

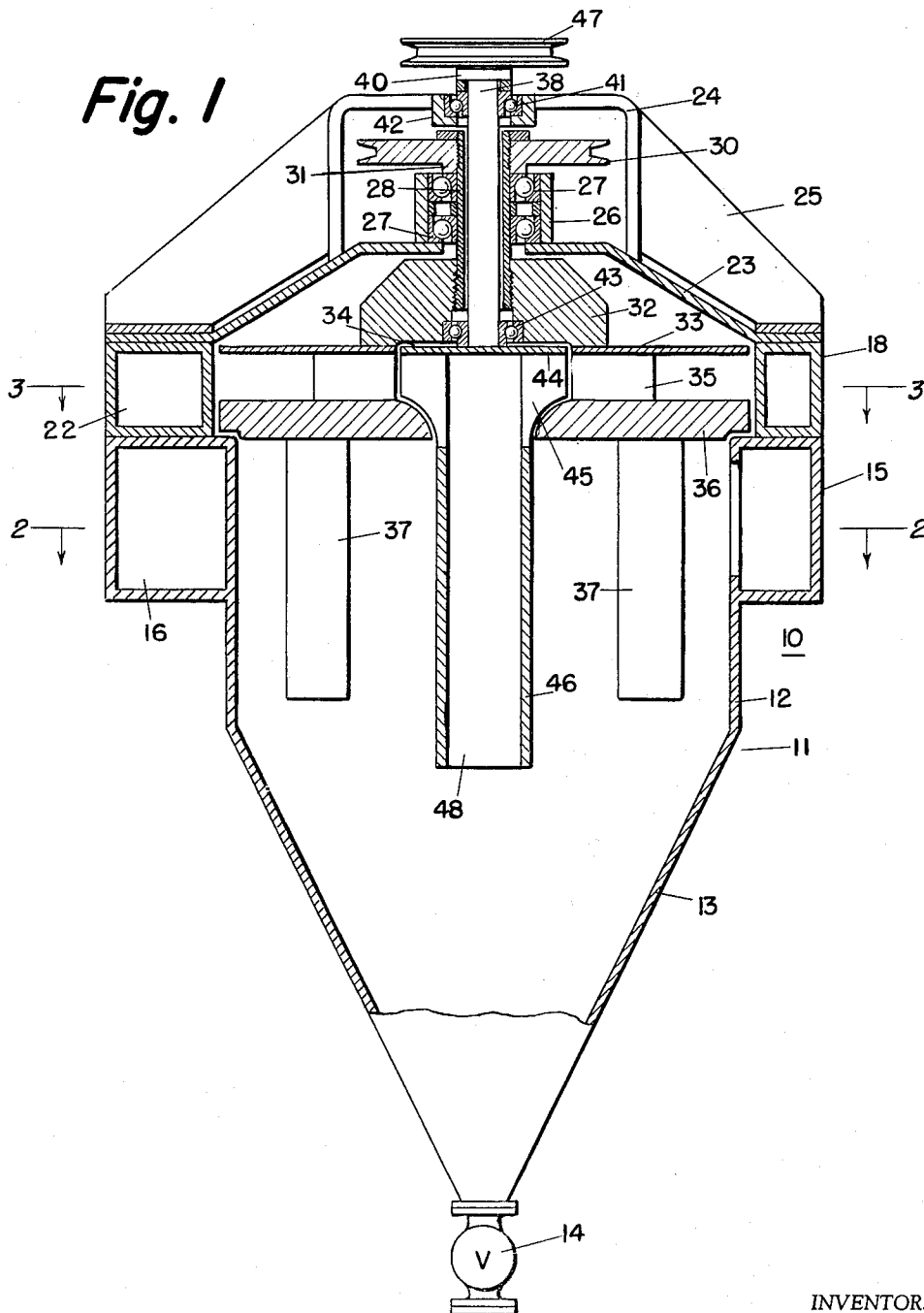
Aug. 15, 1961

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CYCLONE SEPARATOR

2,996,187

Filed Sept. 24, 1958

2 Sheets-Sheet 1



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Fig. 2

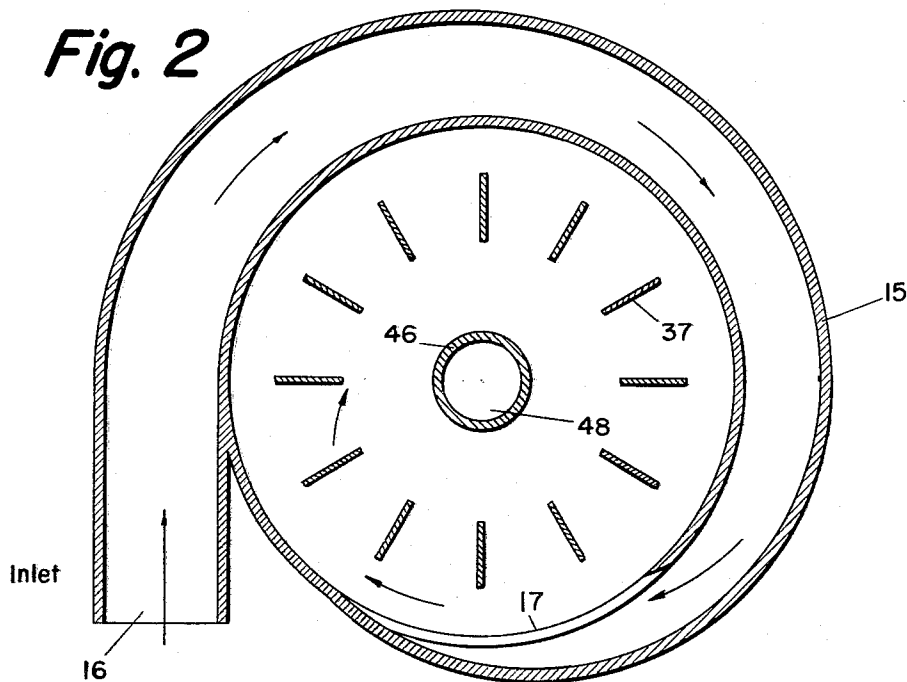
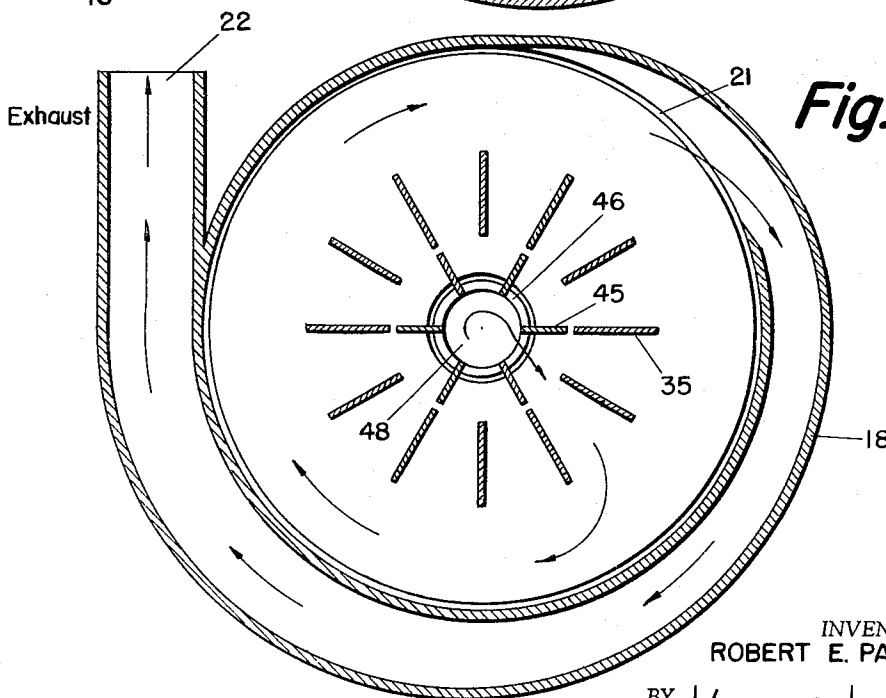


Fig. 3

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Filed Sept. 24, 1958, Ser. No. 763,032

5 Claims. (Cl. 209—211)

This invention pertains generally to the treatment of liquids having finely divided solid particles admixed therewith, and particularly to apparatus for the separation of said finely divided particles, either partially for the classification of said finely divided particles as to size and density, or totally for the clarification of said liquids. This invention pertains more particularly to the efficient utilization under simplified conditions of the cyclone principle of separation for the above purposes.

Prior to the present invention, apparatus employing the vortex principle of separation has been available for the classification or total separation of finely divided solid particles admixed with liquids. Certain such apparatus efficiently utilizes the separating characteristics of an inwardly spiraling vortex, the ideal of which being one in which the tangential velocity varies inversely with distance from the axis of rotation. Under such ideal conditions, the radial component of force applied to the particles by the inwardly spiraling liquid and tending to drag the particles radially inwardly, is, for particles of a given selected size, balanced by the centrifugal force applied to the particles due to the vortex motion.

Although ideal vortex motion in separations of this character are not attainable, except in apparatus having a specially designed separating zone which preferably is rotatable, results satisfactory for certain types of needs may be obtained in apparatus lending itself to less costly manufacture, particularly in large capacity sizes, provided that due consideration is given to the efficient utilization of the spiraling flow in the simplified arrangement, and it is to such separations that this invention is directed.

Further features of the invention will become apparent to persons skilled in the art upon becoming familiar with the following particular description made in connection with the accompanying drawings in which:

FIGURE 1 is an elevation partly in section of a separator of the cyclone type;

FIGURE 2 is a section taken on line 2—2 of FIGURE 1; and

FIGURE 3 is a section taken on line 3—3 of FIGURE 1.

Referring now more particularly to the drawings, at 10 is shown a separator having a casing 11, the upper portion 12 of which is generally cylindrical, and the lower portion 13 of which is illustrated as being conical. Conical portion 13 is provided with valve 14 at its lower end.

Separator 10 preferably is made of metal, and the various parts may be secured together by any desired means known in the art, such as by bolts, screws, welding or otherwise. For convenience in description, these and other well known means for securing parts together will not be repeated when the description calls for securing one part to another.

The upper end of cylindrical portion 12 is provided peripherally with a scroll 15 having an inlet 16 and an outlet 17, the latter opening tangentially into the interior

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of cylindrical portion 12, e.g. as illustrated in FIGURE 2.

Resting upon and secured to scroll 15 is a second scroll 18 having a tangentially arranged inlet 21, and an outlet 22, e.g. as illustrated in FIGURE 3.

Resting upon and secured to scroll 18 is a supporting member 23, upon which is secured a U-shaped member 24. Member 24 is buttressed on its opposite sides by circumferentially spaced members 25 secured thereto and to member 23.

Resting upon and secured to member 23 is a tubular member 26 containing bearings 27 in which is journaled a tubular drive shaft 28. Drive shaft 28 has secured thereto pulley 30 having a collar 31 which rests upon the inner race of upper bearing 27 to provide a vertical support for shaft 28, the outer race being supported on member 23, e.g. as illustrated. Member 32 is secured to the lower end of shaft 28, and annular plate 33, having a circular opening 34 at its center, is secured to the lower face of member 32. Circumferentially spaced vanes 35, the spacing being more clearly seen in FIGURE 3, are secured to the lower face of plate 33, and are attached at their lower edges to the upper face of annular member 36. Secured to the lower face of annular member 36 are a plurality of circumferentially spaced elongated vanes 37.

A second drive shaft 38 is positioned within tubular drive shaft 28. Shaft 38 has an annular shoulder 40 which rests upon the inner race of bearing 41. The outer race of bearing 41 rests upon supporting member 42 which in turn is secured to U-shaped member 24. Shaft 38 at its lower end is journaled in bearing 43 positioned within member 32. Circular plate 44 is secured to the lower end of shaft 38, and the lower face of plate 44 has attached thereto a plurality of circumferentially spaced vanes 45. To the lower edges of vanes 45 is secured tubular member 46.

In operation the mixture of liquid and finely divided solids, such as a mixture of water and clay to be classified, is pumped into inlet 16 of scroll 15 at a desired rate to impart the desired rotary motion thereto as it enters cylindrical portion 12. Since the clay particles are of substantially uniform density, but of varying size, the larger particles are thrown outwardly by centrifugal force, are deposited upon the inner periphery of cylindrical portion 12, and slide down into conical portion 13 from which they are removed through valve 14. The desired rotary motion in the mixture of liquid and solids is assisted by the rotation of vanes 37 through the driving of pulley 30, such as by means of a motor and belt not shown.

The mixture of liquid and solids acquires a vortex motion within casing 11, with consequent increase in angular velocity inwardly of the vortex. Tube 46 is positioned within the center of the vortex, and is preferably rotated through drive pulley 47 at at least approximately the same angular velocity as that of that portion of the vortex in contact with its outer surface.

The spiraling liquid, carrying the smaller size particles therewith, enters the lower end 48 of tube 46, and ascends through tube 46 without large loss in rotary motion due to the rotation of said tube. This effluent flows outwardly between vanes 45, and enters the spaces between vanes 35, whereby a substantial part of the energy of rotation is recovered, for the angular velocity of the

mixture ascending through tube 46 and flowing outwardly between vanes 45 is much greater than that of the vanes 35. It will be seen that the speed of rotation of tube 46, and of the inner portion of the vortex in contact therewith, is much greater than the speed of rotation of the vanes 37, with which vanes 35 are interconnected, for vanes 37 rotate with the same speed as the outer portion of the vortex. The reduction in speed of rotation of the effluent as it flows outwardly between vanes 35 imparts rotational energy to vanes 35, and in turn to vanes 37, thus substantially reducing the total power input.

The mixture of liquid and finely divided particles moves outwardly from vanes 35 in swirling condition, enters inlet 21 of scroll 18, and is discharged through outlet 22.

Pulleys 30 and 47 are conveniently driven by the same prime mover, thereby facilitating the maintenance of a constant difference in their relative speeds of rotation.

From the foregoing it will be seen that interference with the maintenance of a desired inwardly spiraling flow or vortex motion due to frictional resistances are in very large measure overcome. Vanes 37 assist in maintaining the desired rotation in the outer portions of the vortex, and thereby compensate for frictional resistance to flow at the inner periphery of casing 11, and particularly portion 12 thereof. The rotation of tube 46 in very large measure prevents the loss of energy in, and the slowing down of, the spiraling flow due to friction at the radially inward portion thereof. The reduction of loss of energy in the spiraling flow at and adjacent its central portion is of major importance in the classification of finely divided particles, particularly when this takes place in liquid medium.

Thus the ideal condition of vortex motion for the classification of particles wherein the tangential velocity is inversely proportional to the distance from the axis of rotation is approached more closely, albeit not ideally, than in structurally related prior art apparatus.

It will, of course, be understood that when it is desired to clarify the liquid by the removal of all or substantially all of the finely divided solid particles, it is merely necessary to impart to the inwardly flowing mixture a substantially higher tangential velocity, and to rotate vanes 37 and tube 46 at a correspondingly higher velocity. It will also be understood that as the tangential velocity of the mixture pumped into inlet 16 decreases, the average size of the particles carried off through tube 46 increases. Thus any desired cut point as to particle size may be obtained by control of the velocity at which the mixture is pumped into inlet 16. The term "cut point" is well understood in the art. There are various definitions, one of which is the top size of the particles comprising the fine fraction.

In the foregoing particular description it has been convenient to refer only to the size of the particles as though this were the only variable. It is obvious that separation of particles depends not on size alone but also on other factors, e.g. density and shape. It will be understood that where these factors are not constant, they are to be taken into account. For example, an increase in the density of the particles is equivalent to an increase in their size, and vice versa. Accordingly the term "size" is used herein in the broader sense to include difference in density, shape and/or other factors which gives rise to an effect the same as difference in size.

While it is highly preferred for the reasons given above to employ the vanes 35 to recover energy from the discharging liquid mixture, broadly speaking, such function may be dispensed with, e.g. by eliminating vanes 35, or reducing the radial length of vanes 35 so that the latter serve primarily as a support for member 36, without departing from the broader aspects of the invention. Moreover, while it is highly preferred to drive tube 46 to cause its rotation, broadly speaking, the power source may be disconnected from tube 46 and shaft 38, thus permitting tube 46 to float with the spiraling mixture, tube 46 being carried along with the rotation thereof. In the

latter event, it is preferred to reduce the radial dimension of vanes 45, e.g. down to that of tube 46.

Having particularly described the invention, it is to be understood that this is by way of illustration, and that changes, omissions, additions, substitutions and/or other modifications may be made without departing from the spirit thereof. Accordingly it is intended that the patent shall cover, by suitable expression in the claims, the various features of patentable novelty that reside in the invention.

I claim:

1. In a cyclone separator, the combination comprising a housing, a tangential inlet for said housing, a plurality of circumferentially spaced vanes in said housing extending longitudinally thereof, a rotatable mounting for said vanes, a tubular member in said housing extending longitudinally and centrally thereof, said vanes surrounding and spaced radially outwardly from said tubular member, a rotatable mounting for said tubular member separate from said first-mentioned mounting, and an outlet for said housing, one end of said tubular member communicating with the interior of said housing and the other end of said tubular member communicating with said outlet.

2. In a cyclone separator, the combination comprising a housing having a cylindrical portion, a tangential inlet for said cylindrical portion, a plurality of circumferentially spaced vanes in said cylindrical portion extending longitudinally thereof, a rotatable mounting for said vanes, a tubular member in said cylindrical portion extending longitudinally and centrally thereof, said vanes surrounding and spaced radially outwardly from said tubular member, a rotatable mounting for said tubular member separate from said first-mentioned mounting, and an outlet for said housing, one end of said tubular member communicating with the interior of said housing and the other end of said tubular member communicating with said outlet.

3. In a cyclone separator, the combination comprising a housing having a cylindrical portion, a tangential inlet for said cylindrical portion, a plurality of circumferentially spaced vanes in said cylindrical portion extending longitudinally thereof, a mounting for said vanes rotatable about the axis of said cylindrical portion, a tubular member in said cylindrical portion extending longitudinally and centrally thereof, said vanes surrounding and spaced radially outwardly from said tubular member, a mounting for said tubular member rotatable about the axis of said cylindrical portion and separate from said first-mentioned mounting, and a tangential outlet for said housing, one end of said tubular member communicating with the interior of said housing at a locus longitudinally removed from said inlet and the other end of said tubular member communicating with said tangential outlet.

4. In a cyclone separator, the combination comprising a housing having a cylindrical portion, a tangential inlet for said cylindrical portion, a plurality of circumferentially spaced vanes in said cylindrical portion extending longitudinally thereof, a mounting rotatable about the axis of said cylindrical portion, said vanes being attached to said mounting and rotatable therewith, a tubular member in said cylindrical portion extending longitudinally and centrally thereof, said vanes surrounding and spaced radially outwardly from said tubular member, a second mounting rotatable about the axis of said cylindrical portion and separate from said first-mentioned mounting, said tubular member being attached to said second mounting and rotatable therewith, an outlet for said housing, one end of said tubular member communicating with the interior of said housing at a locus longitudinally spaced from said inlet and the other end of said tubular member communicating with said outlet, and means positioned between said last-mentioned end of said tubular member and said outlet for the interchange of energy between said first-mentioned and second-mentioned mountings.

5. In a cyclone separator, the combination comprising a housing having a cylindrical upper portion and a con-

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cal lower portion joined to said cylindrical portion, a bottom outlet for said conical portion, a tangential inlet for said cylindrical portion, a plurality of circumferentially spaced vanes in said cylindrical portion extending longitudinally thereof, said vanes being attached to a mounting rotatable about the axis of said cylindrical portion, a tubular member in said cylindrical portion extending longitudinally and centrally thereof, said vanes surrounding and spaced radially outwardly from said tubular member, said tubular member being attached to a mounting separate from said first-mentioned mounting and rotatable about the axis of said cylindrical portion, a tangential outlet for said housing, one end of said tubular member communicating with the interior of said housing at a locus longitudinally spaced from said inlet and

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the other end of said tubular member communicating with said tangential outlet, and means positioned between said last-mentioned end of said tubular member and said tangential outlet for the interchange of energy between said first-mentioned and second-mentioned mountings.

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