeller as provided by the cone itself.

It is obvious that any short circuiting of the feed into the separatory zone (which short circuiting would occur but for the presence of disc **44**) would not only destroy the pumping function but would materially interfere with the vortex action within the cone.

It has been found to be characteristic of the operation of this invention that where the velocity is constant, the intensity of centrifugal force increases as the radius of the action decreases. It is thus clear that any particle passing through the free vortex system of the present invention is subject to increasingly greater outward impelling forces as it passes from periphery to the axis of rotation.

It will be observed that the feed of the material from the pumping zone to the separatory zone is applied at the extreme periphery in the passage **65** and is already in uniform rotary motion of the desired peripheral velocity when it enters the separatory zone through said passage. No abrupt change of direction is involved. In this connection, it will be noted that while the action of the impeller **43** within the pumping zone is similar to that in a radial discharge pump, it actually discharges axially and involves little or no change in direction over and above its uniform rotary motion. The downward spiral is accordingly started as the feed reaches the delivery channel **65** and continues in motion advancing downwardly approximately an equal distance for each revolution within the separatory zone. The velocity and pressure being applied uniformly and evenly over the entire periphery with only a gentle change in direction, the feed is incapable of setting up any currents and undesirable turbulence in the free vortex of the separatory zone and so in the present invention there is nothing to interfere with either the establishment or the maintenance of the full development of inner stream cylinders of higher angular velocity.

It is apparent that the apparatus described above has several advantages. One important advantage is that the speed of the impeller, and therefore the peripheral speed of the liquid undergoing treatment, is controllable independently of the throughput of the material, and conversely, the throughput of the material to the device is controllable independently of the speed of the impeller. Accordingly, by appropriate adjustment of the speed of the impeller and the throughput of the material, or either one, the apparatus can be operated as a clarifier to completely clarify a liquid, or as a classifier to achieve a size separation of the suspended solids. Furthermore, the peripheral speed can be maintained at a constant rate and is not dependent upon or limited by the uncontrollable rate of speed through a restricted orifice.

The ability to develop maximum intensities of centrifugal force and vary them at will are of vital importance, especially when the suspended matter is in a finely divided state or has a specific gravity which differs but little from the specific gravity of the suspending medium. In all of the prior forms of cyclonic separators, the intensity of centrifugal force could only be increased by employing prohibitive head or pressure, or by reducing the machine to a smaller diameter which would then affect and greatly reduce the time of residence of any particular fraction of material in the device and therefore nullify any possible gain by the reduction in size.

The "effectiveness" of any centrifugal device is measured in terms of maximum centrifugal force applied and residence, the time during which any given particle in suspension is subjected to that force. In general the degree of "effectiveness" determines what size and weight of particle will pass out through the delivery orifice **14a** and what will pass out through the outlet orifice **31**. The greater the product of time and force, the finer will be the material delivered through the outlet **14a**. Thus, the effectiveness serves as an index of the fractionating power of the present device.

It will be observed that the present invention provides a machine which is capable of wide variation in peripheral speed and an infinite variation in throughput or time of residence. The result is a machine which, in a mechanical sense, has infinite "effectiveness." By proper selection of the conditions of operation it can be set to make a separation at any desired point in a wide range of particle sizes. This is particularly important in the treatment of suspended materials in the range of particle sizes lower than 200 mesh. Accordingly, it is not only possible to treat finely divided materials such as clay, but also such suspensions as sewage wastes and sludges wherein the suspended organic matter is but slightly greater in specific gravity than the suspending liquid.

It will be seen that a machine is provided which greatly improves the practice of heavy media separation. The peripheral speed imparted to the material to be treated and the manner of feeding it to the device, assures complete and thorough contact of the artificially weighted liquid and the material undergoing treatment, thus eliminating rafting and channeling which are common faults in such separations which are accomplished largely by simple gravity type separators. The ability to vary both the intensity of peripheray speed and the time of residence at the will of the operator in the present invention, makes it possible to take cuts or separations at any point in a wide range and with very fine tolerances. Thus, though the float material differs in specific gravity from the artificial liquid only by a few percent, a satisfactory separation may be made without danger of contaminating the heavy media liquid or the loss of such fluid.

A further important advantage resides in the fact that peripheral speed is not dependent upon a tangential restricted inlet orifice. The device, as will be seen, does not have any constrictions or orifices carrying abrasive material at high velocity. Hence abrasion is greatly reduced and to the extent that it does occur, it is not of any serious consequence.

It will thus be apparent that the centrifugal separating apparatus provided achieves the several objects stated hereinabove. The device is essentially simple in its construction and operation and accomplishes results not capable of achievement with prior cyclone separators.

While the invention has been described and illustrated in a preferred form, it is to be understood that various changes may be made therein by those skilled in the art without departing from the spirit of the invention as set forth in the appended claims.

It is to be understood that for optimum performance the motor 13 should be a variable speed motor or such other drive means as will lend itself to speed control.

The present application is a continuation in part of the copending application filed April 28, 1950 and serially numbered 158,821, now abandoned.

I claim:

1. A centrifugal separator for free vortex separation comprising a chamber, solid baffle rotary impeller means having an uninterrupted bottom surface mounted openly in said chamber for imparting and maintaining peripheral speed to liquid introduced into said chamber, said means defining a pumping zone and a separatory zone, inlet means for introducing a liquid containing suspended material into said pumping zone, outlet means for separated suspended material and outlet means for separated liquid medium, both of said outlet means being in the separatory zone.

2. A centrifugal separator comprising a chamber, solid baffle rotary impeller means having an uninterrupted botttom surface mounted openly in said chamber for imparting and maintaining a peripheral speed to a liquid feed material containing suspended solids introduced into said chamber, said means also defining a pumping zone and a separatory zone in said chamber, unrestricted inlet means for introducing a liquid into said pumping zone, outlet means for separated suspended material, and outlet means for separated liquid medium, both of said outlet means being disposed coaxially of said rotary means, and within said separatory zone.

3. A centrifugal separator for free vortex separation comprising a separator chamber having an outlet for separated heavy material, solid baffle pumping means having an uninterrupted bottom surface disposed openly within said chamber separating and defining a pumping zone and a separatory zone for imparting peripheral speed to material introduced into said separatory zone and thereby effecting centrifugal separation, inlet means for said chamber for introducing a liquid material to said baffle thereby subjecting it to the action of said impeller, and outlet means in the separatory zone coaxial to said baffle for removing separated light material.

4. A centrifugal separator of the cyclone type for free vortex separation comprising a cylindrical chamber, an inlet therefor, a conical hopper having an outlet for separated solid material, a central tubular outlet for egress of the separated liquid phase and a solid baffle with vanes on the inlet surface and an uninterrupted bottom surface separating said chamber from said hopper mounted for rotation about the axis of said central tubular outlet, and for imparting and maintaining a peripheral speed to the liquid suspension introduced through said inlet.

5. A centrifugal separator of the character described for free vortex separation comprising a cylindrical chamber, a solid baffle with vanes on the upper surface and an uninterrupted bottom surface mounted for rotation about the longitudinal axis of said chamber and separating the chamber into a pumping zone and a separatory zone, outlet means coaxial with said baffle, and inlet means adjacent said baffle for introducing a suspension of solids in a liquid into said pumping zone to be subjected to angular acceleration by said baffle.

6. A continuous centrifugal separator for free vortex separation comprising a conical chamber, a solid impeller with vanes on the upper surface and an uninterrupted bottom surface mounted openly therein to impart and maintain a peripheral speed to liquid material supplied to the chamber, said impeller separating said chamber into a pumping zone and a separatory zone, inlet means for said chamber for introducing a suspension of material in a liquid medium into said pumping zone, said inlet means being disposed about the axis of rotation of said impeller and being spaced inwardly from the periphery of the impeller, and tubular outlet means for separated liquid phase, said outlet means being coaxial to said impeller.

7. A continuous centrifugal separator for free vortex wet separation comprising a single cyclone vessel including a cylindrical upper end and a conical lower end, said lower end having an outlet, said upper end having a closure formed with annular inlet means concentric to said vessel, a tubular rotor mounted for rotation in said cylinder and extending upwardly through said closure, said rotor having a radial outlet above said closure, a solid baffle with vanes on its upper surface and an uninterrupted bottom surface fixed to said rotor within said cylinder to rotate adjacent said annular inlet means, said rotor separating said vessel into a pumping zone and a separatory zone, unrestricted supply means including a chamber communicating with said annular inlet means, and outlet means including a chamber communicating with said radial outlet.

8. A continuous centrifugal separator for free vortex wet separation comprising a cyclone body including a cylindrical upper end having a top closure and a conical lower end having a bottom outlet, supply means including an inlet compartment communicating with said cylinder through said top closure and concentrically to the longitudinal axis of said body, a tubular rotor mounted coaxially of said body, having its lower end within said cylindrical upper end and extending upwardly through said closure, said rotor having radial outlet passages above said closure, means for driving said rotor, a solid baffle with vanes on its upper surface and an uninterrupted bottom surface fixed to said rotor at its lower end for imparting a peripheral speed to liquid supplied through said supply means, and outlet means communicating with said radial passages.

9. In a centrifugal separating device of the character described for free vortex separation, comprising a separating chamber having an inlet for liquid feed containing a heavy material to be subjected to centrifugal separation, and outlet means for separated heavy material, the improvement which comprises solid baffle rotary pumping means having an uninterrupted bottom surface mounted openly within said chamber to impart and maintain a given peripheral speed to said liquid introduced through said inlet means and thereby effect centrifugal separation, and outlet means for separated light material extending through said rotary pumping means, said outlet means for light material being also coaxial with respect to said rotary means.

10. A centrifugal separator of the cyclone type for free vortex separation comprising a single vessel including a conical separating chamber, an inlet to said vessel, a central outlet for removal of separated liquid phase, and solid baffle rotary means having an uninterrupted bottom surface mounted openly within said separating chamber adjacent said inlet for rotation about said central outlet for imparting a peripheral speed to the suspension, said rotary means being operable independently of the throughput of suspension, said solid baffle rotary means also dividing said vessel into a pumping zone and a separatory zone.

11. A continuous centrifugal separator for free vortex wet separation comprising a cylinder having a closed upper end, a conical hopper having an outlet for heavy material at its apex continuous with and communicating with the lower end of said cylinder to form a single vessel, a tubular rotor mounted for rotation in said cylinder extending through said closed upper end and having a radial outlet thereabove, and a solid baffle with vanes on its upper surface and an uninterrupted bottom surface fixed to said rotor for rotation therewith and separating said vessel into a pumping zone and a separatory zone, said closed upper end being formed with inlet perforations spaced about the axis of said cylinder.

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