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HYDRO-CYCLONE SEPARATOR

Filed July 21, 1964

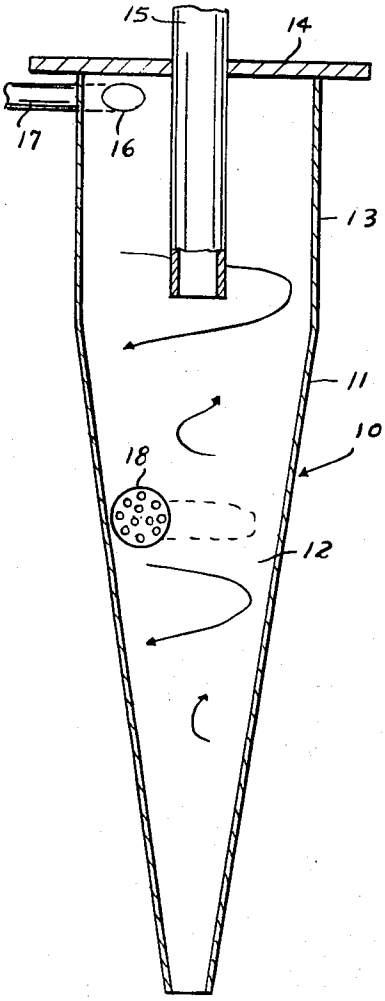

Fig-1

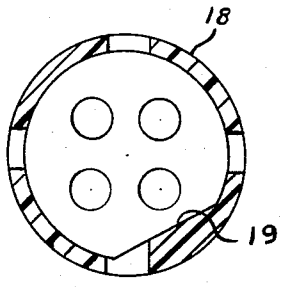

Fig-3

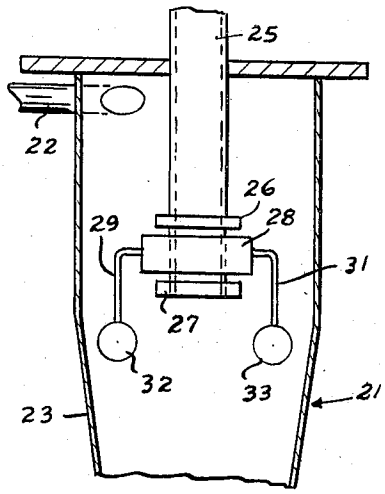

Fig-2

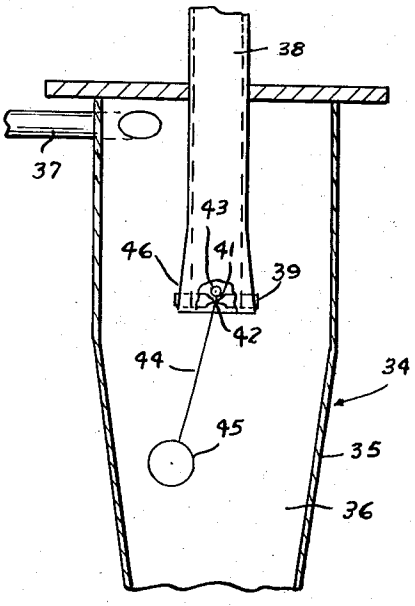

Fig-4

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HYDRO-CYCLONE SEPARATOR

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This invention relates to hydrocyclones separating a flowing slurry or the like into accepted and rejected fractions, and particularly to improvements therein achieving greater operating efficiency.

While not so limited, the invention has special reference to hydrocyclone separators, used in paper making processes to separate clean, usable fibrous material from a flowing slurry which, in addition to the usable material, contains unwanted heavier particles and dirt. A device of the kind described comprises means defining a separating chamber circular in cross section and open at its opposite ends to define outlets for the respective fractions. Through an inlet at the accepts end the flowing slurry is introduced tangentially into the separating chamber in a manner to progress from one end to the other in a swirling helical motion. The open, accepts end is located to receive and guide an inner vortex in which is comprised the accepted fraction, the rejected fraction discharging through the opposite or rejects end of the separating chamber. The described accepts and rejects ends of the separating chamber are considered as providing for overflow and underflow of respective slurry portions. These terms, however, do not denote attitude limitations since the hydrocyclone can be mounted in any position which is convenient from an installation standpoint, the speed of movement of the slurry through the separator making the device operationally independent of gravity.

In widespread, successful, use hydrocyclone separators as described are nevertheless the subject of continuing research and development looking toward increased operating efficiency, that is, a more thorough and precise separation between the acceptable and rejectable fractions. It has, in this connection, been observed that the average relative efficiency of a cleaner increases with lowering slurry consistency. Also, it has been observed that efficiency may be adversely affected by a tendency of slurry particles to orbit within the cleaner, in conditions of equilibrium brought about by counteracting hydraulic and centrifugal forces.

The object of the invention is to simplify the construction as well as the means and mode of operation of cyclonic separators, whereby such separators may not only be economically manufactured, but will be more efficient and satisfactory in use, adaptable to a wide variety of application, and be unlikely to get out of order.

Another object of the invention is to present a generally new method of achieving more efficient separation in a hydrocyclone.

A further object of the invention is to present a method and apparatus in hydrocyclonic separators wherein means are provided exerting a disturbing influence within the separating chamber.

Still another object of the invention is to introduce in hydrocyclone separators a concept of use of an orbiting object which may be either free or captive within the cleaner and which has an effect on the separation process improving the efficiency thereof.

A further object of the invention is to provide a hydrocyclonic separator possessing the advantageous structural features, the inherent meritorious characteristics and the mode of operation herein mentioned.

With the above and other incidental objects in view as will more fully appear in the specification, the invention

intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings, or their equivalents.

Referring to the accompanying drawing wherein is shown one but obviously not necessarily the only form of embodiment of the invention,

FIG. 1 is a view in longitudinal section, and partly diagrammatic, of a hydrocyclonic separator in accordance with a first illustrated form of the invention, showing flow disturbing means in the cleaner in the form of a free object.

FIG. 2 is a fragmentary view similar to FIG. 1 showing a second illustrated form of the invention wherein the flow disturbing means is in the form of a captive object means.

FIG. 3 is a view in cross section of the object means as shown in FIG. 1, FIG. 3 being enlarged relative to FIG. 1; and

FIG. 4 is a view similar to FIG. 3, showing a further form of the invention utilizing a different arrangement for fixing the motion of the object means.

Like parts are indicated by similar characters of reference throughout the several views.

In its illustrated embodiments, the invention is disclosed in a hydrocyclone separator as used especially in the pulp and paper industry to enable high standards of paper cleanliness. From a flowing pulp slurry containing not only the light fibrous material desirable for paper making but also various undesirable materials, the unit operates to separate the slurry into acceptable and rejectable fractions, directing these to respectively different outlets. According to the objectives of the separator the highest possible percentage of bark specks, dirt solids, fibre aggregates, shives and the like is excluded from the accepts outlet and directed as a part of the main slurry to the rejects outlet.

Structurally a hydrocyclone separator according to the illustrated inventive forms comprises a shell having a unitary structure, as by being made of a plurality of sections bolted or otherwise secured together. In FIG. 1 such a shell **10** includes a section **11** having the shape of a truncated cone, the interior of section **11** being hollow to define a separating chamber **12** and the opposite ends of such chamber opening through the base and apex ends of the cone. Further comprised in the shell **10** is a cylindrical section **13** on the base end of conical section **11** and in superposed aligned relation thereto. A back wall **14** of section **13** closes what may be considered the head of the device, except for the installation therein of a tubular nozzle **15**. The latter is concentrically disposed in the shell **10** and projects through and beyond the wall **14** at its opposite ends. The nozzle **15** thus has an outer end projecting outside the shell **10** and an inner end within the shell, the enclosed portion of the nozzle extending some distance within the shell. The nozzle **15** is open at its ends for a free flow therethrough while within the shell it occupies a position in spaced concentric relation to the walls of shell **10**.

At a point intermediate the inner end of the nozzle **15** and back wall **14** there further is formed in section **13** an inlet **16** communicating through a laterally projecting boss **17** with the exterior of the shell, the boss **17** being adapted to be connected in a system to supply thereto a pulp slurry under pressure. The arrangement is one to introduce the pulp slurry into the shell **10** tangentially of the walls thereof, the continued application of pressure at the inlet causing the pulp slurry to progress from the base end of the device toward the apex end in a swirling helical motion inducing centrifugal forces.

As a result of these forces there is left in the axis of the device an area of low pressure creating what may be considered to be an inner vortex moving contra to the outer vortex, that is in a direction from the apex end to the base end. The nozzle **15** serves in this connection as a vortex finder, its inner end extending inwardly of the shell to receive the inner vortex and to conduct it out of the shell, the outer end of the nozzle being adapted for connection in a suitable conduit to conduct the materials caught in the inner vortex to a subsequent process step. In accordance with the concept and mode of operation of the separator, relatively light and desirable fibres from the liquid pulp slurry are gathered up by the inner vortex and conducted out the base end of the device as the accepted fraction while the remainder of the slurry leaves the device through the apex end thereof as the rejected fraction.

Considering further the flow effects taking place in the separator, the velocity of flow of the slurry accelerates rapidly and uniformly as it encounters the decreasing diameter of conical section **11**. The centrifugal action forcing heavier particles outward toward the wall of the separating chamber is greatly multiplied. At the same time, however, a reversely spiraling column is formed in the central region of the separating chamber, at the axis of which is a liquid free core. In operation, the light desirable pulp particles transfer from the outer vortex to the inner vortex and are directed thereby to and through the accepts nozzle **15**.

The device provides opposed components of flow directed respectively toward the base and apex ends of the cleaner. A pressure differential from the outer chamber wall toward the centerline or axis of the chamber produces a movement of liquid in this direction, this being in conjunction with the downward component of liquid flow. Some "dirt" particles moving toward the outer wall under centrifugal influence may find themselves balanced by the involved forces. As a result, these particles assume a position of equilibrium and go into a more or less fixed orbit. Eventually, however, these particles leave their orbits and appear, unpredictably, in the accepts or the rejects fractions. Also, when the slurry is introduced into the cleaner the pulp and dirt begin to move to the outside of the separator wall. The population of solids adjacent the chamber wall increases. As subsequent dirt particles attempt to join or move through this population collisions occur. Some dirt particles thus may not reach the outer wall but instead be caused to intersect the inner vortex and come under the influence of this stream. The increased consistency in the region of the separator wall thus has the effect of restricting outward motion of dirt particles, allowing some of these particles to be drawn into the center vortex along with acceptable material. Pulp material is separated or "cleaned" in stages and improvements in the efficiency of the hydrocyclone are desirable as reducing the number of required stages, as well as providing clean, conditioned pulp for the paper making process in as facile and economical a manner as possible.

In accordance with the instant invention improved efficiency is achieved by purposefully introducing into the separating chamber a flow disturber having the effect of reducing consistency at the separator wall and of inhibiting orbiting by dirt particles. This is, in the illustrated invention, an orbiting, physical object. Thus, and as shown in FIG. 1, an object **18** is in the separator shell **10**. Caused by generated forces within the separating chamber to revolve in an orbital path therein, object **18** disturbs the equilibrium area conducive to orbiting of dirt particles and accordingly inhibits such orbiting tendency thereby. Also, the circling motion of the object restrains the tendency of pulp particles to assume dense relatively impenetrable formations. The consistency toward and in the region of the separator wall is accordingly inhibited from increasing or is relatively reduced as before described.

The object **18** may assume various structural forms. It is, in the instance of FIGS. 1 and 3 a hollow sphere made of a light weight plastic material and perforated for flow of the slurry therethrough. The object is thus responsive to centrifugal forces but is relatively unresponsive to pressure exerted by the rejects flow toward the apex end of the cleaner. It readily assumes, therefore, an orbiting position, in the operation of the hydrocyclone, at a point intermediate the accepts and rejects ends of the separator chamber. With the hydrocyclone at rest the object may occupy a position seated in a relatively smaller diameter portion of the separating chamber. Under operating pressures, however, the object is lifted from its resting position and placed into orbit, the holes in the object allowing the slurry to pass through and out the object.

The object has a size exceeding in diameter the nozzle **15** and the apex end of the hydrocyclone. While it may have a balanced construction it may also be eccentrically weighted, as for example as shown in FIG. 3 wherein a larger mass of material is located at point **19**. So eccentrically weighted the object tends to slide along the wall of the separating chamber thus giving what is thought to be a more predictable behavior pattern. It is not considered, however, that the invention is limited to the use of an object of any particular structural or balance characteristics. The invention comprehends use of any physical means purposefully introduced into the separating chamber to accomplish by its orbiting action of noted efficiency improvements.

The object means **18** of FIG. 1 is a "free" object in the sense that it is unconnected to any part of the hydrocyclone. It is at liberty to find and assume its own position of equilibrium within the separating chamber and its orbital path may be at any location in a longitudinal sense therein. In another aspect of the invention, however, captive object means may be used, which means has a fixed orbital path, that is, fixed as to a certain height or endwise position in the cleaner. One form of captive object apparatus is shown in FIG. 2. As shown therein, a hydrocyclone shell **21** is constructed like the shell **10** of FIG. 1. It has inlet means **22** for the pulp slurry and a conical section **23** defining a separating chamber **24**. In the present instance, however, an accepts nozzle **25** installed in the base end of the hydrocyclone has on its inner end two spaced apart collars **26** and **27**. Interposed between these and freely rotatable on nozzle **25** is a slip ring or bearing **28**. Installed in the periphery of the latter are the one ends of rods **29** and **31** having at their opposite ends object means in the form of spheres **32** and **33** respectively. The rods **29** and **31** project a short distance radially of the slip ring **28** and are then bent in the direction of the apex end of the cleaner shell to lie beyond the inner end of nozzle **25** in longitudinal planes parallel to the shell axis. Accordingly, the spheres **32** and **33** at the ends of the rods **29** and **31** are in a projected relation to the inner end of nozzle **25** while being disposed in the path of flow of the helically moving slurry in such manner as to cause the assembly comprising the spheres **32–33** rods **29** and **31** and ring **28** to rotate with the slurry.

The spheres turn in a fixed lateral orbit and affect the pattern of flow substantially in the manner of the free object discussed in connection with FIG. 1. The objects **32** and **33** may be structurally characterized like the object of FIG. 1 or given any other structural embodiment found suitable to their purpose. In the illustrated instance two diametrically opposed spheres are shown. A captive apparatus according to the concept of FIG. 2 may comprise a single sphere, however, or the number and arrangement may be otherwise varied. Also, while the spheres are shown in a common transverse plane they may if desired be longitudinally offset to revolve in different orbital paths.

The apparatus of FIG. 4 is similar to that of FIG. 2 in illustrating captive object means. As in the instances of FIGS. 1 and 2, hydrocyclone in accordance with the em-

bodiment of FIG. 4 comprises a shell 34 having a conical section 35 defining a separating chamber 36. Inlet means 37 introduces the pulp slurry tangentially, setting up counter flowing vortices as before described. A nozzle 38 is installed in the base end of the shell as a finder for the inner vortex. At the inner end of the nozzle 38 is installed a cross pin 39 which intermediate its ends is formed with a seat 41 and a through opening 42. A ball 43 is seated in the recess 41 and a rod or other connector 44 is attached thereto and extends through opening 42 to a point substantially beyond the inner end of nozzle 38, the outer end of the connector being attached to a sphere 45. The arrangement is thus one to suspend the sphere 45 from the nozzle 38 with the sphere being free to move in an orbital path in response to flow of slurry through the cleaner but constrained to occupy a fixed orbit. The object 45 may be structurally characterized like the objects 18 and 32–33 and performs a like function.

The accepts or overflow nozzle may be adapted to inhibit access thereto of dirt rich slurry portions under the influence of eddy currents in the forming outer vortex. In FIG. 2 the parts 26–27–28 deflect such currents away from the nozzle inlet. In FIG. 4 a similar result is obtained by forming the nozzle exterior with an angularly sloping surface 45.

The object means of the invention has been described as operating to improve the efficiency of a hydrocyclone by inhibiting particles orbiting therein and by reducing consistency toward the separator wall. It is possible, however, that other operational factors are involved presently unknown. Thus no attempt is made exhaustively to analyze the effects of the orbiting objects. It is known that efficiency improvements results and it has been the object herein merely to define some of the likely or probable causes therefor without excluding others.

In the case of a free object, such object is preferably spherical, hollow, perforated and eccentrically weighted. Some of these factors are of less importance in the instance of a captive object. For example, the spheres 32–33 and 45 may be made of an inert solid such as plexiglass. A suspension arrangement as shown in FIG. 2 substantially obviates a need for eccentrically weighting, although this principle may advantageously be used in the form of FIG. 4, particularly if the connection 44 is a flexible one. The invention contemplates both a rigid and a flexible connection. A solid sphere may be eccentrically weighted in various ways as by drilling a hole from the surface of the sphere to the center thereof. This moves the center of gravity of the sphere in the direction in which the hole is drilled.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several modes of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

I claim:

1. In a hydrocyclone operating to separate an acceptable fraction from a slurry containing acceptable and rejectable fractions, said hydrocyclone having oppositely disposed accepts and rejects outlets and inlet means admitting slurry in a manner to induce helical flow within the hydrocyclone; an object foreign to both fractions and unable to discharge with either purposefully introduced into said hydrocyclone and characterized by means responding to a slurry in-flow to cause said object to orbit in said hydrocyclone around said liquid free core, in the area between said outlets, for increased separating efficiency.

2. Apparatus according to claim 1, wherein the object is free to assume its own equilibrium position within the hydrocyclone, said last named means residing in the structure of the object which is a perforate hollow article and physically unconnected to any part of the hydrocyclone.

3. Apparatus according to claim 2, wherein the object is formed as an eccentrically weighted hollow body having a dimension too large to allow it to pass through either said accepts or rejects outlet.

4. Apparatus according to claim 1, wherein the object is constrained to followed a fixed orbit, said last named means comprising elongate means having a lateral dimension substantially less than that of said object to suspend said object from one end of the hydrocyclone while it orbits between said outlet.

5. In a hydrocyclone operating to separate an acceptable fraction from a slurry containing acceptable and rejectable fractions, said hydrocyclone having oppositely disposed accepts and rejects ends and inlet means admitting slurry in a tangential fashion near said accepts end for helical flow toward said rejects end, a reverse vortex forming in the center of such flow and discharging through said accepts end; an object foreign to both fractions and of a size too large to pass through either of said ends received in said hydrocyclone and orbiting therein said helical flow about said center vortex and inhibiting orbiting and density increasing tendencies of particles in said flow, said object being of a hollow, light weight construction having openings for passage of slurry therethrough and physically unconnected to any other part of the hydrocyclone.

6. A hydrocyclone providing a separating chamber circular in cross section, a tangential inlet for admitting a slurry containing acceptable and rejectable fractions with opposite ends of said chamber providing outlets for respective fractions, a nozzle installed in the accepts end to project into said chamber and define a vortex finder for the acceptable fraction, said hydrocyclone being free of any interfering structure along the axis thereof between said nozzle and rejectable fraction outlet whereby a liquid free core is formed along said axis and object means suspended from said nozzle within the chamber to occupy a position between said nozzle and the rejects end of said chamber to follow an orbital path around said liquid free core therein inhibiting orbiting and density increasing tendencies of slurry particles.

7. A hydrocyclone according to claim 6, characterized by a slip ring rotatably mounted on said nozzle and suspending said object means.

8. A hydrocyclone according to claim 6, characterized by said object means comprising hollow ball means and anti-friction bearing means on said nozzle mounting suspension means for said ball means.

9. A method of improving the efficiency of hydrocyclone separators which operate to remove an acceptable fraction from a flowing slurry containing acceptable and rejectable fractions, including the step of purposefully disturbing the normal pattern of flow of slurry through the separator by orbiting in a transverse plane thereof object means which operate in a manner to inhibit orbiting and density increasing tendencies of slurry particles.

10. A hydrocyclone for separating light acceptable fibres from a flowing pulp slurry, including a conical section through which the slurry is swirled in a helical path from the base end toward the apex end, an accepts outlet centrally positioned in the base end for discharge of the accepted fraction, the apex end having an outlet for discharge of the rejected fraction said hydrocyclone

being free of any interfering structure along the axis thereof between said outlets whereby a liquid free core is formed along said axis, and flow disturbing means in the form of a body foreign to both fractions revolving in a transverse orbital path adjacent to the wall of said conical section around said liquid free core intermediate said accepts outlet and said apex end.

11. A hydrocyclone according to claim **10**, characterized by means suspending the flow disturbing body from the base end of the hydrocyclone, said suspending means being long and slender relative to said body.

12. A method of improving the efficiency of hydrocyclone separators which operate to remove an acceptable fraction from a flowing slurry containing acceptable and rejectable fractions, said fractions being discharged at respective opposite ends of the separator, including the steps of admitting a flowing slurry into the hydrocyclone separator, purposefully introducing into said separator an object foreign to both fractions, rendering the object unable to discharge with either fraction, and of causing said object to orbit in said separator in a plane between the ends thereof in a manner to inhibit orbiting and density increasing tendencies of slurry particles.

13. A method according to claim **12**, characterized in that said step of causing said object to orbit in said separator is in part a function of the manner of admitting the flowing slurry into the hydrocyclone, the slurry being admitted tangentially therein and flowing in a helical path to define a normal pattern of flow wherein a rejected fraction of solids in the slurry moves in a longitudinal sense toward the rejects end of the separator while an accepted fraction of solids moves inwardly toward the center of the hydrocyclone and discharges through an accepts end oppositely disposed relative to said rejects end, and further is a function of the structural characteristics of said object which is a free body of susbstantial mass relative to the solids comprised in either fraction and tending thereby to assume a position of equilibrium in the separator orbiting with the slurry in a plane between said accepts and rejects ends.

14. A method according to claim **12**, wherein said step of rendering the object unable to discharge with either fraction is accomplished by limiting endwise movement of the object substantially to confine it to motion in said plane.

15. A hydrocyclone for separating light acceptable fibres from a flowing pulp slurry, including a conical section defining a separator chamber through which the slurry is swirled in a helical path from the base end toward the apex end, an accepts outlet positioned centrally of the base end, said slurry containing unwanted rejectable solids and the apex end having an outlet for discharge of a rejected fraction comprising said rejectable solids, a free body foreign to both said fractions in said separator chamber unconnected to any part of the hydrocyclone, and said body being characterized by means causing said body to revolve in a transverse orbital path adjacent to the wall of said conical section intermediate said accepts outlet and said apex end and to constitute flow disturbing means for increased separating efficiency.

16. A hydrocyclone according to claim **15**, characterized in that said free body is eccentrically weighted for sliding motion along said wall.

17. In a hydrocyclone operating to separate an acceptable fraction from a slurry containing acceptable and rejectable fractions, said hydrocyclone having oppositely disposed accepts and rejects ends and inlet means admitting slurry in a manner to induce helical flow within the hydrocyclone; an object foreign to both fractions and unable to discharge with either purposefully introduced into said hydrocyclone and characterized by means responding to a slurry in-flow to cause said object to orbit in said hydrocyclone, in the area between said ends, for increased separating efficiency, the object being formed as a perforated hollow sphere having a diameter too large to allow it to discharge through either the accepts or the rejects end.

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