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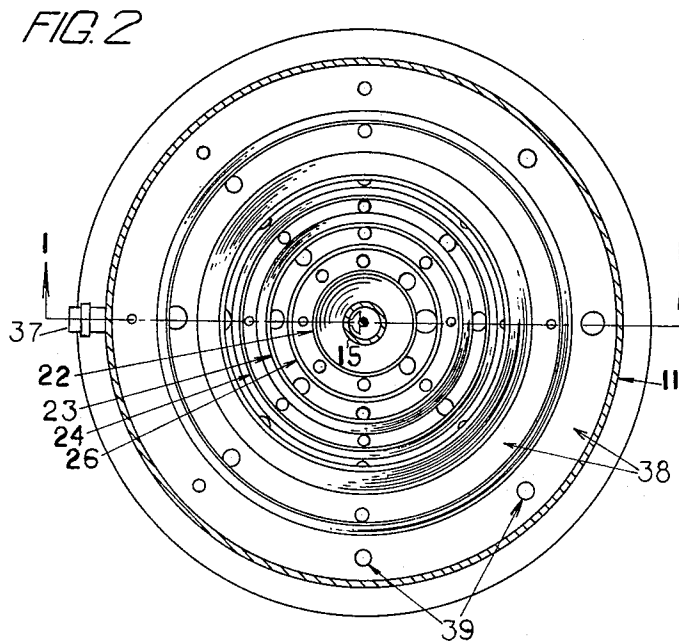
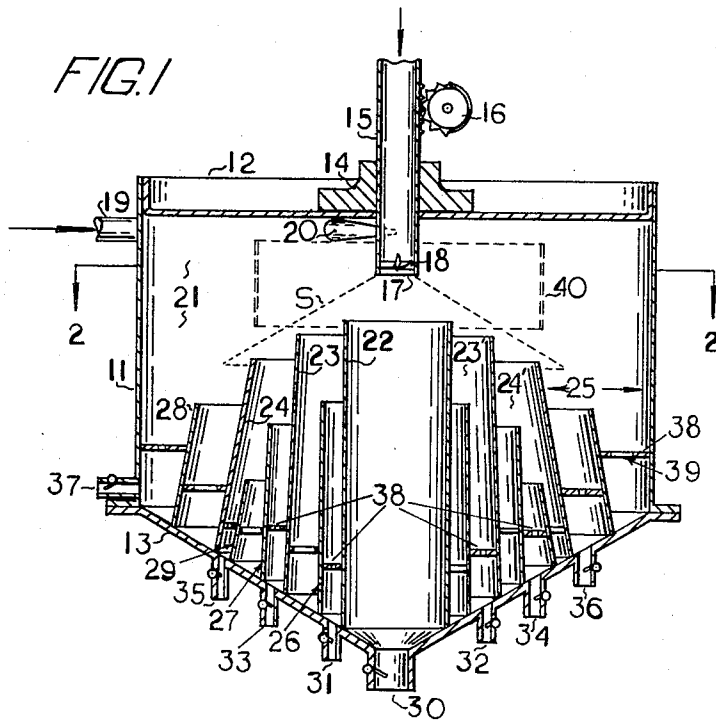
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CENTRIFUGAL SEPARATION APPARATUS

Filed Jan. 29, 1958

2 Sheets-Sheet 1



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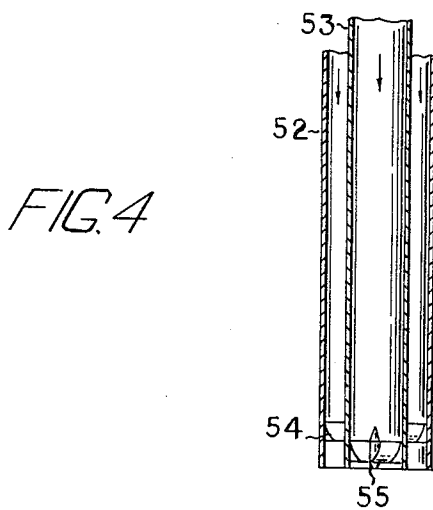
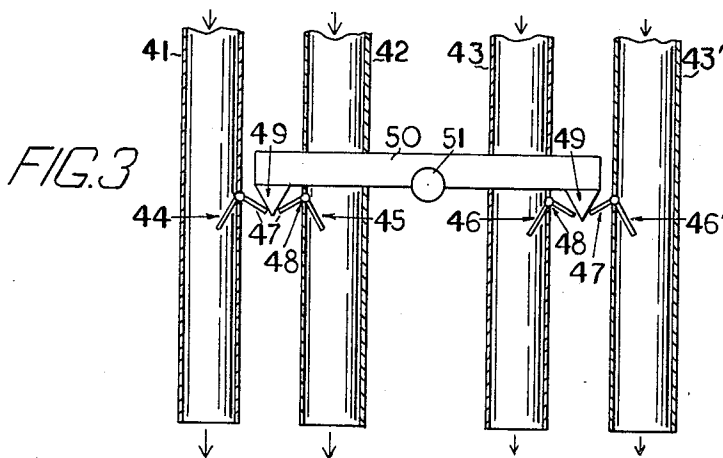
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CENTRIFUGAL SEPARATION APPARATUS

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This invention relates to improvements in centrifugal separating methods and apparatus, and more particularly to multiple separations of suspended solid particles by density difference.

In the prior art, the starting point for density separations of fine solids is a completely stratified mixture in a spinning carrier. Generally, the components are separated from the stratified mixture in a radial or axial direction. When the product of separation is to be treated again, as it is necessary for instance to separate an excess of the carrier from the solid component, such secondary separation is to be performed in a new apparatus, or apparatus section. Consequently, conventional apparatus possess little compactness of structure and uniformity of method, and are often a mere aggregation of separators, wherein intermediate steps of evacuating and refeeding, conveying and propelling the handled materials accompany a positive separation work. In this invention, spinning particles in suspension are separated out into concentric layers of different density ranges through the action of a free vortex of carrier fluid spinning helically, and are intercepted during their radially outward travel by a system of concentric sleeves. The spin and the radial spreading is continued within said system, the first separation being followed by one or several subsequent separations, using the same primary spin. In this novel method, the starting point of separation is the discharging of a concentrated separable material into a spinning column of a pure carrier fluid. As the stratification of the separable mixture proceeds, the resulting density layers are intercepted by separating means. This novel method divides the spinning carrier into layers wherein the separable material just started to be stratified according to density, and is, therefore, able to operate more economically by treating one separable component in two or more separation steps performed in the same separation chamber while spinning the separable material only once. In this invention, the separation of the particles and the evacuation of the carrier fluid are performed in a compact structure in the shortest possible manner, thereby reducing working surfaces in contact with the handled material, decreasing the time of contact on these surfaces, thus saving in construction material, power of operation, time of separation, and in wear by abrasion.

It is an object of this invention to provide a novel method and apparatus for multiple separations of suspended particles according to density by spreading fine solids in a spinning carrier from the center thereof and by intercepting the carrier with therein suspended solid particles during its flow in an axial direction by a system of separating sleeve partitions.

Another object of the invention is to provide a novel compact separating structure allowing for further sub-separating the product of the primary separation.

Other objects of this invention will become apparent from the following description and accompanying drawings in which

Figure 1 is a longitudinal section of my new apparatus,

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Figure 2 shows a horizontal section of the same along the line 2—2 in Figure 1,

Figure 3 is a diagram showing a proposed volume control for the same apparatus, and

Figure 4 is a modification of an embodiment of the apparatus in Figure 1.

Figure 1 shows the novel apparatus wherein the numeral 11 generally designates a shell defining a vortex chamber. The upper part of the separator is provided with a tight cover 12, the lower part with a conically shaped bottom 13. The cover 12 supports a flange 14, wherein a feeding tube 15 can slide in an axial direction, this movement being controlled by any suitable conventional means, as for example a toothed gear 16. The tube 15 terminates downwardly by a discharge nozzle 17, and is provided with spin imparting vanes 18, of any conventional type known. A horizontal feeding pipe 19 supplies a carrier fluid by a tangential inlet 20 into the upper part of the vortex chamber 21. On the bottom 13, a series of intercepting partition sleeves 22, 23 and 24 are fixed concentrically below the discharge nozzle 17. The sleeve 22 is placed centrally in the axial path of said nozzle 17; the sleeves 23 and 24 are placed concentrically in a downwardly sloping sequence around the sleeve 22, forming the annular spaces 23', 24' and that one marked by numeral 25, between the sleeve 24 and the shell 11. The primary separation takes place on their edges which define the primary separation area. After the primary separation, the fractions of the suspension, spinning within the annular spaces 23', 24' and 25, are subject to a further density stratification and are separated in the secondary separation areas which are defined by the edges of shorter sleeves 26, 27 and 28, placed inside the annular spaces 23', 24' and 25 respectively. A tertiary separation area is provided in the annular space 24', by the very short sleeve 29. The inner space of the sleeve 22 and all the annular spaces are provided each with an outlet draining the respective separation area; these outlets are marked by numerals 30 to 37 respectively. All of the annular spaces are further provided with drain regulating covers 38, fixed at a small distance from the bottom 13. The covers 38 are shown in plan view in Figure 2 in their operative positions. Each cover 38 is a large washer of a thin material as sheet metal, fitting exactly in its annular space and provided with a series of openings 39, varying from relatively small to large in cross-sectional area. The smallest opening is close to the outlet draining the area; for instance, the cover 38 in the annular space 25, between the shell 11 and the sleeve 28, has its smallest opening 39 close to the outlet 37, the largest opening 39 being on the opposite side of the circumference of the same cover. The volume of flow passing through the largest opening 39 must travel the longest distance to reach the outlet 37. The shorter the distance for the fluid to reach the outlet 37, the smaller the opening 39, so that the fluid passing through any one of the openings 39 has to overcome the same resistance. Therefore, equal volumes of fluid will pass through each opening 39, whatever its size. In this manner, the spinning fluid will be drained evenly along the whole circumference of each annular space, thus avoiding any turbulence in the adjacent separation areas. The throughflow in outlets 30 to 37 is controlled by variable valves of any well known type.

In operation, two different flows are fed into the apparatus. The carrier fluid is supplied by the feed pipe 19 through the tangential inlet 20. The concentrated separable material, having a uniform grain size due to a preliminary classification, is fed through the feeding tube 15 toward the center of the vortex chamber 21. The separable material, rotated by vanes 18 and discharged by the nozzle 17 into the spinning flow of carrier fluid traveling on a helical path of the vortex chamber 21 from

the inlet 20, is spread in said spinning carrier in the form of a truncated cone S. Particles heavier than the carrier are driven outwardly in a radial direction by centrifugal action. In this radial travel, the heavier particle works its way faster than the lighter one. All the particles being of the same size, it is the density which will determine for each of them the velocity of the radial escape. By the time the spreading mass of fine solids reaches the primary separation area, a clear density spectrum is formed on the base of the cone S. The height of this cone will depend upon the two components of the helical movement of the carrier fluid, and the spreading of the fine solids which is represented by the base of the cone should cover the whole primary separation area. The distance of the nozzle 17 from the primary separation area being variable, the optimum position of the nozzle 17 will be found by sliding the feeding tube 15 in an axial direction, with a simultaneous actuating of variable valves in the outlet passages. Thus, the spreading mass meets, in its axial travel, the edges of the primary separation sleeves 22, 23 and 24, as shown in Figure 1, when the heaviest particles are approaching the periphery of the chamber 21, while the lightest ones stay close to the axis thereof. The stratified suspension is split by said edges into concentric cylinders, yielding fractions of fluid carrying fine solids with densities ranging as in said density spectrum. The spin of fractions in annular spaces 23', 24' and 25 continues whereby a further stratification is achieved within the spaces, and the suspension is thus separated again on the edges of the secondary separation areas. A third separation follows in the same manner in the tertiary separation area by the sleeve 29, as explained above, and the partial flows are then evacuated by the outlets 30 to 37. As a result, numerals 32, 34, 35 and 37 yield fine solids in a state of thickened suspension, outlets 30, 31 and 36 yield the surplus carrier fluid.

As stated above, the covers 38 provide for a uniform draining along the circumference of each space. The use of said covers may be avoided either by providing each annular space with several outlet openings equally spaced on the bottom, or by extending said spaces so as to decrease the velocity of the flow before it reaches the outlet.

When the passages of central outlets 30 and 31 drain the large part of the carrier fluid, they promote a lateral inward flow of the spinning fluid toward the center of the chamber 21. When this way of draining is used in a vortex chamber of a certain height, wherein the distance of the tangential inlet 20 from the intercepting sleeves 22 and 23 is large, the helical fluid flow will tend to rotate rather in the center of the chamber 21, cutting short its way towards sleeves 22 and 23, the remote peripheral layers will be idle, thus producing little or no lateral inward flow. This condition may be corrected by installing in the chamber 21, one or more feeding sleeves 40, marked in dotted lines. The spinning carrier directed by the lower edges of these sleeves 40 will exert a lateral pressure at any desired height onto the conically outstretched fine solids material, and all layers will rotate.

The volume of fluid passing through the outlets 30 to 37 is controlled in order to obtain the maximum efficiency of separation in the annular spaces. Many conventional devices may be used for this purpose. Figure 3 shows diagrammatically, by way of example, one possible solution for controlling the secondary and tertiary separations as those, for instance, in the annular spaces 23' and 24'. In Figure 3, the outlets 41 and 43 evacuate fine solids, the outlet 42 evacuates the clean carrier fluid. The outlet numeral 43' which may or may not exist, is an auxiliary outlet for illustration purposes only. Baffles 44, 45, 46 and 46' are pivotally mounted in the walls of outlets 41, 42, 43 and 43'; the lever arms 47 forming one piece with the baffles and with the journals 48 will move said baffles. The control

of the flow through the outlets 41 and 42 is regulated by a triangular guide 49. One side of this guide 49 actuates, through the lever arm 47, making sliding contact therewith as a follower, the baffle 44 in the outlet 41, the other side of the same guide actuates the baffle 45 in the outlet 42. A similar triangular guide 49 makes sliding contact with the baffles 46 and 46' in the outlets 43 and 43'. The triangular guides 49 are coupled by a bar 50 which is supported in its center by a fulcrum 51. This fulcrum may be moved horizontally a short distance; it also allows a slight pivoting movement of the two guides 49, so that a vertical movement of one of them in one direction causes the other guide to move in the opposite direction. When the fulcrum 51 moves horizontally to the right, the volume of flow drained by the outlets 41 and 43 will be increased, and that drained by the outlets 42 and 43', if any, will be decreased to the same extent. The same movement to the left will reverse the effect in the same outlets. An upward movement of the guide 49 on the left hand side, will increase the volume drained by the two outlets 41 and 42, to the same extent in each member of this couple, while simultaneously the guide on the right hand side will cause a reduction of the volume drained by the outlets 43 and 43', also to the same extent in each member of the couple.

Considering now the two outlets 41 and 42 belonging to the same primary separation area, a horizontal movement of the guide 49 between them will change the ratio of the throughflows in the two secondary separation spaces drained by said outlets, while nothing is changed in the involved primary separation area. However, when the same guide 49 moves vertically, the throughflows in the same outlets are either increased or decreased to the same extent, and such a change finds its expression in the primary separation area in a changed volume and density of the fluid passing therethrough. When a tertiary separation is operated and controlled in a depending relation with the secondary ones performed in the same line, a third outlet, either numeral 43 or 43', is connected by the bar 51 to the couple 41, 42, or even both of them at the same time, in which case two pairs of outlets may vary the throughflow volumes in the respective secondary and tertiary separation areas, while nothing is changed in the remaining separation areas of the same unit. It will be noted that the connections shown in Figure 3 are only illustrative and the possible combinations far too numerous to be mentioned here. Generally, any particular problem of the kind can find a suitable solution.

The viscosity of the carrier fluid is a constant obstacle to a lateral penetration, and is that factor which makes, in this method, density separations possible. In precision work, it is necessary that all particles leaving the nozzle 17, start their spinning motion at the very moment of discharge, if they are to be correctly separated. This requirement is not always met in a single discharge nozzle 17, as shown in Figure 1, wherein the flow leaving said nozzle forms a solid cylinder containing the axis of the spin. There is little or no radius of rotation in this cylinder axis, thus, there is little or no centrifugal tension to move the particles radially into the spinning fluid. As said cylinder disintegrates progressively in the nearby spinning carrier, a small cone of the handled material projects downwardly from the discharge nozzle 17, and will be spread out later than the other particles discharged at the same time from the same nozzle 17. In Figure 4, a new feed tube 52 is shown which corrects this condition. The tube 52 is provided with a core, concentric pipe 53, and the annular space between them has spin imparting vanes 54, of any conventional type. The pipe 53 has its own helix 55. A fine solid material discharged by this device, will leave by said annular space, and all its particles will start rotating instantly as soon as discharged. The effect may be further as-

sisted by feeding a clean carrier fluid through the core pipe 53. The spreading solids will form a layer, achieving a density spectrum at the base of the cone S, provided, the discharged particles have a fairly uniform size. However, in the separation of materials in which the respective densities of the components are far apart from each other, relatively large grain size differences are admissible.

The intercepting edge of sleeves 22, 23 and 24 may be at the same level or in various positions, if desired. The friction in the partition sleeves is reduced by their conical shape shown in Figure 1. At the same time, the bottom space needed for connections is larger and helpful for slowing down the angular velocity of the partial flows before they are evacuated.

I claim:

1. An apparatus for multiple separation of suspended fine solid particles from a mixture by density difference, comprising in combination: a closed vortex chamber having a substantially horizontal top portion, a circular wall section and a bottom portion, tangential feeding means in said circular wall section enabling a carrier fluid to spin in said vortex chamber, separate feeding means for a mixture of fine solid particles, arranged concentrically with said vortex chamber and substantially perpendicular to said tangential feeding means and movable in an axial relation thereto, said separate feeding means being open in an axial direction to discharge said mixture axially so as to spread the same radially outwardly in a fine layer into said spinning carrier, a first series of partition sleeves arranged concentrically within said vortex chamber and providing primary annular spaces to split into fractions said carrier fluid with said particles suspended therein, a second series of partition sleeves arranged concentrically within said primary annular spaces and providing secondary annular spaces, and draining means for each of said annular spaces.

2. Apparatus of claim 1 in which each of said annular spaces is provided with an outlet and with drain regulating means having openings therein in spaced relation along the circumference of each space and graduated from small to large, each of said openings having a cross-section area thereof proportional to its distance from the outlet, to equalize the resistance to the throughflow in each of said openings.

3. Apparatus of claim 1 in which said separate feeding means consists of a tube open in an axial direction into said vortex chamber and provided with a core fixed concentrically in said tube, said core being a pipe of smaller diameter than said tube and having an open end substantially at the same level with said tube open end, thus defining an annular space in said tube open end, said annular space having fixed spin imparting means therein to impart a spin to said mixture of fine solid particles and to discharge it in the form of a hollow cylinder in said carrier fluid substantially in an axial direction, said core discharging simultaneously another fluid flow in an axial direction.

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