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VORTEX SEPARATORS
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## VORTEX SEPARATORS

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4 Claims. (Cl. 92-28)

This invention relates to methods and apparatus for separating gases, vapor and solid particles such as dirt, from liquids and liquid suspensions, the invention among various other possible uses being particularly adapted for the treatment of paper pulp suspensions.

In our co-pending application Serial No. 314,248 , filed October 11, 1952, and now abandoned, entitled "Method and Apparatus for Separating Undesired Particles and Gases from Paper Pulp Suspensions and Other Fluids," and a continuation-in-part thereof, Serial No. 324,561, filed December 6, 1952, and entitled "Method and Apparatus for Treating Pulp Suspensions and Other Fluids for Removal of Undesired Particles and Gases," reference to which is hereby made, there are disclosed methods and apparatus for separating dirt particles, dissolved and occluded gas and bubbles from pulp suspensions and the like by maintaining a high velocity vortex of the suspension sarrounding a gas core maintained under a low sub-atmospheric pressure by continuously exhausting gas therefrom, whereby dissolved gas and any occluded gas is liberated from the inner portions of the liquid of the vortex and the resulting bubbles and any bubbles originally present are forced by the action of the centrifugal force of the vortex into the core and evacuated, while the dirt particles are flung to the outer portions of the vortex, a stream of the treated suspension being continuously discharged from the mid portions of the vortex, while separately a small anount of the suspension containing the dirt particles is also continuously discharged from an outer portion of the vortex.

With the embodiments of the invention disclosed in the above-mentioned applications, the suspension is introduced tangentially at one end of a cylindrical separating chamber from which the vortex travels to the remote end of such chamber and then reverses and extends back as an inner vortex to a treated stock outlet located centrally of the first end of the chamber and from which the stock is withdrawn by suction means such as a vacuum pump or barometric leg, while the gases are being exhausted through a gas outlet at the center of the remote end of the chamber by means of a vacuum pump, the dirt particles also being discharged from adjacent the periphery of the vortex at such remote end.

The present invention relates to certain simplified embodiments of the methods and apparatus disclosed and claimed in the aforesaid co-pending application, and in which embodiments the apparatus is so constructed and arranged as to cause a vortex of the stock being treated to pass directly through a separating chamber and thence directly into a suction pump or barometric leg, without reversing the vortex. A gas core in the vortex is maintained under low subatmospheric pressure by constantly evacuating gas from the mid portion of the intake end of the separating chamber and toward the other end of the separating chamber, the vortex passage is so shaped that the gas core is caused to diminish in diameter and disappear before the treated stream passes on to the suc-
tion pump or for any considerable distance into a barometric leg if such is used instead of a pump.

Preferably also the separating chamber walls are so restricted and shaped at regions spaced from the intake end that the liquid immediately surrounding the core will tend to travel back toward the gas exhausting connection and thus any bubbles or gas which have been forced to the innermost portions of the vortex will be kept from passing on with the treated stock, whereas the liquid in the outer portions of the vortex will be free to pass on to the barometric leg or equivalent suction pump, and meanwhile also a small amount of the liquid or suspension containing the undesired solid particles which have been fiung to the outermost part of the vortex, will be skimmed off and discharged. With another form of the invention, the vortex core at a region spaced from the stock inlet is caused todisappear by reason of the combined effects of the restricted shape of the chamber walls and of an axial obstruction located in the mid portion of the stream of treated stock.

Various further and more specific objects, features and adyantages of the invention will appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate merely by way of example, preferred forms of apparatus for the practice of the invention. The invention consists in such novel features, arrangements and combinations of parts and method steps as may be shown and described herein.

In the drawings:
Fig. 1 is a vertical sectional view of the presently preferred embodiment of the invention herein disclosed;

Fig. 2 is a vertical sectional view of another embodiment of the invention; and

Fig. 3 is a horizontal sectional view taken substantially along line 3-3 of Fig. 2.

Referring to Fig. 1 in further detail, the liquid suspension or flowing mixture to be treated is forced under pressure from an intake pipe 10 through a headpiece member 11, the inlet portion 12 of which is so shaped as to greatly restrict the cross-section of the incoming stream (for example in the neighborhood of $50 \%$ ) and from this trumpet-like portion 12 the stream is directed tangentially into a chamber 13 to form a vortex layer 14 of the mixture around on the inside walls of the headpiece chamber 13 and then around the inside wall of a chamber 15 preferably of cylindrical cross-section, the direction of flow of the liquid in the vortex being indicated by the helical line 16.

In view of the form of the restricted inlet, a substantial part of the pressure energy of the incoming stream will be converted to velocity energy in the vortex layer 14 , and the resulting high velocity will promptly cause solid particles in the mixture to be flung toward the inner wall of the chamber 15, whereas any bubbles will be forced inwardly of the vortex and into a gas core thereof as indicated at 17.

Within the chamber portion 13 of the headpiece an axial gas discharge outlet 18 is provided for connection to a vacuum pump as indicated, which should be of sufficient capacity to maintain the core 17 constantly at a low subatmospheric pressure, for example from about 5-8 cms. Hg absolute. Thus the liquid in the innermost portions of the vortex layer 14 will be maintained under low subatmospheric pressure with the result that any dissolved or occluded gases contained therein will be liberated into the core 17 , into which also any bubbles in the liquid will be discharged, so that the gases and any vapors thus liberated, as well as the gas of such bubbles, will be exhauisted through the outlet 18.

As shown the lower end of the chamber 15 is connected
to another chamber portion 20, having walls to provide a funnel-like shape, the upper portions of which are more and more outwardly flared, whereby the outer diameter of the vortex layer as at $14 a$ becomes smaller and smaller and the diameter of the core as at $17 a$ correspondingly diminishes, the core ceasing to exist as indicated at point $17 b$ so that beyond this point the flow of liquid will be free of any gas core. To accomplish this result effectively, the restriction of the wall of chamber portion 20 should preferably be such that the components of centrifugal force and of the force of gravity effective on the liquid at points in the innermost portions of the vortex layer 144, will be such as to cause such inner portions to tend to rise, whereas the licuid in the outer portions of the vortex layer $14 a$ are left free to pass downwardly. Thus, assuming that a vertical cross-section at a point $p$ is at the ande $\theta$ to the horizontal, then a particle at that point will be subject to acceleration upwardly along the wall equal to

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\frac{V^{2}}{r} \cos \theta
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and this acceleration of the particle will be opposed by one directed downwardly along the wall equal to $g \sin \theta$, where $V$ equals the velocity of the steam tangentially introduced; $r$ equals the radius of the point $p$ about the axis of the apparatus; and $g$ represents gravity.
As more fully explained in cur above-mentioned application entitled "Method and Apparatus for Treating Pulp Suspensions and Other Fluids for Removal of Undesired Particles and Gases," one may, by taking into consideration these opposed forces, so form the vertical crosssection of a funnel-shaped chamber as to accomplish the above-mentioned result of causing the liquid of the inner portions of the vortex layer therein to rise while the liquid in the outer portions descends. In case the outlet 26 constitutes a barometric leg, it should be of such height as to maintain the hydraulic liquid level in or above the tapered section 20, and if the discharge is a suction pump, such pump should be capable of accomplishing an equivalent effect. Consequently substantially all of the gases, vapor and bubbles liberated from the vortex layer throughout the chanzer portions $\mathbf{1 5}$ and $\mathbf{2 0}$ will either be promptly exhausted from the core 17 , or if some thereof remains, contained in the innermost parts of the vortex in the chamber portion 20, there will be no opportunity for such remaining gas to pass on in the treated flow, because of the upward movement of the innermost parts of the vortex.
As shown, the chamber portion 20 is connected to a succeeding chamber portion 21, the greater part of which may be cylindrical. In this portion the solid particles in the vortex will have been thrown to the wall surfaces along which they travel downwardly and pass outwardly to the exterior of an annular lip 22, i. e. into a small annular cavity 23 from which a small amount of the stock, along with the particles, is discharged tangentially through a rejected stock outlet 24 having a suitable regulating valve as at 25 , the construction here being similar to that shown in the horizontal sectional view of Fig. 3. Either a barometric leg, an upper portion of which is indicated at 26 , or a suitable suction pump intake, then receives the swirling stream of treated stock as at 27 , free of bubbles and gases, as well as free of the undesired solid particles.
The various chamber parts of the apparatus may be interconnected by flanges as indicated, detachably held together by bolts (which for clearness and simplicity are omitted from the drawings.)
Thus a relatively simple form of device is provided having no moving parts, but which is adapted concurrently for removing from the liquid not only the solid particles such as dirt, but also gases and vapors, whether in the form of bubbles or as dissolved or occluded gas. And by reason of the manner in which the gas core is in effect extinguished and kept from penetrating into the liquid
outlet stream, substantially no bubbles or froth can be carried out with the outlet stream of accepted stock, even when subjected to a strong suction force. The embodiment of the invention here shown has the further advantage that in the upper portions of the device, the greater part of the gases are separated from the liquid and exhausted from the core, and hence such gases can no longer tend to float the suspended matter, such as fiber or the undesired particles. Thus in the lower portions of the apparatus, more effective separation of the solid particles is made possible.
While the embediment of the invention shown in Fig. 2, except for the features below mentioned, is similar to that of Fig. 1 and the corresponding parts are identified by the same reference numerals accompanied by prime marks. In Fig. 2 the walls of the chamber portion 20', instead of being formed with the particular curvature above-cxplained in connection with Fig. 1, are here shown of a slightly conical shape, i. e. with a straight taper. The chamber portion with this form of taper is incapable of diminishing a vortex gas core as at 30 to the point of extinction, but instead such core as indicated at 31 will tend to continue on within the vortex stream and consequently here, a central streamlined obstructing member 32 is mounted, preferably to extend into the lower end of chamber portion $21^{\prime}$, and down for some distance into the upper end of outlet $\mathbf{2 6}^{\circ}$. This member 32 may be supported as by small rods or spider-like means $\mathbf{3 3}$ affixed in or about member 32 with outer portions extending through the walls of chamber portion 26'. By means of the member 32, the vortex core is caused to finally terminate as indicated at the upper end of this member.
Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this application, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. Apparatus for separating gas and solid particles from liquid pulp suspensions comprising an elongated chamber having a body portion of circular internal crosssection, means for so discharging liquid into one end of said chamber as to maintain a helical high velocity flow of the liquid about the inside walls of the chamber, surrounding a core of gas and extending to the other end of the chamber, a gas outlet at the mid portion of said first-named end of said chamber, means connected to such outlet for evacuating gas therethrough and for maintaining said core at a low sub-atmospheric pressure, a portion of said chamber which is spaced from the firstnamed end thereof being progressively restricted in crosssection, the restriction being such as to cause said core gradually to diminish in diameter and then terminate, suction means in the form of and a barometric leg connected to said other end of said chamber in a position whereby said helical flow after passing the end of said core may continue on directly into such leg, means providing an annular cavity for receiving the outermost portions of said helical flow at a region adjacent said other end of said chamber, whereby said particles as thrown by centrifugal action to the walls of the chamber will be received in such cavity, and a tangentially positioned connection for discharging a small amount of hiquid with such particles from said annular cavity.
2. Apparatus for separating gas and solid particles from liquid, comprising an elongated chamber having a body portion of circular internal cross-section, means for so introducing the mixture of liquid particles and ges into one end of said chamber as to cause a helical high velocity flow thereof about the inside walls of the chamber and surrounding a core of gas, with the helical flow extending to the other end of the chamber, means for constantiy

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evacuating gas from said core, suction means at said other end of the chamber for discharging said helical flow, the passage provided for said helical flow at a region spaced from the said first-named end of the chamber being so restricted as to cause gradual restriction and then disappearance of said gas core before the helical flow is discharged to said suction means, and means providing an annular cavity for receiving the outermost portions of said helical flow at a region adjacent said other end of said chamber, whereby said particles as thrown by cen- 10 trifugal action to the walls of the chamber will be received in such cavity, and a connection for discharging a small amount of liquid with such particles from said annular cavity
3. Apparatus in accordance with claim 2 and in which the diameter of the chamber is diminished to cause said gradual restriction and an axial obstruction is provided for causing termination and disappearance of the gas core.

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4. Apparatus in accordance with claim 2 and in which the means for introducing the mixture comprises a restricted tangential inlet and the means for evacuating gas comprises an outlet conduit positioned centrally of the chamber and at the same end thereof as the inlet and a vacuum pump connected to such conduit.

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