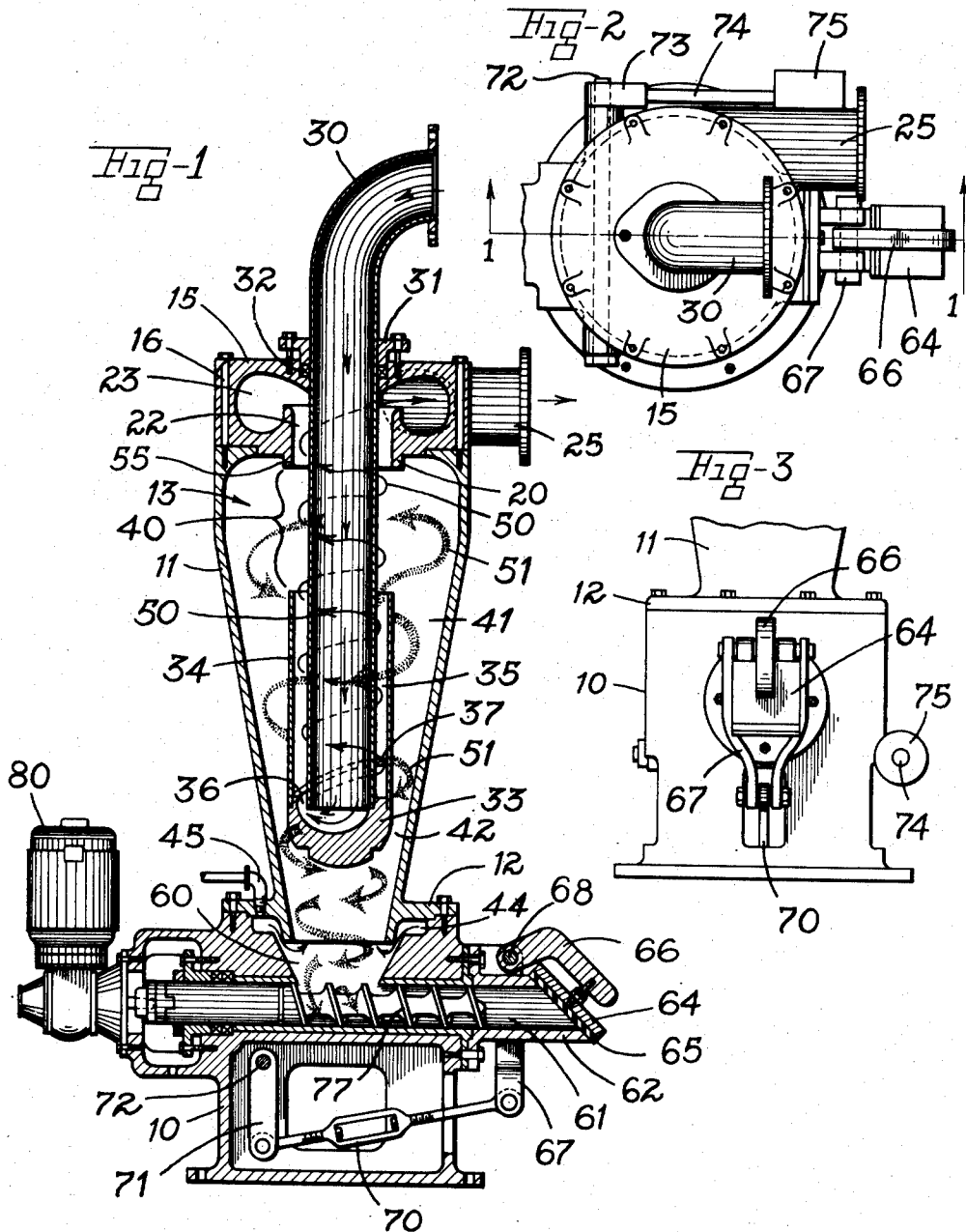


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J. BAXTER, JR
VORTEX SEPARATOR FOR PULP

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INVENTOR.

BY JOSEPH BAXTER, Jr.

Marchant & Ruebel
ATTORNEYS

UNITED STATES PATENT OFFICE

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VORTEX SEPARATOR FOR PULP

Joseph Baxter, Jr., Franklin, Ohio, assignor to
The Black-Clawson Company, Hamilton, Ohio,
a corporation of Ohio

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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 the separating chamber is relied upon to set up desired conditions of centrifugal force for effecting separation of the heavy particles from the stock without requiring a rotor or other driven agitator. However, in place of relying upon a reversal of flow within the separating chamber such that an inner helix of clean stock is caused to flow 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 a circumferential discharge passage of substantial axial extent within the separating chamber under controlled conditions such that heavy particles are discharged through this passage into the surrounding 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 a circumferential discharge passage of substantial axial extent for the reject particles, and the resulting avoidance of reversal of flow within itself 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 for the separating action.

These operating characteristics are obtained in accordance with the invention with a vortex separator having the further advantage of a simplified construction which is economical to produce and to maintain and which also is particularly suitable for use in relatively small sizes to handle comparatively small volumes of stock as well as in larger sizes. In this construction, the inlet pipe through which the stock is conveyed to the separating chamber includes an outer tube forming an annular inlet passage within the separating chamber which is maintained in spaced alignment with an annular outlet passage, and the

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stock is supplied through this inlet passage with a whirling helical motion for travel directly to the outlet passage across the intervening annular portion of the separating chamber. This annular portion of the chamber thus forms a circumferential discharge passage through which heavy particles in the stock are discharged radially outwardly for subsequent settling to the bottom of the chamber while the clean stock flows through and out of the chamber.

Provision is made for washing the reject material within the separating chamber to remove usable paper fiber therefrom for return to the flow of clean stock and also for the controlled removal of the reject. Clean water is introduced at the bottom of the separating chamber to provide an upward flow through which the heavy particles settle, and this flow of clean water crosses the discharge passage and joins the outward flow of clean stock, thus providing a flow of the clean water across the discharge passage for initial washing of the reject particles as they are discharged radially outwardly from the flow of clean stock. In addition, a restriction is provided near the lower end of the separating chamber through which the reject particles settle in the opposite direction to the upward flow of clean water for further washing, and these particles are then finally discharged from the chamber by a conveyor arranged to cause a controlled discharge of the reject substantially free of liquid.

It is accordingly one of the principal objects of the present invention to provide a vortex separator having the above operating advantages wherein the reject material is discharged into a separating chamber as the stock flows across a portion of the chamber from the inlet to the outlet and wherein the reject while in the separating chamber is subjected to washing with clean liquid to remove and return usable fiber to the flow of clean stock before the reject material is finally removed from the separating chamber.

Another object is to provide a vortex separator wherein the inlet pipe for the stock to be cleaned extends into the separating chamber through the outlet passage for the clean stock to form a core around which all of the stock is forced to whirl with a helical motion as it flows from the inlet passage to the outlet passage across a circumferential discharge passage of substantial axial length for reject material.

It is also an object of the invention to provide such a vortex separator wherein the inlet pipe is readily adjustable vertically in the separating chamber to vary the axial dimensions of the dis-

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charge passage for reject material in accordance with the volumetric rate of flow of stock through the device to assure proper discharge of reject material with minimum opportunity for remixing of reject with the clean stock.

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 view in vertical section through a vortex separator constructed in accordance with the invention, the view being in section on the line I—I of Fig. 2;

Fig. 2 is a fragmentary top plan view of the separator; and

Fig. 3 is a fragmentary front elevational view showing the discharge outlet for reject material.

Referring to the drawing, which illustrates a preferred embodiment of the invention, the base 10 supports a generally frusto-conical casing 11 by means of a flange 12, and this casing encloses a separating chamber 13 of substantial volume and vertical extent. A casting 15 forms a top for casing 11 and is bolted thereto at 16. This casting 15 includes an internal tubular portion 20 which forms the outlet conduit 22 from chamber 13 and leads into an annular duct 23 provided with a tangentially arranged outlet connection 25.

An inlet pipe 30 extends vertically through the casting 15 and conduit 22 and is supported by a gland 31 provided with a packing ring 32 bolted to the top of casting 15. A cap 33 is secured to the lower end of pipe 30 and supports an inlet tube 34 which is concentric with pipe 30 and forms therewith an annular inlet passage 35 aligned with the outlet conduit 22. The cap 33 is formed to provide communication at 36 from the interior of the pipe 30 to the passage 35, and the cap 33 also includes a helical vane portion 37 within the passage 35. This helical portion is shown as approximately 180° in angular extent, but it may extend as far upwards in the passage 35 as is found desirable to give the proper whirling helical motion to stock traveling upwardly in passage 35.

The pipe 30 and tube 34 are proportioned and arranged as shown to provide a circumferential gap 40 of substantial length between the upper end of tube 35 and the lower end of the conduit portion 20 of casting 15. This circumferential gap serves as the discharge passage through which heavy particles in the entering stock are discharged into the interior of the separating chamber 13 as the stock flows upwardly from passage 35 to conduit 22. Also, with the tube 34 of substantially smaller diameter than the interior of casing 11 as shown, an annular space 41 is provided within the chamber which surrounds the discharge gap 40 and extends downwardly therefrom to the lower end of the chamber. The frusto-conical configuration of casing 11 provides a restriction 42 at the lower end of the space 41, and provision is made for introducing a flow of clean water to the interior of chamber 13 below this restriction 42. The base 10 and the lower end of casing 11 are formed as shown in Fig. 1, to provide an annular distributing passage 44 below the flange 12, and clean water may be admitted to this passage as indicated at 45.

Fig. 1 illustrates somewhat diagrammatically the operation of this device in effecting separa-

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tion of heavy particles from paper stock or other liquid slurry supplied to the chamber 13 by way of the inlet pipe 30. As the stock reaches the lower end of pipe 30 and starts upwardly through the passage 36, it has a whirling helical motion imparted thereto by the helix 37, and since the pipe 30 extends all of the way from the cap 33 to the outlet duct 23, it forms a core around which all of the stock is forced to whirl as it flows upwardly through the interior of the discharge gap 40 and the outlet conduit 22, this action being represented in Fig. 1 by the solid line arrows 50.

The centrifugal forces resulting from the whirling motion of the stock causes heavy particles therein to be concentrated along the wall of the tube 34 so that when the stock reaches the gap 40, these particles will be thrown radially outwardly into the annular space 41. Since the pipe 30 forms a central core extending within the entire length of the gap 40, the stock will continue to whirl as it travels the full length of the gap 40 into the outlet conduit 22, and since this discharge gap is of substantial axial extent as shown, effective separation of the heavy particles is assured. The heavy particles will also continue to whirl after they reach the annular space 41 but in a larger spiral provided by the greater size of this space, as indicated by the stippled arrows 51, thus effectively concentrating the reject material along the outer wall of chamber 13 where it will gradually settle towards the restriction 42 and the lower end of the chamber, and the tapered construction of casing 11 in its lower part causes acceleration of these whirling particles and thus maintains an effective centrifugal force on the particles as they settle which holds them along the wall of the casing to minimize the possibility of their remixing with the clean stock.

The axial length of the discharge gap 40 between the upper end of inlet tube 34 and the lower end of the conduit portion 20 should be sufficient to provide ample opportunity for the heavy particles in the upwardly flowing stock to overcome the tendency for the forces of through flow to hold them in the line of the clean stock and thus to discharge outwardly into the space 41. The required length of this gap for optimum separating efficiency depends upon the volume of flow through the device, and satisfactory results have been obtained with the stock flowing at 500 gallons per minute when the pipe 30 is 6½ inches in outer diameter, the tube 34 is 9 inches in inner diameter and the gap 40 is approximately 12 inches in axial length. The construction and arrangement of the inlet pipe 30 as shown facilitates ready adjustment of the length of the discharge gap 40 in accordance with different rates of flow of the stock, the pipe being readily adjustable vertically upon loosening of the gland 31. It will also be noted that the conduit portion 20 is extended downwardly into the interior of chamber 13 to form a cylindrical lip 55 which acts to minimize the possibility of the reject material being drawn back into the flow of clean stock through the conduit 22.

The flow of clean water admitted to the interior of chamber 13 by way of the passage 44 is particularly advantageous in handling paper stock for preventing loss of usable fiber with the heavy reject particles. Since this clean water is admitted to the chamber at a position below the discharge gap 40, it will provide an upward flow

which crosses the discharge gap 40 to mix with the outwardly flowing clean stock through the conduit 22, thus providing a back pressure across the discharge gap tending to prevent discharge of the light fibers. Also, this inward flow of the clean water tends to wash off fiber which may be clinging to reject particles and to return it to the flow of clean stock. An additional effective washing of the reject particles occurs as they settle through the restriction 42, since there will be an upward flow of clean water through this restriction which will tend to remove fibers which might still cling to the reject particles and to carry these fibers upward for return to the clean stock. The reject particles are thus forced at least twice to travel through the flow of clean water for washing, but this flow of clean water is maintained at a low rate approximating the volumetric rate at which solid material is removed from the stock, for example approximately 2 gallons per minute where the flow of stock through the device is at the rate of 500 gallons per minute.

Provision is made for continuous discharge of the reject material after it settles to the bottom of the separating chamber. The base 10 is formed with a tapered throat 60 below casing 11 which leads into a cylindrical passage 61 having a discharge outlet 62 at the front of the base. A closure 64 having a gasket 65 is pivoted at the outer end of the discharge outlet 62 by means of a lever 66. A yoke 67 is secured to the pivot shaft 68 for lever 66 and is adjustably connected at 70 with a yoke 71 secured to a shaft 72 within base 10. One end of the shaft 72 is extended to receive an arm 73 supporting a rod 74 on which is mounted a counterweight 75 normally acting to hold the closure 64 in closed position.

A screw conveyor 77 is mounted within the cylindrical passage 61 and is provided with a drive rotor 80. The conveyor 77 terminates at a position spaced from the closure 64 by an appreciable distance, for example six to eight inches, so that reject material which settles to the bottom of chamber 13 is carried by the conveyor into this collection space for accumulation until it forms a relatively solid slug. Then as additional reject accumulates and is forced against this slug, the closure 64 will be opened against its counterweight 75 to effect gradual discharge of the reject. When this occurs, however, the accumulated slug within the outlet 62 continues to act effectively as a seal against free discharge of liquid, and the reject material is extruded as a sludge comparable in consistency to wet sand or gravel which is accordingly readily handled for disposal without the complication of an accompanying flow of liquid. If it is desired to draw off liquid from the lower end of the chamber to supplement the reject removing action of the conveyor 77, this may be done by way of pipe 45 instead of adding clean liquid as described.

In addition to its advantageous operating characteristics of simplicity, effective separation of heavy particles and continuous discharge of the solid reject material, as well as its ready adjustability as described, this device is also advantageous from the standpoint of the simplicity of its construction and maintenance. The device is wholly free of diaphragms, orifices, or crevices subject to plugging or severe abrasion in use, and further the parts which may be subject to abrasion are readily replaceable at low cost. Thus the inlet pipe 30 and tube 34 may be formed of

a material such as stainless steel which is resistant to wear, and also these parts may be quickly and easily replaced when they do become worn without requiring disassembly of the device beyond simple removal of the top casting 15. The device is accordingly highly economical from the standpoint of maintenance as well as requiring very little space in a mill or other plant.

Reference is made to copending application of Stephen A. Staeger et al., Serial No. 163,112, 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, 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 gap being of smaller outer diameter than said chamber to provide an annular space surrounding said gap, means for delivering said stock to said chamber 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 means forming a central core extending within said gap from within said inlet to said outlet to cause all of said stock to flow with said helical motion as said stock passes from said inlet to said outlet, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means for supplying clean liquid to the interior of said separating chamber at a position within said chamber located on the upstream side of the discharge end of said inlet to cause said clean liquid to flow inwardly of said discharge gap to said outlet and across the path of discharge there-through of said heavy particles for washing said heavy particles and returning light particles clinging thereto into the flow of clean stock through said outlet, and means in said casing below said supplying means for receiving said washed particles.

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 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 gap being of smaller outer diameter than said chamber to

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provide an annular space surrounding said gap, means in said chamber below said gap for receiving solid particles settling in said annular space, means for delivering said stock to said chamber 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 means forming a central core extending within said gap from within said inlet to said outlet to cause all of said stock to flow with said helical motion as said stock passes from said inlet to said outlet, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means for supplying clean liquid to the interior of said separating chamber at a position within said chamber located on the upstream side of the discharge end of said inlet to cause said clean liquid to flow inwardly of said discharge gap to said outlet and across the path of discharge therethrough of said heavy particles for washing said heavy particles and returning light particles clinging thereto into the flow of clean stock through said outlet, and means in said chamber below said gap for directing an upward flow of clean liquid through and over said particles settling in said annular space to effect further washing of said particles.

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 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 gap being of smaller outer diameter than said chamber to provide an annular space surrounding said gap, means in said chamber below said gap for receiving solid particles settling in said annular space, means for delivering said stock to said chamber 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, means forming a central core extending within said gap from within said inlet to said outlet to cause all of said stock to flow with said helical motion as said stock passes from said inlet to said outlet, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means for supplying clean liquid to the interior of said separating chamber at a position within said chamber located on the upstream side of the discharge end of said inlet to cause said clean liquid to flow inwardly of said discharge gap and across the path of discharge therethrough of said heavy particles for washing said heavy particles and returning light particles clinging thereto into the flow of clean stock through said outlet, means in said chamber below said gap for directing an upward flow of clean liquid through and over said particles settling in said annular space to effect further washing of said particles, and means cooperating with said receiving means to effect controlled discharge of said washed par-

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ticles from said casing substantially free of entrained liquid.

4. 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 outlet at the upper end of said chamber, an inlet positioned below and in alignment with said outlet for delivering stock into said chamber, 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 said gap being of smaller outer diameter than said chamber to provide an annular space surrounding said gap, means for delivering said stock to said chamber 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 to said outlet, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means forming a restriction at the lower end of said annular space, means for admitting clean liquid to said chamber below said restriction for upward flow through said restriction and across said discharge gap to said outlet to effect washing of said particles discharged through said gap and to effect further washing of said particles settling through said restriction, and means in said casing below said admitting means for receiving said washed particles.

5. 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 outlet at the upper end of said chamber, an inlet positioned below and in alignment with said outlet for delivering stock into said chamber, 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 said gap being of smaller outer diameter than said chamber to provide an annular space surrounding said gap, means for delivering said stock to said chamber 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 to said outlet, said space continuing downwardly in said chamber below said gap to receive said particles discharged through said gap and settling downwardly therefrom, means forming a core extending axially through said inlet and said discharge gap into said outlet to cause all of said stock to whirl with said helical motion in passing from said inlet to said outlet, means forming a restriction at the lower end of said annular space, means for admitting clean liquid to said chamber below said restriction for upward flow through said restriction and across said discharge gap to said outlet to effect washing of said particles discharged through said gap and to effect a further washing of said particles settling through said restriction, and means in said casing below said admitting means for re-

ceiving particles settling through said restriction.

6. 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, means forming a vertically arranged opening at the upper end of said chamber forming an outlet from said chamber, an inlet pipe extending downwardly through said opening to a position spaced between said opening and the lower end of said chamber, said pipe being of smaller diameter than said opening to form therewith an annular outlet passage, means for delivering stock to said chamber through said pipe, means at the lower end of said pipe for causing said stock to reverse the direction of flow thereof and to flow upwardly in said chamber outwardly of said pipe, means for confining said upwardly flowing stock within a circumferential space of smaller outer diameter than said chamber, means defining an annular gap between said confining means and said outlet passage communicating with the outermost portion of said chamber, means for causing said upwardly flowing stock to whirl with a helical motion while passing from said confining means to said outlet passage to effect radial discharge of heavy particles therein through said gap, means defining an annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means at the lower end of said chamber for receiving said particles settling through said chamber outwardly of said confining means.

7. A vortex separator for separating heavy particles from a liquid slurry stock, comprising a casing forming a chamber adapted to be filled with liquid, means forming an outlet opening at one end of said chamber, an inlet pipe extending through said opening into the interior of said chamber, said pipe being of smaller diameter than said opening to form therewith an annular outlet passage, a tube supported concentrically on said pipe within said chamber and receiving said pipe internally, said tube being of larger diameter than said pipe to define therewith an inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said opening to provide therebetween a circumferential discharge gap within said chamber, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said tube and said discharge gap, means forming an enclosed connection between the interior of said pipe and said inlet passage, means for delivering stock to said chamber through said pipe and inlet passage, and means for causing said stock to flow with a whirling helical motion through said inlet passage and radially inwardly of said discharge gap to said outlet passage to effect radial discharge of heavy particles therein through said gap into said annular space, said annular space continuing downwardly in said chamber below said gap for receiving said discharged particles settling downwardly from said gap.

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, means forming an outlet opening at one end of said chamber, an inlet pipe extending through said opening into the interior of said chamber, said pipe being of smaller diameter than said opening to form therewith an annular outlet passage, a tube supported concentrically

on said pipe within said chamber and receiving said pipe internally, said tube being of larger diameter than said pipe to define therewith an inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said opening to provide therebetween a circumferential discharge gap within said chamber, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said tube and said discharge gap, means forming an enclosed connection between the interior of said pipe and said inlet passage, means for delivering stock to said chamber through said pipe and inlet passage, means for causing said stock to flow with a whirling helical motion through said inlet passage and radially inwardly of said discharge gap to said outlet passage to effect radial discharge of heavy particles therein through said gap into said annular space, means for effecting withdrawal of said particles from said chamber through said annular space, and means for introducing a flow of clean liquid to the interior of said chamber at a position spaced axially within said chamber from said gap to provide a flow of said clean liquid through said space and across said gap to said outlet passage for washing said particles discharged through said gap.

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, means forming a vertically arranged cylindrical opening at the upper end of said chamber, a pipe extending downwardly through said opening to a position spaced between said opening and the lower end of said chamber, said pipe being of smaller diameter than said opening to form therewith an upper annular passage, a tube supported concentrically on said pipe within said chamber and receiving said pipe internally, said tube being of larger diameter than said pipe to define therewith a lower annular passage aligned with said upper annular passage, means for maintaining said tube in axially spaced relation with said opening to provide therebetween a circumferential discharge gap within said chamber, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said discharge gap, means forming an enclosed connection between the interior of said pipe and said lower annular passage, means for delivering stock to said chamber through one of said passages with a whirling helical motion to cause said stock to flow axially radially inwardly of said discharge gap to the other of said passages with accompanying radial discharge of heavy particles therein through said discharge gap into said annular space, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means at the lower end of said chamber for receiving and collecting said particles settling in said annular space.

10. 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, means forming a vertically arranged outlet passage at the upper end of said chamber, an inlet pipe of smaller diameter than said outlet passage extending downwardly through said outlet passage to a position spaced between said outlet passage and the lower end of said chamber, an inlet tube

supported concentrically on said inlet pipe within said chamber and receiving said pipe internally, said tube being of larger diameter than said pipe to define therewith an annular inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said outlet passage to provide therebetween a circumferential discharge gap, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means on the lower end of said inlet pipe for causing stock therefrom to flow upwardly through said inlet passage, means for causing said upwardly flowing stock to whirl with a helical motion through said inlet passage and across said discharge gap to said outlet passage to cause heavy particles therein to be discharged radially outwardly through said gap into said annular space as said stock passes from said inlet passage to said outlet passage, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means at the lower end of said chamber for receiving and collecting said particles settling in said annular space.

11. 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, means forming a vertically arranged cylindrical opening at the upper end of said chamber, a pipe extending downwardly through said opening to a position spaced between said opening and the lower end of said chamber, said pipe being of smaller diameter than said opening to form therewith an upper annular passage, a tube supported concentrically on said pipe within said chamber and of larger diameter than said pipe to define therewith a lower annular passage aligned with said upper passage, means for maintaining said tube in axially spaced relation with said opening to provide therebetween a circumferential discharge gap, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means forming an enclosed connection between the interior of said pipe and said lower passage, means for delivering stock to said chamber through one of said passages with a whirling helical motion to cause said stock to flow axially radially inwardly of said discharge gap to the other of said passages with accompanying radial discharge of heavy particles therein through said gap into said annular space, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means below the upper end of said tube for restricting said annular space, means in said chamber below said restricting means for receiving said particles settling through said restricting means, and means for admitting clean liquid to said chamber below said restricting means to provide an upward flow of said liquid through said restricting means for washing said particles.

12. 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, means forming a vertically arranged outlet passage at the upper end of said chamber, an inlet pipe of smaller diameter than said outlet passage extending downwardly through said outlet passage to a position spaced between said outlet passage and

the lower end of said chamber, an inlet tube supported concentrically on said inlet pipe within said chamber and of larger diameter than said pipe to define therewith an annular inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said outlet passage to provide therebetween a circumferential discharge gap, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means on the lower end of said inlet pipe for causing stock therefrom to flow upwardly through said inlet passage, means for causing said upwardly flowing stock to whirl with a helical motion through said inlet passage and radially inwardly of said discharge gap to said outlet passage to cause heavy particles therein to be discharged radially outwardly through said gap into said annular space as said stock passes from said inlet passage to said outlet passage, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means for admitting clean liquid to the lower end of said annular space to provide a flow of said clean liquid across said discharge gap to said outlet passage for washing particles discharged through said gap, and means at the lower end of said chamber for receiving and collecting said particles settling in said annular space.

13. 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, means forming a vertically arranged outlet passage at the upper end of said chamber, an inlet pipe of smaller diameter than said outlet passage extending downwardly through said outlet passage into said chamber, an inlet tube supported concentrically on said inlet pipe within said chamber and of larger diameter than said pipe to define therewith an annular inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said outlet passage to provide therebetween a circumferential discharge gap, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means on the lower end of said inlet pipe for causing stock therefrom to flow upwardly through said inlet passage, means for causing said upwardly flowing stock to whirl with a helical motion through said inlet passage and radially inwardly of said discharge gap to said outlet passage to cause heavy particles therein to be discharged radially outwardly through said gap into said annular space as said stock passes from said inlet passage to said outlet passage, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means cooperating with the lower end of said pipe to form a restriction at the lower end of said annular space, means below said restriction for receiving and collecting particles settling in said space, and means for admitting clean liquid to said chamber below said restriction for upward flow through said restriction and across said discharge gap to said outlet for washing particles discharged through said gap and settling through said restriction.

14. 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, means

forming a vertically arranged outlet passage at the upper end of said chamber, an inlet pipe of smaller diameter than said outlet passage extending downwardly through said outlet passage to a position spaced between said outlet passage and the lower end of said chamber, an inlet tube supported concentrically on said inlet pipe within said chamber and of larger diameter than said pipe to define therewith an annular inlet passage aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said outlet passage to provide therebetween a circumferential discharge gap within said chamber, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said discharge gap, means on the lower end of said inlet pipe for causing stock therefrom to flow upwardly through said inlet passage, helix means in said inlet passage for causing said upwardly flowing stock to whirl with a helical motion radially inwardly of said discharge gap to said outlet passage to effect radial discharge of heavy particles from said stock through said gap into said annular space as said stock passes from said inlet passage to said outlet passage, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, and means at the lower end of said chamber for receiving and collecting said particles settling in said annular space.

15. 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, means forming a vertically arranged outlet passage at the upper end of said chamber, an inlet pipe of smaller diameter than said outlet passage extending downwardly through said outlet passage to a position spaced between said outlet passage and the lower end of said chamber, an inlet tube supported concentrically on said inlet pipe within said chamber and of larger diameter than said pipe to define therewith an annular inlet passage

aligned with said outlet passage, means for maintaining said tube in axially spaced relation with said outlet passage to provide therebetween a circumferential discharge gap within said chamber, said tube being of smaller diameter than said chamber to provide an annular space within said chamber surrounding said gap, means on the lower end of said inlet pipe for causing stock therefrom to flow upwardly through said inlet passage, means for causing said upwardly flowing stock to whirl with a helical motion through said inlet passage and radially inwardly of said discharge gap to said outlet passage to cause heavy particles therein to be discharged radially outwardly through said gap into said annular space as said stock passes from said inlet passage to said outlet passage, said annular space continuing downwardly in said chamber below said gap to receive said discharged particles settling downwardly from said gap, means at the lower end of said chamber for receiving and collecting said particles settling in said annular space, and means for adjusting said pipe vertically with respect to said casing to vary the axial length of said circumferential discharge gap.

JOSEPH BAXTER, JR.

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FOREIGN PATENTS

Number	Country	Date
190,419	Switzerland	July 1, 1937