Feb. 12, 1929. 1,701,942

L. ANDREWS

VORTEX CLASSIFIER SUITABLE FOR USE IN THE CLASSIFICATION OF POWDERED MATERIALS BY ELUTRIATION

Filed July 23, 1927 2 Sheets-Sheet 1

Fig. 1.

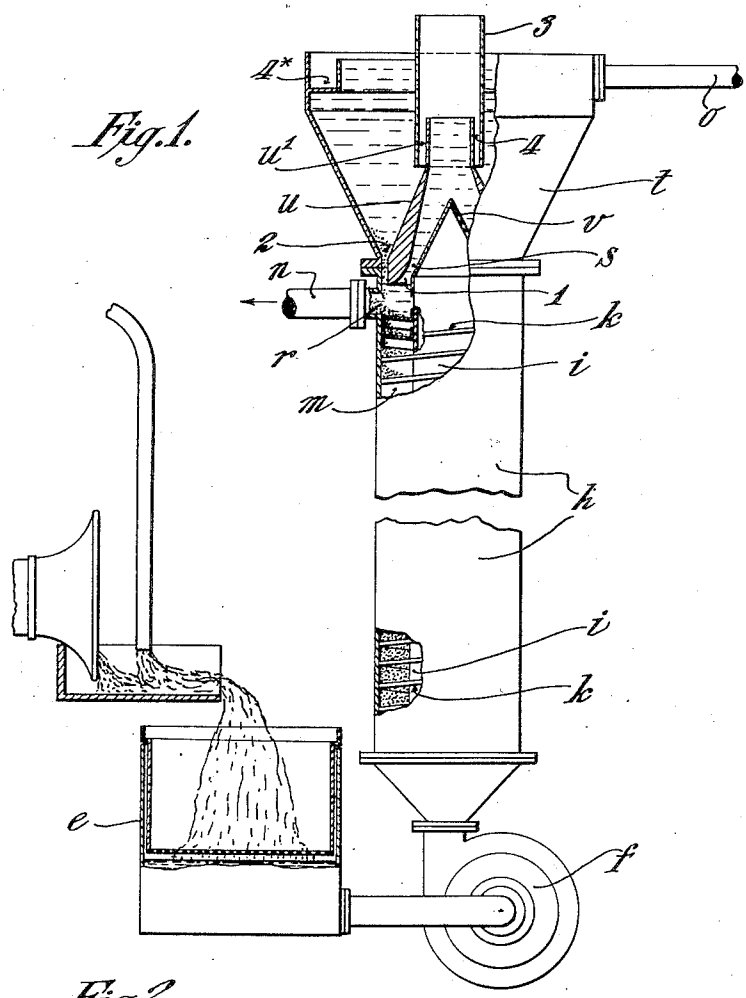


Fig. 2.

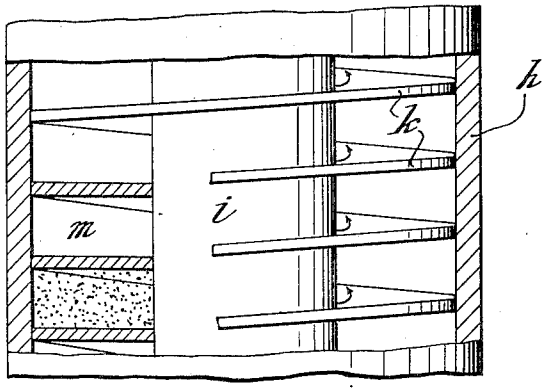
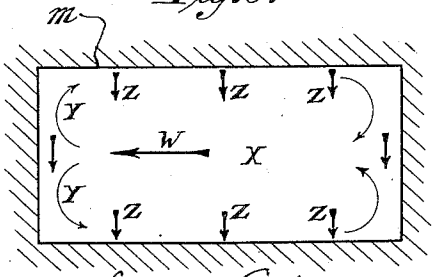


Fig. 3.



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Fig. 4.

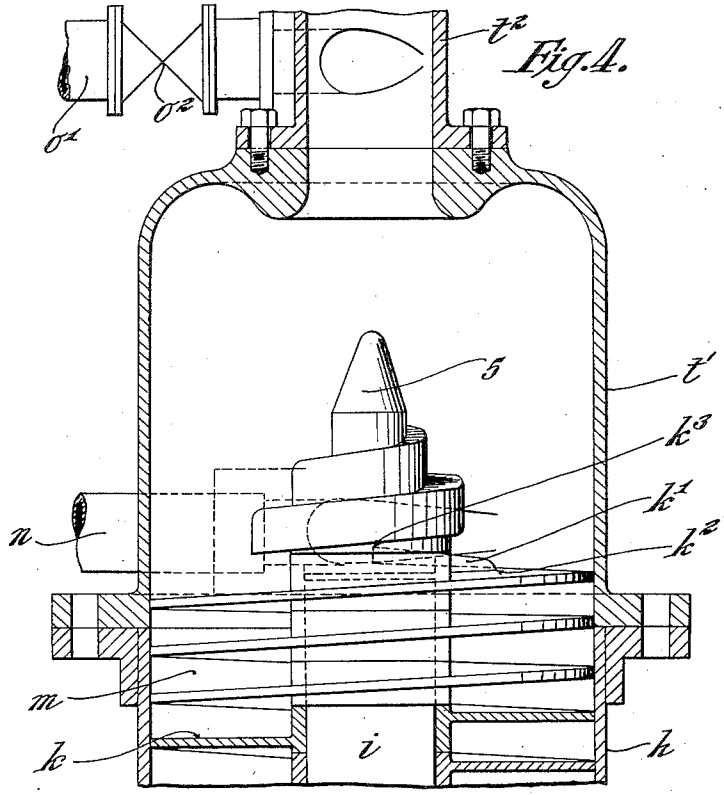
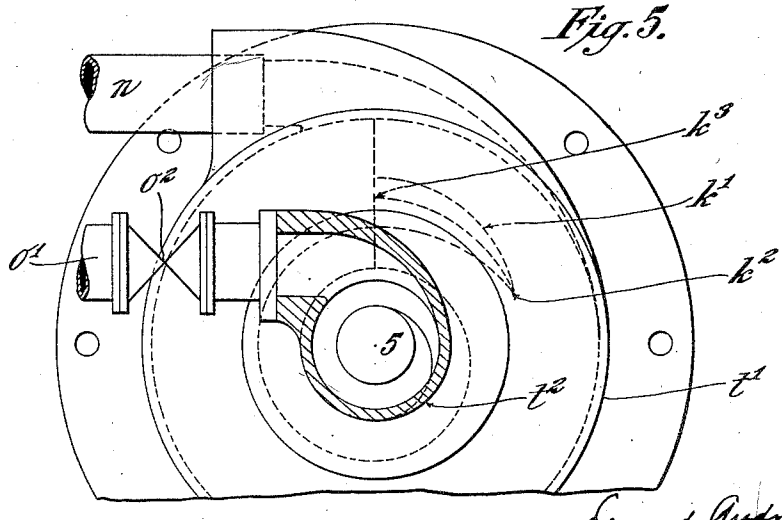


Fig. 5.



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UNITED STATES PATENT OFFICE.

LEONARD ANDREWS, OF WESTMINSTER, ENGLAND.

VORTEX CLASSIFIER SUITABLE FOR USE IN THE CLASSIFICATION OF POWDERED MATERIALS BY ELUTRIATION.

Application filed July 23, 1927, Serial No. 207,976, and in Great Britain July 30, 1926.

This invention has reference to vortex classifiers of the helical flow type and suitable for use in the classification of powdered materials by elutriation, and it has for its object to provide classifiers of this kind that shall be more effective in use and simpler in construction than those heretofore proposed.

For this purpose a vortex classifier of the kind referred to, comprises, according to the present invention, inner and outer vertical cylinders having a helical rib between them so as to form a closed helical passage through which water carrying the powdered material to be classified, is free to flow in an upward direction at a rapid rate as by a centrifugal pump, so that the particles of solid material will be separated from each other by centrifugal action, gravity and eddy currents combined. The upper end of the said classifier is provided with an outlet for water carrying separated oversize particles and with an outlet for water carrying fine particles. When a very fine product is required, the upper end portion of the classifier may be adapted at a part thereof above the outlet for oversize particles, to separate from the water carrying fine particles, particles of an intermediate size and add them to the oversize particles.

In the accompanying illustrative drawings, Fig. 1 shows partly in elevation and partly in vertical section, one construction of vortex classifier, embodying the invention, with centrifugal pump and associated feed tank. Fig. 2 shows, to a larger scale, a portion of such vortex classifier. Fig. 3 is a diagram. Fig. 4 is a vertical sectional detail view, showing a modification of the upper end portion of the vortex classifier and Fig. 5 is a plan thereof partly in horizontal section.

According to the construction shown in Figs. 1 and 2, the vortex classifier comprises a vertical cylinder *h* within which is arranged a hollow cylinder *i* provided externally with a helical rib *k* forming, with the outer cylinder, a closed helical channel *m* through which the mixture of powdered material to be classified and water, coming from a feed tank *e*, is caused to flow rapidly by a centrifugal pump *f*, and in which fine and oversize particles are separated from each other by centrifugal action, gravity and eddy currents combined, the coarse or oversize particles in the material treated, collecting near the outer periphery of the helical channel *m* and travelling upwardly along the helical rib *k* and being discharged through an outlet pipe *n* at the top of the channel, and the fine particles passing upwardly with the water and being discharged through a separate outlet pipe *o* at the top of the classifier.

The classification of particles under the combined influence of centrifugal action, gravity and eddy currents, may be explained by Fig. 3, which represents a section through the helical channel *m*. Particles of solid matter suspended in a stream flowing through a closed helical channel *m* are subjected to four distinct but interdependent forces, all tending to displace the individual particles from the positions they may occupy at any moment. By far the greatest of these several displacing forces is that due to the translational velocity of the stream through the channel. This force is proportional to the area of the particle presented to the direction of the stream and to $V_1^2 - V_2^2$, where V_1 is the velocity of the stream impinging on the particle and V_2 is the velocity of the particle. Being perpendicular to the diagram, this force is represented by a cross *x*. It is obvious that this force varies with the velocity gradient of the stream which, as is well known, varies from practically zero in contact with the walls of the channel to double the mean velocity in the centre of the stream.

A second displacing force, represented in the diagram by a heavy horizontal arrow W, is that due to the centrifugal force resulting from causing the water with solid particles in suspension to flow in a curved path around a central axis of rotation. The magnitude of this force upon any particle may be ascertained from the well known formula for centrifugal force, $\frac{M.V^2}{R.}$. It will be obvious that the magnitude of the stress will be much greater for large and heavy solid particles than for the smaller and lighter ones. The former particles will therefore be carried away from the axis of rotation more rapidly than the lighter particles, thereby effecting a preliminary classification of the solid particles. The water particles of the stream are, however, also subjected to the same centrifugal forces as the solid particles, differing only in respect to their relative specific gravities.

The centrifugal force acting upon both water and solid particles will have a maximum value in the centre of the translational

stream and a minimum value in contact with the walls of the channel. Hence eddy currents will be induced perpendicular to the translational stream, causing water particles to flow outwards from the axis of rotation and to return in a thin stream adjacent to the bottom and top walls of the channel towards the axis of rotation, as indicated by the fine curved arrows Y.

All particles are obviously subjected to the force of gravity, indicated by short thick arrows Z, but in the centre of the stream, where the acceleration due to the translational velocity may be several hundred times greater than gravity acceleration, any displacement of the solid particles by gravity may be ignored, but adjacent to the outer wall of the channel m, where the translational velocity approaches zero, the force of gravity is sufficient to cause the larger and heavier particles to fall to the bottom of the channel, whereas the finest particles are carried to the top of the channel by the eddy current, indicated by the arrows Y, against the action of gravity. Any large or intermediate particles carried up and transversely across the top wall of the channel, by the eddy current stream, tend to fall into the centre of the main stream where they are again subjected to centrifugal force and again carried to the outer wall of the channel.

All solid particles falling down the outer wall to the bottom wall of the channel, tend—in varying degrees—to be carried towards the axis of rotation, but since the large particles project further into the translational stream, where, owing to the rapidly increasing velocity gradient, both the acceleration due directly to the translational velocity and that due to centrifugal force will be much greater, these larger particles, which are subjected to the eddy current stream mainly on their bottom surfaces only, will not be carried across the bottom wall of the channel, whereas the fine and intermediate particles, which have their entire surface areas in the eddy and low translational velocity stream, will be carried towards the axis of rotation.

The classification of the particles is assisted by the fact that in accordance with the well known hydrodynamic law

$$\frac{(p^1-p^2}{w}=\frac{V_2{}^2-V_1{}^2)}{2g}$$

where p^1 and p^2 represent the pressures and V_2 V_1 represent the velocities of the streams. The pressure on the under surface of a large particle is much greater than on the upper surface thereof since the velocity of the stream is greater above than below, with the result that the larger the particle, the more it is lifted against the force of gravity into the higher velocity translation stream where it is subjected to greater centrifugal force and to less eddy current stress, and finally collects in the angle between the outer wall and bottom of the channel. The fine and intermediate particles, owing to their smaller surface areas, are not lifted against gravity into the high velocity stream and are consequently carried by the eddy stream towards the axis of rotation.

The process provides a means of classifying materials of different specific gravity which, though of greatly different size, tend to fall at the same velocity and are consequently impossible to classify by means of ordinary elutriation or hydraulic classification.

The upper end of the helical channel m, Fig. 1, is provided with two outlets r and s thus enabling the classified material to be discharged in two separate streams carrying coarse and fine material respectively. The outlet r for coarse particles is arranged tangentially to the cylinder h so as to communicate with the space between the bottom and outer walls of the channel m. The outlet o for fine particles may be arranged to communicate directly with the space between the bottom and inner walls of the channel.

For many industrial purposes, the classification thus effected, is sufficient, but when a very fine finished product is required, a supplementary classification is necessary. Thus, in cases where it is desired to extract all the intermediate particles from the finished product, an inverted conical discharge head or tank t (Fig. 1) may be attached directly to the top of the outer hollow cylinder h, and a conical shell u be supported in the discharge head t so as to surround a central cone v attached to the top of the inner cylinder i, the combination of cones forming inner and outer annular channels 1 and 2 respectively which communicate with the helical conduit m in the vortex classifier and with the discharge head. The intermediate cone u terminates in a central tube u^1, the top of which is below the top of the discharge head t and may, as shown, be surrounded by a vertical pipe 3 that forms therewith a vertical annular channel 4 and extends above the top of the said discharge head t so as to admit of the free escape of bubbles of air from the liquid entering it, the said vertical passage communicating at the bottom directly with the discharge head. The inner channel 1 and vertical channel 4 direct the water carrying the fine product from the helical vortex classifier into the conical discharge head t where the finest particles or finished products rise to the top with the water, overflow into a circular trough 4* and are carried away by an outlet pipe o to a thickener or settling tank. The intermediate particles separated from the water flowing through the discharge head t, collect at the lower portion of the conical discharge head t immediately above the outer annular channel 2, thereby

increasing the density of the mixture at that point, and, by restricting the upward flow of water from the helical channel m through the said channel 2, allows the intermediate particles to discharge on to the top of the main stream of oversize particles passing away through the outlet at n.

When it is not desired to separate intermediate particles from the finest or finished product, the upper end of the vortex classifier may be constructed as shown in Figs. 4 and 5. In this case the outer cylinder h of the vortex classifier is provided with a discharge head t^1 from which the water carrying fine particles directly flows through an outlet pipe o^1, or it may be over its upper edge, say into an annular trough to which an outlet pipe is connected. The discharge head t^1 may be provided with a stand pipe t^2, say three or four feet in height, to hold a static head of water for the purpose of forcing water carrying the oversize particles through the lateral outlet pipe n. Or the said head may be closed at the top and be provided with an outlet pipe o^1 having a regulating valve o^2 by regulation of which the static pressure of the water in the head t^1 can be regulated to ensure the flow of the required amount of water carrying coarse particles through the outlet pipe n. When the required static pressure is adjusted to suit requirement, the amount of liquid flowing off by the outlet pipe n will remain constant notwithstanding any increase in the volume of mixture flowing through the classifier in unit time. In order to assist the upward flow of fine particles of material along the inner circumference of the helical passage m, the upper end of the inner cylinder i, may advantageously be provided with a guiding device 5 of spiral shape, along the upper spiral surface of which the inner portion of the circulating stream of water adjacent to the inner cylinder i and carrying the fine particles of solid material, will be caused to flow and be directed into the upper part of the head t^1. The upper free end portion of the helical rib k may be provided on its upper side with a projection k^1 (see Fig. 5) of Λ shape in cross section and of increasing height from k^2 to k^3, for the purpose of dividing the rising circulating stream of water into two portions, namely an inner one, carrying fine particles, and an outer one carrying coarse particles, the inner one being directed into the guiding device 5, and the outer one to the outlet pipe n.

All oversize particles, still suspended it may be in several times their own weight of water, are or may be conveyed by the outlet pipe n, at a high stream velocity, to the feed end of a wet grinding mill to be reground and afterwards returned with additional ground material and water to the vortex classifier for treatment as hereinbefore described.

Before returning the oversize material to the mill, it is however important, as affecting the efficiency or grinding, that all fine particles remaining in suspension in the water, should be removed from the oversize particles and that the water escaping with the oversize particles should be reduced to it may be about one third of the weight of the particles being discharged.

What I claim is:—

1. A vortex classifier, suitable for the purpose herein set forth, comprising inner and outer longitudinal members and an intervening helical rib or plate together forming a helical passage of closed formation in cross section, such classifier being adapted to be supported in a vertical position, for use, and having an inlet at its lower end for water carrying powdered material to be classified, an outlet at the top for water carrying separated fine particles of material and also an outlet at the top for water carrying separated coarse particles of material.

2. A vortex classifier according to the preceding claim, having its upper end portion provided internally with means for dividing the rising stream of water with particles of solid material into separate streams one of which is directed to the outlet for water carrying coarse or oversize particles and the other to the outlet for water carrying fine and intermediate size particles.

3. A vortex classifier according to claim 1, having at a part thereof above the outlet for coarse or oversize particles, means adapted to separate from the water carrying fine and intermediate size particles, the intermediate size particles and add them to the coarse or oversize particles.

4. A classifier according to claim 1, having at its upper end, above a lateral outlet for coarse particles, a discharge head provided internally and below its upper end with a conical shell adapted to form with an upper extension of the inner vertical member of the classifier and the head, two concentric annular spaces the inner of which has its lower end located over the inner peripheral portion of the helical passage and the outer of which is substantially of inverted conical section and has a narrow lower annular outlet located above the outer peripheral portion of the helical passage and the outlet for coarse particles, substantially as described.

5. A vortex classifier according to claim 1, having at its upper end, above a lateral outlet for coarse particles, a discharge head provided internally and below its upper end with a conical shell adapted to form with an upper extension of the inner vertical member of the classifier and the head, two concentric annular spaces the inner of which has its lower end located over the inner peripheral portion of the helical passage and the outer of which is substantially of inverted conical section and has a narrow lower annular out-

let located above the outer peripheral portion of the helical passage and the outlet for coarse particles, and a tubular vertical extension of the conical shell that terminates below the top of the head and is surrounded by a vertical tube that extends above the top of the head and forms, with the extension of the shell, an annular passage through which liquid can pass from the inner to the outer of the two annular spaces at opposite sides of the shell.

6. A vortex classifier according to claim 1, wherein there is arranged above the inner circumferential portion of the helical passage therein, an upwardly extending guiding device of spiral shape, substantially as described.

7. A vortex classifier according to claim 1, wherein there is arranged above the inner circumferential portion of the helical passage therein, an upwardly extending guiding device of spiral shape and the upper exit end portion of the helical rib is adapted to divide the rising circulating stream of water into inner and outer portions and direct one to the spiral guiding device and the other to the outlet for coarse particles.

Signed at London, England, this 14th day of July, 1927.

LEONARD ANDREWS.