July 14, 1953 S. A. STAEGE ET AL 2,645,346

PAPER MACHINERY

Filed May 20, 1950

Fig-1

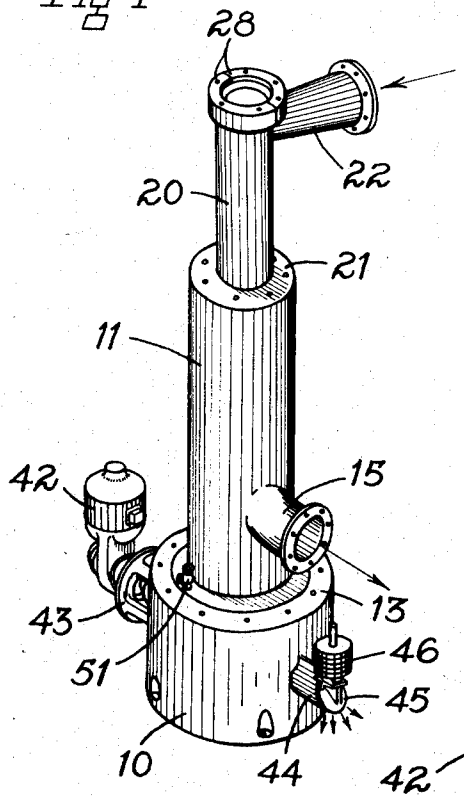


Fig-2

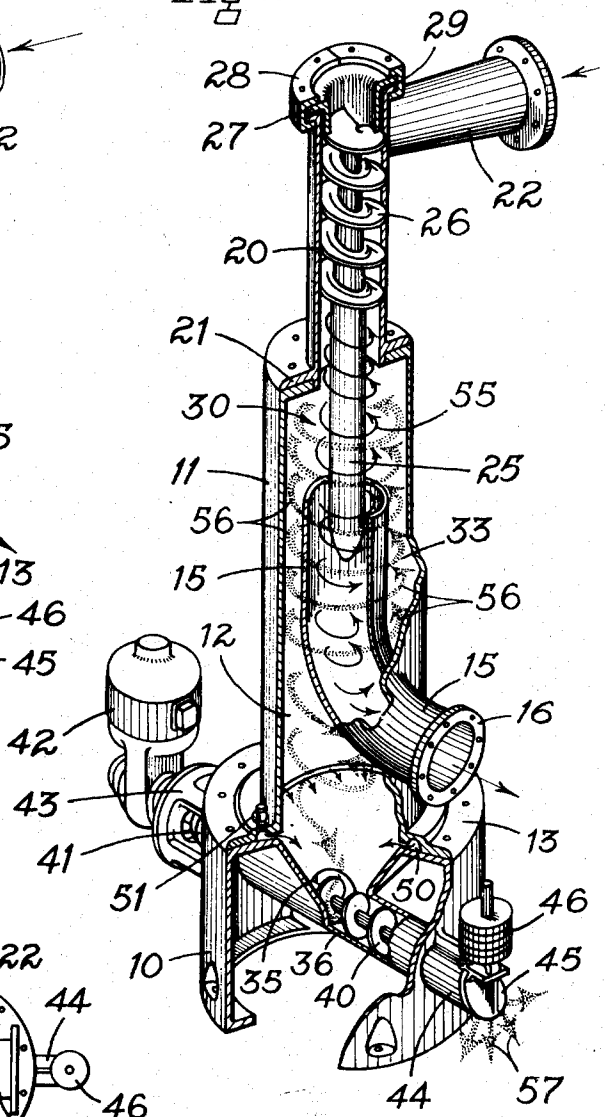
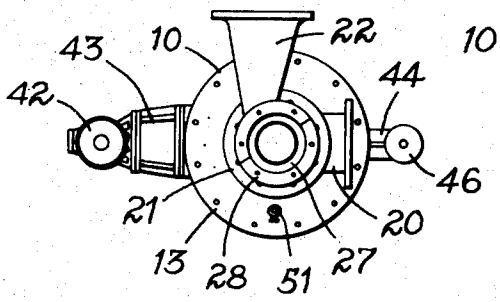


Fig-3



INVENTORS
STEPHEN A. STAEGE &
ALBERT G. GIBSON

BY Marshall & Biebel
ATTORNEYS

Patented July 14, 1953

2,645,346

UNITED STATES PATENT OFFICE

2,645,346

PAPER MACHINERY

Stephen A. Staege, Hamilton, and Albert G. Gibson, Middletown, Ohio, assignors to The Black-Clawson Company, Hamilton, Ohio, a corporation of Ohio

Application May 20, 1950, Serial No. 163,112

9 Claims. (Cl. 209—211)

1

This invention relates to a vortex separator for separating heavy particles from paper making stock and other liquid slurries.

The invention relates more particularly to a vortex separator of the type wherein a whirling motion initially imparted to the stock as it enters a separating chamber is relied upon to set up desired conditions of centrifugal force for effecting separation of the heavy particles therefrom. However, in place of relying upon a reversal of flow within the separating chamber such that an inner helix of clean stock flows within an outer helix of uncleaned stock and in the opposite direction, the present invention provides a vortex separator wherein the stock flows in a substantially straight line from the inlet of the separating chamber to the outlet across an annular or circumferential discharge passage or gap of substantial length within the separating chamber under controlled conditions such that heavy particles are discharged through this passage into the interior of the separating chamber while the resulting clean stock flows directly to the outlet from the chamber.

In addition to this operating characteristic of straight through flow of the stock across an annular discharge passage of substantial axial extent for the reject particles, and the resulting avoidance of reversal of flow and conditions of oppositely flowing inner and outer strata of stock which give rise to turbulence, the present invention provides a vortex separator of such construction that all of the stock is subjected to the desired whirling helical motion as it flows across the discharge passage. This in turn makes it possible to obtain a desired effective centrifugal force with lower pressure and lower power consumption than when the stock is operated upon within a cylindrical separating chamber or when reversal of the flow within itself is relied upon. Furthermore, the invention provides operating conditions such that the rate of flow of the clean stock leaving the separating chamber may be decelerated after the stock crosses the discharge passage, thus further assuring effective separation of the heavy particles and minimizing the carrying capacity of the clean stock for reject material.

These operating characteristics are obtained in accordance with the invention by a construction of the separator wherein the inlet and outlet conduits for the separating chamber are positioned with their adjacent ends aligned within the upper part of the separating chamber in such manner that the outlet conduit receives stock directly from the inlet conduit and in substantially straight line flow. The adjacent ends of these conduits are spaced from each other to leave an annular or circumferential discharge passage therebetween of substantial axial extent which opens into the interior of the separating chamber, and a core is provided which extends axially through this passage between the conduits. One of the conduits includes a portion of substantial length which is positioned within the chamber but is of substantially smaller diameter than the chamber to provide therein an annular portion or space surrounding the annular discharge passage and extending downwardly below the level of this passage within the chamber.

2

With this arrangement, when the stock is fed in through the inlet conduit in such manner as to impart to it a whirling helical motion as it enters the chamber, it will continue to whirl as it continues to flow across the discharge passage and thus cause heavy particles therein to be discharged through the discharge passage into the annular portion of the chamber while the clean stock passes directly to the outlet conduit. The heavy particles which are thus discharged are then free to settle within the outer annular space and down to the bottom of the chamber, and the same whirling motion which causes their initial discharge through the discharge passage causes a continuing whirling of the particles as they settle and thus effectively prevents their return into the flow of clean stock.

Provision is also made in accordance with the invention for effecting a controlled continuous discharge of heavy particles accumulating in the separating chamber while substantially preventing discharge of liquid other than the comparatively insignificant amount which may adhere to the reject particles. The bottom of the separating chamber is provided with a horizontally arranged screw conveyor which is motor driven at one end and is provided at the other end with an outlet having a counterweighted closure. This conveyor collects reject material settling to the bottom of the separating chamber and conveys it to its outlet until there is sufficient accumulation of reject material at the outlet to force open the closure. When this occurs, the reject material is discharged as a damp sludge comparable in consistency to wet sand or gravel, but since the accumulated slug of material between the conveyor and the outlet remains in place, it effectively seals against loss of liquid through the outlet except for the relatively small amount of liquid which adheres to the reject particles.

It is accordingly one of the principal objects of the present invention to provide a vortex separator which is free of small orifices and restrictions capable of plugging with reject material or of excessive wear in use, and which effectively separates heavy particles from a liquid slurry stock by causing all of the stock to flow with a helical motion as it crosses an annular discharge passage of substantial axial extent located between the inlet and outlet conduits for the separating chamber.

Another object is to provide a vortex separator wherein the direction and rate of flow through the separating chamber of the stock to be cleaned are readily controlled and maintained under conditions of low turbulence which effectively minimize the carrying capacity of the stock for heavy particles and thus facilitate efficient operation of the device with low power requirements to give resulting economy of operation and maintenance.

It is also an object of the invention to provide a vortex separator wherein the heavy particles are separated from the stock and caused to settle in the separating chamber under conditions tending to minimize possible remixing with the clean stock and wherein the reject material is collected and continuously discharged as a damp sludge substantially free of entrained liquid.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawing and the appended claims.

In the drawing—

Fig. 1 is a perspective view of a vortex separator in accordance with the invention;

Fig. 2 is a diagrammatic view of the separator on a larger scale than Fig. 1 and with portions of the casing broken away to illustrate details of internal construction and operation; and

Fig. 3 is a top plan view of the device.

Referring to the drawing, which illustrates a preferred embodiment of the invention, the main base 10 supports a cylindrical casing 11 which encloses a separating chamber 12 of substantial volume and vertical extent. The casing 11 is mounted on base 10 by means of a flange 13, and it includes an outlet conduit 15 which projects upwardly for a substantial distance within chamber 12 and is curved forwardly through the front of the casing for attachment at 16 to a suitable discharge pipe. An inlet conduit 20 is mounted on the upper end of casing 11 by means of a flange 21, and it includes a tangentially arranged inlet connection 22 at its upper end. A helix comprising a core 25 and a helical vane 26 is mounted within the inlet conduit 20 by means of a flanged upper end portion 27 and a two-piece clamping ring 28 provided with an annular gasket 29.

The adjacent ends of the inlet and outlet conduits 20 and 15 are maintained in axially spaced relation as shown to provide an annular or circumferential gap 30 of substantial length between the lower end of the inlet conduit 20 and the upper end of the outlet conduit 15. This gap 30 serves as the discharge passage through which heavy particles in the inner stock are discharged into the interior of the separate chamber 12 as the stock flows downwardly from conduit 20 to conduit 15. It has been found that desirably effective separating action is obtained when this gap 30 is of substantial axial extent, for example an overall axial length of approximately 14 inches where the conduits 15 and 20 are 9 inches in diameter and the casing 11 is approximately 13 inches in inner diameter. It will also be noted that with the conduits and chamber 12 of these relative dimensions, an annular space 33 is provided within chamber 12 which includes an upper portion surrounding the discharge gap 30 and a lower portion continuing downwardly therefrom around conduit 20 to the lower end of the chamber.

The core 25 of the helix in the inlet conduit 20 is of increasing diameter in the direction of flow through conduit 20 to provide a progressively decreasing cross sectional flow area through the inlet conduit and thus to effect acceleration of the rate of flow of the incoming stock. Below this tapered portion of core 25 is a cylindrical portion which extends downwardly below vane 26 and completely through the interior of the discharge gap 30 into the upper end of the outlet conduit 15. For example, with the conduits and casing 11 of the above dimensions, satisfactory results have been obtained with this cylindrical portion of the core approximately four inches in diameter and with the lower end thereof extending from seven to eight inches below the upper end of outlet conduit 15, and this downwardly projecting end portion of the core is shown as tapered to a rounded end of small radius to minimize turbulence. In addition, it will be noted that the lower end of the helical vane 26 is shown as terminating at a point substantially above the lower end of the inlet conduit 20, for example approximately eight inches above the lower end of conduit 20 when the other dimensions of the device are as stated above.

The base 10 includes a tapered throat portion 35 which provides the bottom for separating chamber 12, to receive reject material settling in the chamber, and a cylindrical passage 36 extends horizontally through the base below and in communication with this tapered throat 35. A screw conveyor 40 is mounted in the passage 36 for removing reject material settling therein, and it is connected through a flexible coupling 41 with a drive motor 42 mounted in the back of the base by means of a housing 43. The forward end of the passage 36 is provided with an outlet 44 which extends forwardly beyond the end of screw 40, and a closure door 45 for this outlet is pivoted at the top of the outlet casting and provided with one or more counterweights 46 for normally holding the door 45 in sealing position on the outer end of the outlet 44. Provision is made for introducing a flow of clean water to the separating chamber 12 above the throat 35, an annular distributing passage 50 being formed between the bottom flange 13 of casing 11 and the upper portion of the base 10, and a valve 51 is provided for controlling the admission of water to this passage from outside the casing. If it is desired to draw off liquid from the lower end of the chamber to supplement the reject removing action of the conveyor 40, this may be done by way of valve 51 instead of adding clean water as described.

Fig. 2 illustrates somewhat diagrammatically the operation of this device in effecting separation of heavy particles from paper stock or other liquid slurries entering the chamber 12 through the inlet conduit 20. The tangential arrangement of the inlet connection 22 provides an initial whirling motion to the stock in the inlet conduit which is maintained by the action of the helical vane 26, and the flow of this entering stock is accelerated as it flows toward the chamber 12 by

reason of the progressively decreasing effective flow area of the inlet conduit resulting from the tapered construction of the core **25**. Also, with the vane **26** terminating above the lower end of the conduit as disclosed, the whirling motion of the stock is uniformly distributed around the core **25** before the stock reaches the separating chamber, thus suppressing the tendency towards a jet-like discharge which occurs if the vane continues to the separating chamber and causes undesirable turbulence at the discharge gap.

Since the stock is thus whirling with a helical motion when it reaches the upper end of the chamber **12**, and since the core **25** extends completely through the discharge gap **30** into the outlet conduit, all of the stock will be subjected to this whirling motion as it flows towards the outlet conduit, this action being represented in Fig. 1 by the solid line arrows **55**. The centrifugal force resulting from this motion of the stock causes heavy particles therein to be concentrated in the outer part of the whirling mass of stock, and accordingly when this mass reaches the gap **30**, the heavy particles will be thrown radially through this gap into the surrounding upper portion of the annular space **33**. The clean stock will continue to whirl as it travels downwardly across inwardly of gap **30** and along the core **25** into the upper end of the outlet conduit **15**, and with gap **30** of substantial length as shown, effective discharge of the heavy particles will take place while the stock traverses the length of the gap. In this connection, it should be noted that the length of gap **30** should be sufficient to provide adequate opportunity for the effective centrifugal force to overcome the forces of through flow and gravity tending to hold the heavy particles in the line of flow, while at the same time the gap should not be so long as to provide opportunity for remixing of the separated particles with the clean stock. Satisfactory results from both of these standpoints have been obtained with this gap of the dimensions given above and with the stock flowing through the device at a rate of the order of 1000 gallons per minute at a consistency of approximately 0.8% and an inlet pressure of approximately 20 pounds.

The heavy particles which are discharged into the space **33** will also whirl but in a larger spiral as indicated by the stippled arrows **56**, thus effectively concentrating the reject material along the outer wall of chamber **12** as settling thereof takes place downwardly in the chamber towards the conveyor **40**, and it will thus be seen that the conditions set up within the chamber **12** all contribute to effective separation of heavy material and to prevention of remixing of the separated material with the clean stock. Since all of the stock is forced to whirl as it traverses the inlet conduit and the discharge passage, there is no relatively stagnant central portion such as might exist if the core **25** were not present, and at the same time the construction of the device as shown effectively prevents shortcircuiting of the stock of a high pressure inlet to a low pressure outlet. The arrangement with the outlet conduit located centrally within the annular space **33** is also of assistance in maintaining continued separation of the reject once it has been discharged through passage **30**. Not only does the whirling of the reject in itself tend to prevent remixing, but since the space **33** continues below the level of gap **30** to the lower portion of chamber **12**, gravity also acts on the separated material and causes it to settle until it reaches the conveyor **40**.

Effective separation is aided by the inward flow of clean liquid from the passage **50**, which is maintained at a low volumetric rate approximately the volumetric rate at which the reject material is removed, for example approximately two gallons per minute under the operating conditions described above. This clean liquid replaces the reject in the flow of clean stock into the outlet conduit, and it provides a back pressure across the discharge gap which tends to maintain the clean stock on its desired course and is particularly useful in the case of paper stock since it aids in preventing discharge of fiber with the heavy particles. In fact, if bits of fiber should initially be discharged through gap **30** by clinging to heavy particles, the upward flow of the clean water through the space **33** tends to wash off this fiber and carry it back into the outgoing stream of the clean stock. It will also be seen that this back pressure provided by the added flow of clean liquid can be readily predetermined and controlled as desired to regulate the discharge through gap **30**.

A further aid to effective separating action and the prevention of remixing of reject material with the clean stock is provided by the arrangement of the core **25** with its lower end extending a substantial distance into the outlet conduit and then terminating. The presence of the core in the upper end of the outlet conduit aids in maintaining the desired whirling motion of all of the stock until after it has entered the discharge conduit, since it maintains the effective flow area of this portion of the outlet conduit substantially equal to that of the discharge end of the inlet conduit. In addition, the termination of the core at a position as shown within the outlet conduit increases the effective flow area of the outlet conduit beyond that point and thus produces a corresponding deceleration of the rate of flow of the clean stock, which is desirable in effectuating the proper separation of the reject material since the resulting reduced rate of flow of the clean stock materially reduces its carrying capacity for heavy particles. Also with the device substantially free of restricted passages or orifices and provided with liberal open areas around all parts as shown, both reject material and fiber are prevented from accumulating at any point in such manner as to cause possible change in the flow characteristics of the unit, and the flow velocity thus remains the same during continuous operation of the unit.

The reject material ultimately settles to the bottom of chamber **12** whence it is carried by the screw conveyor **40** towards its outlet **44**. In practice it is found desirable to have the conveyor terminate at a position spaced from the closure door **45** by an appreciable distance as shown in Fig. 2, for example six to eight inches, so that the accumulated reject first forms a relatively solid slug between the end of the conveyor and the door **45**. Then as additional reject accumulates and is forced against this slug, the door **45** will be opened against its counterweights **46** to effect gradual discharge of the reject as indicated by the stippled arrows **57** in Fig. 2. When this occurs, however, there still remains a substantial slug of reject within the outlet **44** which acts effectively as a seal against free discharge of liquid through the outlet. As a result, it is found in practice that the discharge of reject takes place in the form of a damp sludge containing practically no more liquid than adheres to the individual particles

in this sludge, giving it a consistency roughly comparable to wet sand. This sludge is accordingly easy to handle for disposal by shovels or in any other convenient way and without also having to decant or otherwise dispose of reject liquid, and thus the loss or waste of liquid is reduced to a minimum. In addition, this controlled reject removal is highly advantageous in maintaining the desired uniform separating action within the separating chamber 12, since the removal of the reject is compensated for by the clean liquid added at the lower end of the chamber as described. The discharge of the reject material does not cause variations or sudden change in the pressure within the unit such as may result from intermittent cleaning or the opening and closing of a continuously operated port type valve, and the pressure within the unit therefore remains constant with no peaks and valleys in the resulting efficiency curve.

Reference is made to copending application of Joseph Baxter, Jr., Serial No. 163,151, filed of even date herewith and assigned to the same assignee as this application.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A vortex separator for separating heavy particles from a liquid slurry stock comprising a casing forming a chamber adapted to be filled with liquid, a cylindrical inlet conduit adapted to deliver stock into said chamber in substantially vertical flow, a cylindrical outlet conduit from said chamber aligned with said inlet conduit to receive said stock directly from said inlet conduit, means maintaining the adjacent ends of said conduits in axially spaced relation within said chamber to provide a circumferential discharge gap therebetween for radial discharge of particles out of the line of flow therebetween into said chamber, said inlet and outlet conduits being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means for delivering said stock through said inlet conduit with a whirling helical motion to cause solid particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means forming a core in said inlet conduit extending through the interior of said discharge gap into the interior of said outlet conduit to cause all of said stock to flow with said whirling helical motion while passing from said inlet to said outlet, said core terminating at a position spaced within said outlet conduit from said gap to cause deceleration of the rate of flow of said stock through said outlet conduit, and means in said casing below said gap for receiving said particles settling through said annular space.

2. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber adapted to be filled with liquid, an inlet conduit opening into the upper end of said chamber and extending generally vertically with respect to said casing, an outlet conduit from said chamber including a portion of substantial length arranged within said chamber in position to receive said stock directly from said inlet conduit, means maintaining said conduits with their adjacent ends in axially spaced relation within said chamber to provide a circumferential discharge gap between said conduits for radial discharge of particles out of the line of flow therebetween into the interior of said chamber, the portion of said discharge conduit within said chamber and the adjacent end of said inlet conduit being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means for delivering said stock through said inlet with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means forming a core extending axially through the interior of said inlet conduit and said discharge gap into the interior of said discharge conduit to cause all of said stock to flow with said whirling helical motion while passing from said inlet to said outlet, and means in said casing below said gap for receiving solid particles settling through said annular space.

3. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber adapted to be filled with liquid, an inlet conduit opening into the upper end of said chamber and extending generally vertically with respect to said casing, an outlet conduit including a portion within said chamber in axially spaced alignment with said inlet conduit providing a circumferential discharge gap between said conduits within said chamber, the portion of said discharge conduit within said chamber and the adjacent end of said inlet conduit being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means for delivering said stock through said inlet with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means forming a core extending axially through the interior of said inlet conduit and said discharge gap into the interior of said outlet conduit to cause all of said stock to flow with said whirling helical motion while passing from said inlet to said outlet, the portion of said core within said inlet conduit being of increasing diameter in the direction of flow through said conduit to cause acceleration of the rate of flow of said stock entering said chamber, the portion of said core within said discharge gap being substantially cylindrical, and said core terminating in a tapered end portion at a position spaced within said outlet conduit from said gap to cause deceleration of the rate of flow of said stock through said outlet conduit.

4. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a base, a cylindrical casing mounted on said base in substantially upright position to define a sep-

arating chamber adapted to be filled with liquid, an inlet conduit extending upwardly from the top of said casing in coaxial relation with said chamber, an outlet conduit extending through said casing adjacent the lower end thereof and projecting upwardly within said casing in alignment with said inlet conduit, said outlet conduit terminating in axially spaced relation with said inlet conduit to provide a circumferential discharge gap therebetween within said chamber, said outlet conduit and the lower end of said inlet conduit being of smaller diameter than said casing to define therewith an annular space surrounding said gap and extending downwardly therefrom within said chamber to said base, a helix mounted within said inlet conduit for causing stock to be delivered through said conduit with a whirling helical motion for effecting radial discharge of heavy particles therein through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said helix including a cylindrical core extending axially through said discharge gap and into the upper end of said outlet conduit for causing all of said stock to flow with said whirling helical motion while passing from said inlet to said outlet and means in said base for collecting and discharging particles settling through said annular space.

5. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a base, a cylindrical casing mounted on said base in substantially upright position to define a separating chamber adapted to be filled with liquid, an inlet conduit extending upwardly from the top of said casing in coaxial relation to said chamber, an outlet conduit extending through said casing adjacent the lower end thereof and projecting upwardly within said casing in alignment with said inlet conduit, said outlet conduit terminating in axially spaced relation with said inlet conduit to provide a circumferential discharge gap therebetween within said chamber, said outlet conduit and the lower end of said inlet conduit being of smaller diameter than said casing to define therewith an annular space surrounding said gap and extending downwardly therefrom within said chamber to said base, a helix mounted within said inlet conduit for causing stock to be delivered through said conduit with a whirling helical motion for effecting radial discharge of heavy particles therein through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said helix including a cylindrical core extending axially through said discharge gap and into the upper end of said outlet conduit for causing all of said stock to flow with said whirling helical motion while passing from said inlet to said outlet, the lower end of said helix being positioned within said inlet conduit and spaced substantially above the lower end of said inlet conduit to effect substantially uniform distribution of said whirling motion of said stock around said core prior to delivery of said stock from said inlet conduit, and means in said base for collecting and discharging particles settling through said annular space.

6. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber adapted to be filled with liquid, an inlet adapted to deliver stock into said chamber, an outlet from said chamber aligned with said inlet to receive said stock directly from said inlet, means supporting said inlet and said outlet with their adjacent ends spaced in the direction of flow therebetween by a substantial distance to form within said chamber a circumferential gap of substantial axial length for radial discharge of particles into the interior of said chamber from the line of flow from said inlet to said outlet, said inlet and outlet being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, said inlet including an elongated conduit extending in coaxial relation with said gap and said adjacent end of said outlet, means including a vane and a central core within said inlet conduit for effecting delivery of said stock to said chamber with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet to said outlet, said annular space being circumferentially unobstructed and continuing downwardly in said chamber below said gap to cause said discharged particles to continue to whirl therein in a helical path of greater radius than said stock within said gap for effective concentration of said particles along the outer wall of said chamber while settling downwardly from said gap, and means in said casing below said gap for receiving said particles settling through said annular space.

7. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber of substantial vertical extent adapted to be filled with liquid, an elongated inlet conduit arranged to deliver stock into said chamber in substantially vertical flow, an outlet conduit from said chamber coaxial with said inlet conduit to receive said stock directly therefrom, means supporting said conduits with the adjacent ends thereof within the upper portion of said chamber and spaced in the direction of flow therebetween by a substantial distance to form within said upper portion of said chamber a circumferential gap of substantial axial extent for radial discharge of particles into said chamber from the line of flow from said inlet to said outlet, a substantial portion of one of said conduits extending downwardly within said chamber below said gap from the end thereof adjacent the other said conduit, said conduit portion and the adjacent end of the other conduit being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, said inlet including an elongated conduit extending in coaxial relation with said gap and said adjacent end of said outlet, means including a vane and a central core within said inlet conduit for effecting delivery of said stock to said chamber with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly into said surrounding annular space through said gap as said stock passes from said inlet conduit to said outlet conduit, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means for receiving and discharging from said casing particles settling downwardly through said annular space.

8. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber adapted to be filled with liquid, an inlet adapted to deliver stock into said chamber, an outlet from said chamber aligned with said inlet to receive said stock di-

rectly from said inlet, means supporting said inlet and said outlet with their adjacent ends spaced in the direction of flow therebetween by a substantial distance to form within said chamber a circumferential gap of substantial axial length for radial discharge of particles into the interior of said chamber from the line of flow from said inlet to said outlet, said inlet and outlet being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, said inlet including an elongated conduit extending in coaxial relation with said gap and said adjacent end of said outlet, means including a vane and a central core within said inlet conduit for effecting delivery of said stock to said chamber with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet to said outlet, said core extending within said gap from within said inlet conduit to said outlet to cause all of said stock passing from said inlet conduit to said outlet to flow with said helical motion, said annular space being circumferentially unobstructed and continuing downwardly in said chamber below said gap to cause said discharge particles to continue to whirl therein in a helical path of greater radius than said stock within said gap for effective concentration of said particles along the outer wall of said chamber while settling downwardly from said gap, and means in said casing below said gap for receiving said particles settling through said annular space.

9. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber of substantial vertical extent adapted to be filled with liquid, an inlet conduit opening into the upper end of said chamber and including an elongated portion extending generally upwardly from said casing, an outlet conduit from said chamber including a portion of substantial length arranged within said casing in coaxial relation with said inlet conduit to receive said stock directly from said inlet conduit, the adjacent ends of said conduits

terminating in spaced relation in the direction of flow therebetween by a substantial distance to form within the upper portion of said chamber a circumferential gap of substantial axial extent, said portion of said discharge conduit within said chamber being of materially smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means including a vane and a central core within said inlet conduit for effecting delivery of said stock to said chamber with a whirling helical motion to cause heavy particles therein to be discharged radially outwardly through said gap into said surrounding annular space as said stock passes from said inlet conduit to said outlet conduit, said annular space being circumferentially unobstructed and contiuuing downwardly in said chamber below said gap to cause said discharged particles to continue to whirl therein in a helical path of greater radius than said stock within said gap for effective concentration of said particles along the outer wall of said chamber while settling downwardly from said gap, and means in said casing below said gap for receiving said particles settling through said annular space.

STEPHEN A. STAEGE.
ALBERT G. GIBSON.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
429,347	Haskel	June 3, 1890
1,701,942	Andrews	Feb. 12, 1929
1,755,780	Hawley	Apr. 22, 1930
1,825,157	Pardee	Sept. 29, 1931
1,880,185	Kerns et al.	Sept. 27, 1932
2,184,248	Bonotto	Dec. 19, 1939
2,346,005	Bryson	Apr. 4, 1944
2,512,253	Lipscomb	June 20, 1950

FOREIGN PATENTS

Number	Country	Date
190,419	Switzerland	July 1, 1937
868,952	France	Jan. 21, 1942