Feb. 6, 1962 M. D. WOODRUFF 3,019,901

VACUUM RECEIVER AND SEPARATOR

Filed July 1, 1959 2 Sheets-Sheet 1

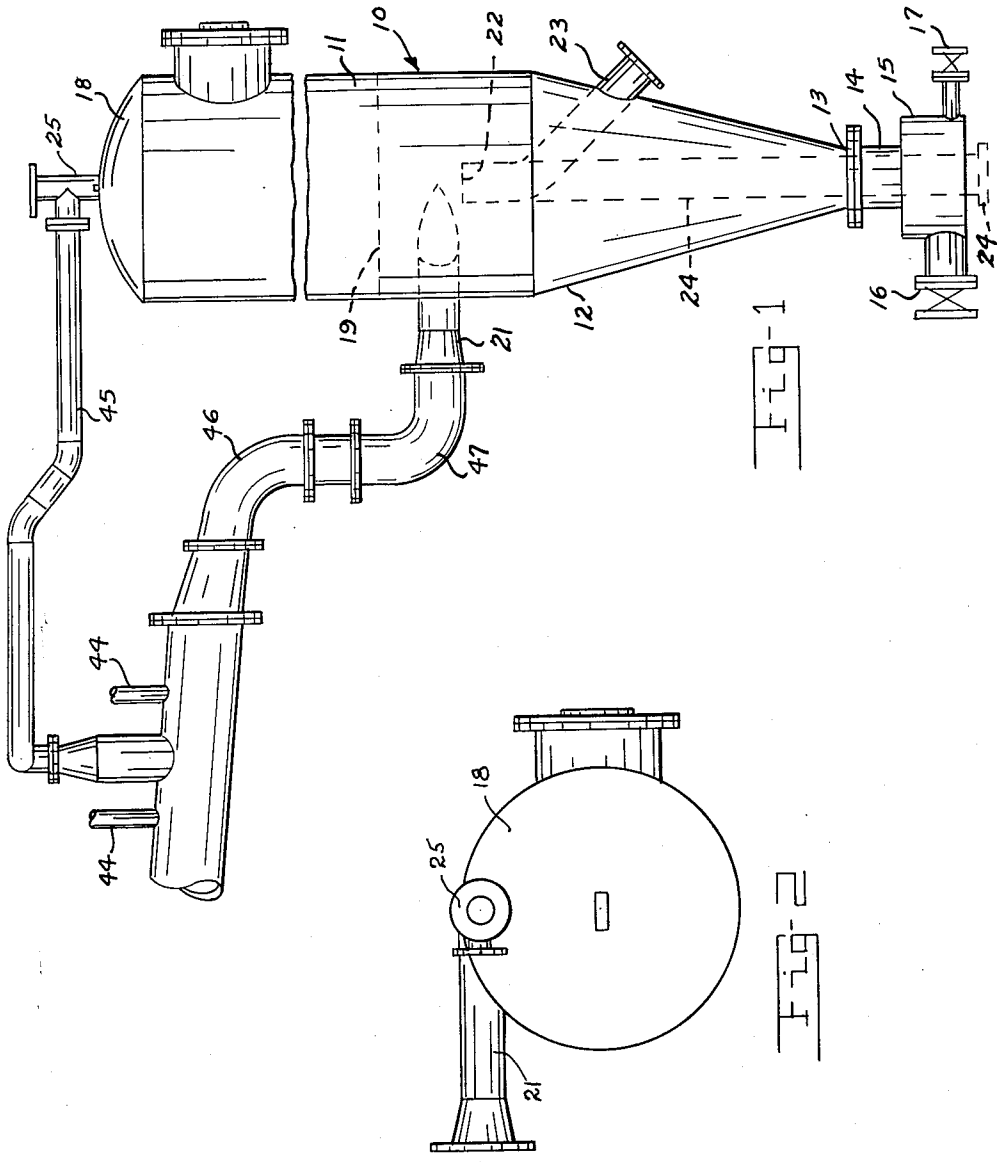


Fig-1

Fig-2

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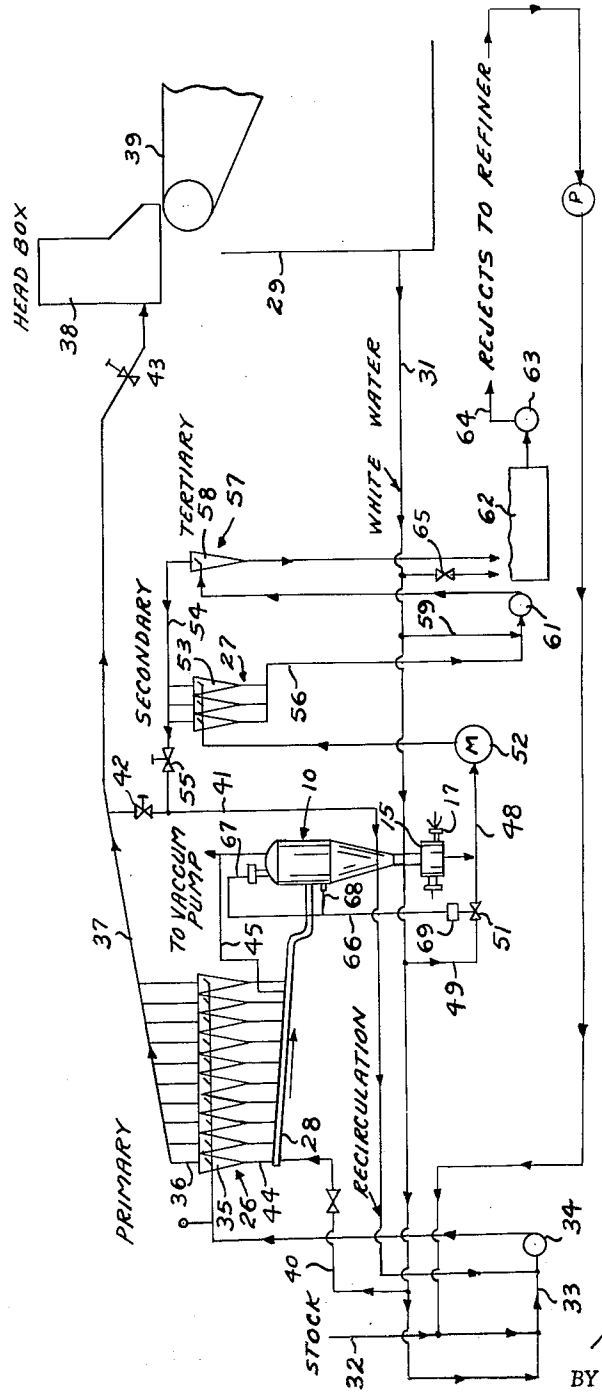


Fig. 2

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VACUUM RECEIVER AND SEPARATOR

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This invention relates to methods of and apparatus for treating a liquid stock containing rejectable and acceptable solids in suspension, and, although not so limited, has especial reference to installations in which cleaning of pulp stock and the like is effected in stages.

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

A further object of the invention is to introduce in a system installation as described a cleaner-separator having special utility in the removal of sand, metal and other foreign material, especially that having an abrasive action upon the interior walls of the cleaning devices.

Another object of the invention is to introduce a cleaner-separator as described subsequent in a system installation to primary cleaning of the liquid stock and at a location to take advantage of a reduction in consistency of the stock favorable to removal of the heavy and abrasive material.

A further object of the invention is to present in a system as described a generally new article of manufacture in the form of a vacuum receiver and separator device combining the functions of the vacuum receiver and hydrocyclone separator as heretofore known in the art and introducing a new mode of carrying off the rejected solids fraction.

Still another object of the invention is to present a vacuum receiver hydrocyclone separator combination in which both the accepted and rejected solid fractions are carried off through the apex end of the hydrocyclone.

A further object of the invention is to provide a stock equipment 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 elevation, partly diagrammatic, of a vacuum receiver and separator device in accordance with the illustrated embodiment of the invention, showing it installed in a cleaning system and receiving liquid stock for treatment from a primary cleaning stage;

FIG. 2 is a top view of the vacuum receiver and separator device of FIG. 1; and

FIG. 3 is a diagram of a system installation showing an application of the invention to the pulp treating industry.

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

Referring to the drawings, a vacuum receiver and separator device in accordance with the illustrated embodiment of the invention comprises, as shown in FIG. 1, a shell 10 having a cylindrical base end portion 11 and a

conical portion 12 terminating in an apex end 13. The latter is open and has fastened thereto an adapter 14 by which the apex end of the device is communicated with the interior of a collecting tank 15. The latter has valves 16 and 17 at its opposite ends by which it may periodically be flushed free of collected reject material as will hereinafter more clearly appear. The base end of the device is closed by an insert 18. The interior of the shell 10 is open throughout its length and contains a liquid pond, the upper level of which lies within the base end of the device, as for example, at a point indicated by line 19. An inlet 21 is mounted to the base end of the device to discharge tangentially into the interior thereof at a point below the liquid level 19. The introduced stock or liquid suspension accordingly causes a vortex movement in the shell 10 and a consequent separation of entrained solids which move to the periphery of the conical portion 12 and are urged downwardly to issue from the device by way of the apex outlet 13. The acceptable fraction, on the other hand, moves toward the longitudinal axis of the device and travels in an opposite direction toward the base end of the device. There it has access to the open end of an overflow nozzle 22 which, in the illustrated embodiment of the invention, has an open inner end facing the base end of the device and terminating beneath the liquid level 19 while extending in the opposite sense into and through the conical portion 12 of the device. In the one instance the nozzle 22 is shown as inclining toward the wall of portion 12 to define a duct 23 projecting laterally outside the device. In the other illustrated instance the nozzle 22 is shown as forming one end of a pipe or conduit 24 extending longitudinally through the conical portion 12, through the open apex end 13 and through the adapter 14 and tank 15. In the event of the use of the conduit 24 the accepted fraction is constrained to move to the exterior surface of the conduit and follows along such surface upwardly or toward the open end of nozzle 22 where it may enter and then reverse its motion, traveling inwardly of the conduit 24 to and through the apex end 13 and outside the device.

Through a duct 25, the interior of the base end 11 of the shell 10 is made into a vacuum chamber, a vacuum applying means being connected to the vacuum receiver and separator device through the duct 25.

Air bubbles rising to the surface of the liquid pond in shell 10 accordingly are evacuated, aiding in deaeration of the liquid suspension. In connection with the admission of the stock for treatment to the shell 10 it will be understood that the arrangement of inlet 21 is such as to produce a vortex motion within the shell 10 having the effect of depressing the center of liquid level 19, as liquid flow into the centrally positioned nozzle takes place. The accepted fraction rising along the pipe 24 in the inner one of the double spirals taking place in the shell is drawn by this vortex movement into the nozzle as it reaches the open mouth thereof.

In the illustrated example the vacuum receiver and separator device is disclosed as installed in a system for the treatment of pulp stock, preliminary to paper making, wherein the device functions as "Magna-Cleaner," removing metallic and like abrasive particles from the flowing stock. In accordance with a feature of the invention the device is located between primary and secondary cleaning stages wherein favorable conditions prevail for the removal of such particles. The Magna-Cleaner is distinguished from hydrocyclonic cleaners as may be used in the primary and other cleaning stages by being relatively oversize in construction, characterized by operation under conditions of high capacity and low pressure drop, these being conditions conducive to a movement of heavy particles through the apex end 13 of the separator while the body

proper of the stock and accompanying liquid forms the acceptable fraction and moves to the nozzle **22**. It is further distinguished by an absence of continuous discharge of the heavy fraction.

Referring to FIG. 3, showing a wood pulp treatment system in diagram, the vacuum receiver and separator is shown located between a primary cleaning stage **26** and a secondary cleaning stage **27**, receiving the rejects from primary stage **26** through a manifold **28** and delivering the acceptable fraction as separated therein to the secondary stage **27**. In the system as illustrated a reservoir **29** of white water supplies the system with liquid through an outlet line **31**. Fibrous stock material is fed to the system by a line **32** and the stock and liquid are combined to form a liquid stock or liquid suspension in a line **33** in which is a pump **34**. The latter places the liquid suspension under pressure and delivers it to the first cleaning stage comprising a battery of conical hydrocyclones **35**. The line **33** constitutes a common inlet for the several hydrocyclones **35** which, in accordance with their usual function, produce a double spiral movement in their interiors, light acceptable fibers making up one movement and flowing out the base end of the hydrocyclone while liquid, dirt, foreign material and non-accepted fibers form the other spiral and issue through the apex end. The accepted material leaves the hydrocyclone by way of an outlet nozzle **36** and enters a line **37** common to all of the several hydrocyclones **35**. The line **37** leads to a head box **38** which in turn supplies paper making machinery **39**. An alternative line **41** leads back to liquid suspension line **33** so that the surplus pulp not required by the paper machine may be returned to the system. The alternative use of the line **41** is under the control of a valve **42** in the line **41** and a valve **43** in the line **37**.

The rejected fraction issuing from the apex ends of the hydrocyclones is discharged through respective conduits **44** to the aforementioned manifold **28**. The latter is of a wide diameter to accommodate the full discharge of the battery of hydrocyclones in a portion only of its full diameter, leaving an upper portion of the diameter to form a vacuum chamber, the manifold being connected at its upper end through a conduit **45** with the duct **25** and line leading to the vacuum producing means. The resulting arrangement is that the manifold **28** is under vacuum or negative pressure. No opportunity thus is afforded for air to be drawn into the hydrocyclones through the apex end thereof to join with the accepted fraction. The high rotation speed of the vortices results in a liquid free space on the axis of the hydrocyclone and any air bubbles in the liquid are forced into this liquid free space or air core. The air core extends the full length of the hydrocyclone and communicates with the manifold **28**. With a vacuum existing in the manifold **28**, the air is drawn into it and passes through conduit **45** to the vacuum producing means. The manifold **28** is inclined for a free flow to the vacuum receiver and separator shell **10** and is selectively located to have that part of the length thereof receiving the conduits **44** above the liquid level **19** or with at least a portion of the diameter thereof above such liquid level. Beyond its connection with the several hydrocyclones **35** the manifold **28** dips and through adapter elbows **46** and **47** communicates with inlet **21** to the shell **10**. Dropping any selected distance from the manifold **28**, the liquid suspension achieves an elevated velocity. Accordingly its tangential discharge into the shell **10** by way of inlet **21** causes the liquid in the pond contained in shell **10** to rotate setting up the vortex pattern as described. The centrifugal forces established are sufficient to throw abrasive materials to the periphery where they descend to the apex end **13** and are discharged into the collecting chamber **15**. Periodically, as before noted, the valves **16** and **17** are opened and the collecting chamber **15** flushed out. Means to supply dilution water to the manifold **28** is provided in the form of a valve controlled line **40** extending from water supply line **31** to the left-hand end of the manifold or header member receiving the rejects from the primary cleaners.

The extension **24** of overflow nozzle **22** extends through and beyond the chamber **15**. As noted, the accepts from the vacuum receiver and separator, whether issuing from axial conduit **24** or from alternative conduit **23**, are discharged into a line **48** leading to the secondary cleaning stage **27**. The line **48** is supplied with make-up water from water supply line **31** by way of a branch **49** thereof under control of a valve **51**. A pump **52** provides for admission of the liquid suspension to the secondary stage under pressure. The stage **27** comprises a battery of hydrocyclones **53** which operate like the hydrocyclones **35** to produce an acceptable fraction issuing through the base ends of the hydrocyclones and entering a line **54**. Through this line, under control of a valve **55**, they are admitted to the aforementioned return line **41** downstream of the valve **42** and thence conducted back to the liquid suspension supply line **33** for reintroduction into the primary stage **26**. The rejects from the secondary stage **27** discharge to a line **56** and are thereby conducted to a tertiary stage **57** comprising one or more hydrocyclones **58**. Make-up water is supplied to line **56** by way of a branch **59** from supply line **31**. A pump **61** supplies the liquid suspension to stage **57** under pressure. The accepts from the tertiary stage are fed into the line **54** as indicated while the rejects are discharged into a tank **62** from which they may be withdrawn by a pump **63** and delivered through a line **64** to a refiner and eventual return to the stock supply line **32**. The salvaging of the final rejects is a feature of the invention made possible by the use of the vacuum receiver and separator in its function of removing abrasive materials. The vacuum receiver and separator is also useful as noted in obviating wear, it being understood that the whirling motions induced in the hydrocyclones have an abrasive action on the walls thereof. As an example of the advantageous use of the invention, in the production of ground wood pulp the abrasive grains from the grinding wheel become dull and break off and are found in the pulp. The pulp is pumped at such a consistency that these grains appear with the rejects from the primary cleaning stage and through the secondary pump where they cause some wear and then go through the secondary cleaners where their more concentrated form produces additional and more severe wear. If this is followed with a third stage, the tertiary pump and cleaner have a still further concentrated amount of abrasive rejects and wear becomes still more severe. In addition to the abrasive grains, a system operation produces pipe scale, metal particles, and other abrasive materials accidentally entering the system. The instant receiver-separator is capable of removing all of this heavy fraction. Concentrated wear as has heretofore taken place in secondary and tertiary pump and cleaner elements is avoided.

A valve controlled line **65** provides additional water from line **31** to supply pump **63**.

The liquid level **19** of the liquid pond in shell **10** is maintained substantially constant through a control system **66** sensing vacuum pressure in the upper end of shell **10** through a connection **67** and sensing liquid pressure in the shell through a connection **68**. The system controls the setting of a valve **51** through a means **69** and it will be understood acts to admit more or less water to the line **48** as the liquid level **19** falls and rises. The control system is schematically disclosed, being the result of a combination of known instruments and devices producing a heretofore known result. The receiver-separator is fitted with differential pressure means including a cell located above the liquid level to measure the vacuum pressure and another cell located below the liquid level to measure the liquid pressure. By adjustment, any desired liquid level can be maintained inside the receiver, by the control

means positioning the automatic valve supplying the make-up water.

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.

Having thus described my invention, I claim:

1. A method of cleaning a liquid stock containing acceptable and rejectable solids in suspension, including the steps of flowing the liquid stock through primary and secondary cleaning stages in which the stock is subjected to hydro-cyclonic separating action under conditions of determined pressure drop and flow rate, intermediate said stages removing heavy and abrasive particles by subjecting the liquid stock to hydro-cyclonic separating action under conditions of low pressure drop and high flow rate, as compared to corresponding conditions in the primary and secondary cleaning stages, and carrying out said hydro-cyclonic separating action in the presence of applied vacuum by connection to a vacuum source.

2. A method of cleaning a liquid stock containing acceptable and rejectable solids in suspension, including the steps of flowing the liquid stock through a primary cleaning stage, diluting the material rejected by said primary stage and flowing it through a secondary cleaning stage, and between said stages and in the presence of applied vacuum putting the material rejected by said primary stage through an intermediate stage under conditions of low pressure drop and high flow rate as compared to corresponding conditions in said primary cleaning stage, said conditions being favorable to separating out of heavy and abrasive particles.

3. A method of cleaning a liquid stock containing acceptable and rejectable solids in suspension, including the steps of flowing the liquid stock through successive cleaning stages reducing the consistency thereof, and at a point between selected stages and in the presence of applied vacuum putting the material rejected in the immediately preceding stage through an intermediate stage under conditions of low pressure drop and high flow rate as compared to corresponding conditions in the said immediately preceding state, said conditions being favorable to a separating out of heavy and abrasive particles.

4. Apparatus for cleaning a liquid stock containing acceptable and rejectable solids in suspension, including primary and secondary hydro-cyclonic cleaners, means for flowing the liquid stock of said primary cleaner and flowing the rejects from said primary cleaner toward said secondary cleaner, another hydro-cyclonic cleaner intermediate said primary and secondary cleaners and in the path of flow to said secondary cleaner, said other hydro-cyclonic cleaner receiving the rejects from said primary cleaner and delivering an accepted fraction thereof to said secondary cleaner, said other hydro-cyclonic cleaner having a large flow capacity under conditions of low pressure drop relative to said primary and secondary cleaners whereby to provide conditions favorable to a removal of heavy and abrasive particles, and means for applying a vacuum in said hydro-cyclonic cleaner.

5. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension, including hydro-cyclonic cleaning means, a vacuum receiver and separator holding a pond of liquid and formed for hydro-cyclonic separation, inlet means for introducing tangentially into said vacuum receiver and separator below the level of said pond the rejects from said cleaner, said introduction being with a force sufficient to produce a vortex in said pond to which heavy and abrasive solids settle toward one end of said vacuum receiver and separator while another fraction moves toward the opposite end thereof, means to conduct said other fraction out of said vacuum receiver and separator, means for creating a vacuum chamber above the level of said pond, and a conduit comprised in said inlet means extending from said cleaning means to said vacuum receiver and separator and communicating with said vacuum chamber.

6. Apparatus according to claim 5, characterized in that said conduit is arranged over a part of its length with at least a part of its internal diameter higher than the level of said pond.

7. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension, including cleaning means, means introducing a liquid stock into said cleaning means, the rejected solids issuing from one end of said cleaning means, a conduit conducting the rejected solids away from said cleaning means, vacuum applying means communicating with said conduit, a hydrocyclone having an apex outlet and an elongated base portion communicating with said vacuum applying means, a pond of liquid in said hydro-cyclone having its level in said base portion, an inlet to said hydro-cyclone receiving the rejects from said cleaning means through said conduit and discharging tangentially below the level of said pond, a rejectable fraction of the solids issuing through said apex and an acceptable fraction moving toward the base of the hydro-cyclone, and means for carrying off said acceptable fraction.

8. Apparatus according to claim 7, characterized by means for maintaining the level of said pond substantially constant.

9. Apparatus according to claim 7, characterized in that said conduit is arranged over a part of its length with at least a part of its internal diameter higher than the level of said pond.

10. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension, including a vacuum receiver and separator device having a base end and an apex end, the apex end being an outlet for rejectable solids, means for maintaining a pond of liquid in said device the level of which is in the base end, means for creating a vacuum in the base end of said device above the liquid level, means for supplying a liquid stock into the device below the liquid level tangentially with sufficient force to create a vortex in the pond, a rejectable fraction moving toward the apex end and an acceptable fraction moving toward the base end, and means for carrying off the acceptable fraction.

11. Apparatus according to claim 10, characterized in that said last named means comprises an outlet facing the said base end of the device.

12. Apparatus according to claim 10, characterized in that said last named means comprises an outlet conduit extending through the apex end of the device and longitudinally through the interior thereof to the base end of the device and having an open inner end terminating in the said base end of the device below the level of the pond.

13. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension, including a vacuum receiver and separator device having a closed base end and an open apex end, a conduit entering said device through the open apex end and extending longitudinally of the device toward the base end and having an open inner end, a tangential inlet for the admission of liquid stock, the whirling motion of the

liquid producing a rejectable fraction moving to said apex and issuing therefrom around said conduit, and further producing an acceptable fraction moving along the exterior of said conduit toward the base end of the device and entering the open inner end of said conduit to flow in a reverse direction through said conduit out of the device, means maintaining a liquid pond in said device submerging said inlet and the open inner end of said conduit, and means for creating a vacuum in said device in the base end thereof above the liquid level.

14. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension, including a vacuum receiver and separator device having a closed base end, an open apex end, a conduit having one end opening to the interior of said device in the base end thereof and extending outside said device at its other end, an inlet for the admission of liquid stock arranged for tangential discharge to produce a whirling motion of the suspension resulting in the formation of a rejectable fraction moving to said apex end and issuing therefrom and further producing an acceptable fraction moving toward the base end of the device and entering the open inner end of said conduit, means maintaining a liquid pond in said device submerging the open inner end of said conduit and said inlet, and means for creating a vacuum in said device in the base end thereof above the liquid level.

15. Apparatus according to claim 14, characterized in that said conduit has its open inner end facing the base end of the device and extends in inclined relation to the longitudinal axis of the device to and through the side thereof.

16. Apparatus according to claim 14, characterized in that said conduit is longitudinally disposed in said device passing through the apex end thereof for discharge of both the rejectable and acceptable fractions through the apex end of the device.

17. Apparatus for removing rejectable solids from a liquid stock containing acceptable and rejectable solids in suspension including a vacuum receiver and separator device having a closed base end and an open apex end, means for maintaining a pond of liquid in said device an inlet for the tangential discharge of liquid stock into said device to induce a separation of the rejectable and acceptable fractions, said inlet being below the level of said pond whereby to create a vortex in said pond, and a conduit in said device to carry off the acceptable fraction, said conduit having its open end in the base end of said device below the level of said pond and intermediate said inlet and the apex end of the device, and means for creating a vacuum in the base end of said device above the liquid level.

18. A method of cleaning a liquid stock containing acceptable and rejectable solids in suspension, including the steps of flowing the liquid stock through successive cleaning stages, at a point between selected stages putting the material rejected in the immediately precedinng stage through an intermediate stage under conditions of low pressure drop and high flow rate as compared to corresponding conditions in the said immediately preceding stage, said conditions being favorable to a separating out of heavy and abrasive particles, and carrying out the operation of said intermediate stage in the presence of applied vacuum by connection to a vacuum source.

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