

Oct. 6, 1964

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3,152,074

DEHYDRATION OF GRANULAR MATERIAL

Filed Nov. 10, 1958

4 Sheets-Sheet 1

FIG. 1a

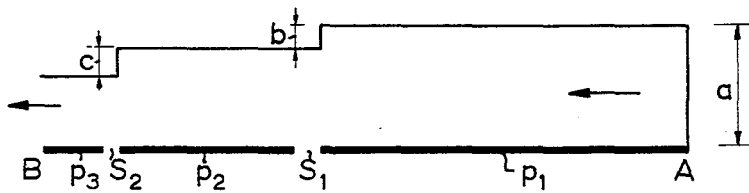


FIG. 1b

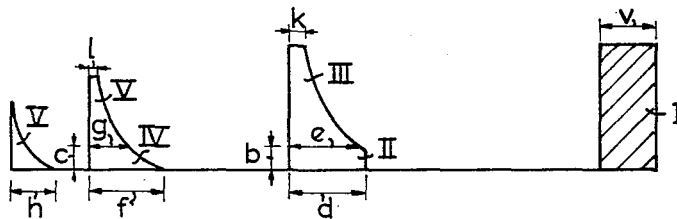


FIG. 2a

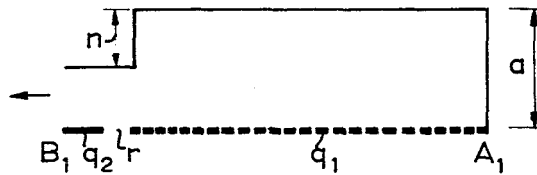
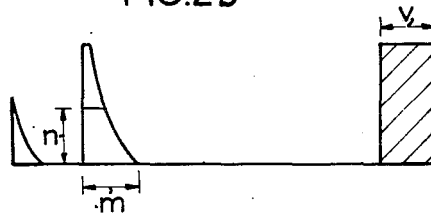


FIG. 2b



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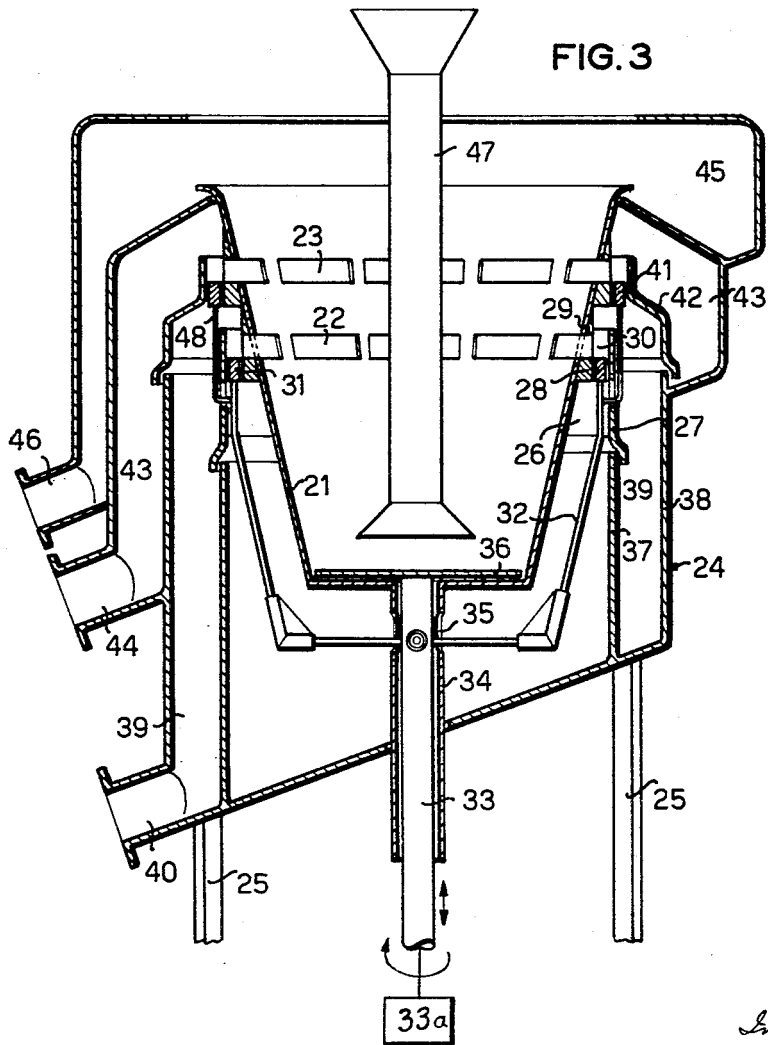


FIG. 3

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FIG. 4

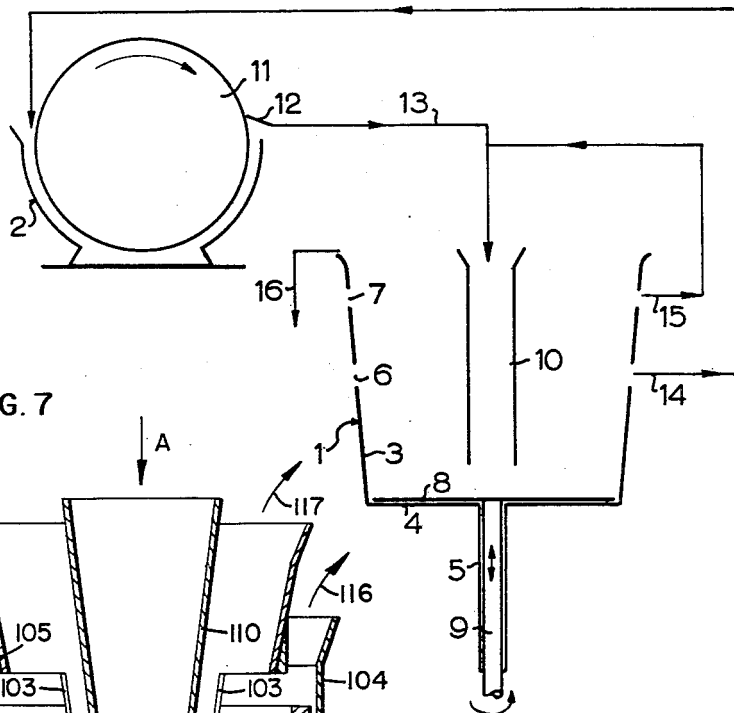
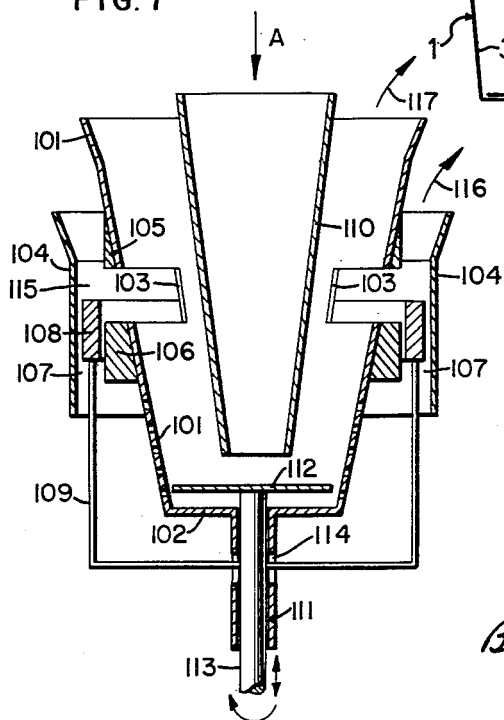


FIG. 7



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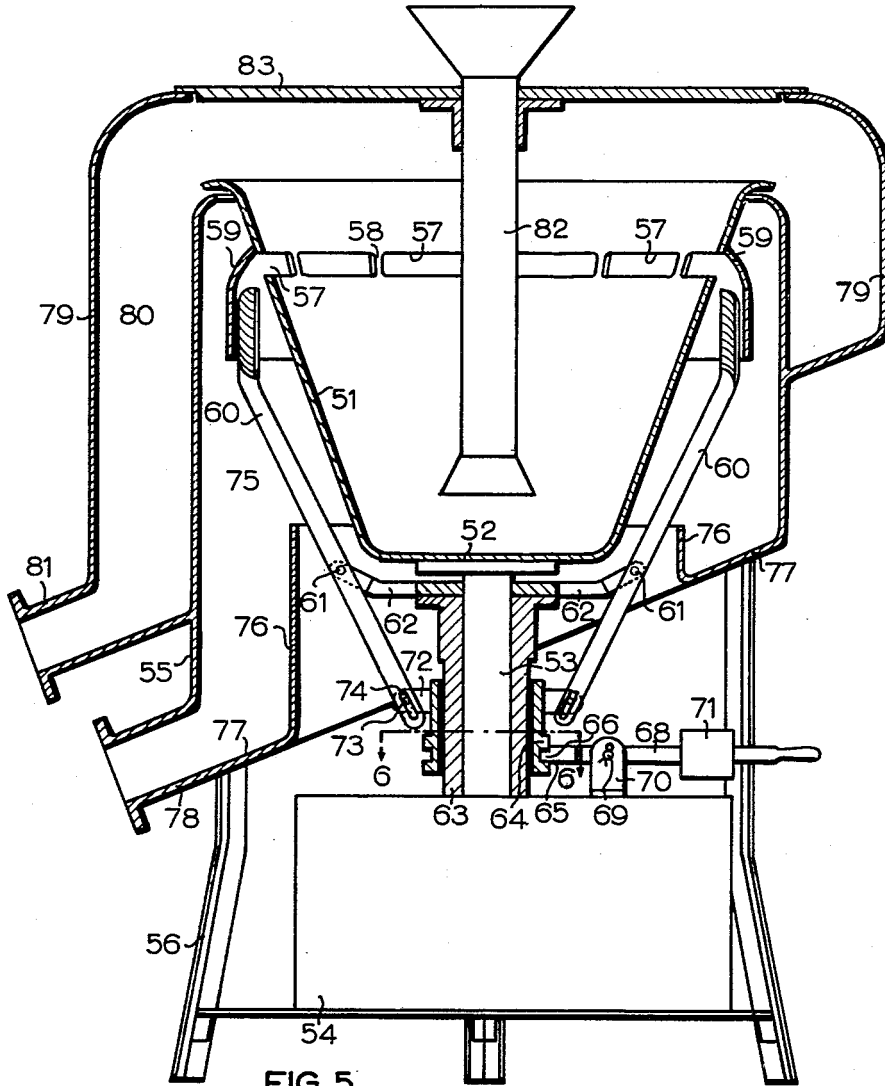


FIG. 5

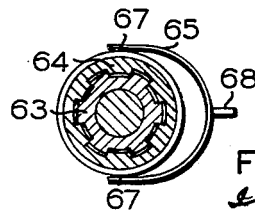


FIG. 6

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DEHYDRATION OF GRANULAR MATERIAL

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Filed Nov. 10, 1958, Ser. No. 772,737

Claims priority, application Netherlands, Nov. 12, 1957, 222,367, 222,368, 222,369

1 Claim. (Cl. 210-73)

This invention relates to the dehydration of granular materials and more particularly to improvements in process for effecting either partial or complete dehydration of fine-grained material containing free liquid.

The term "fine-grained material" as herein used is understood to mean material having a large fraction of very fine particles, for example, smaller than 0.2 mm., through which, as a result of its capillarity, liquid can pass only with difficulty.

In general, the centrifuges used for this process have perforated walls. The materials to be dried forms such a compact layer under these circumstances that little if any fine particles are flung out through the openings. The structure of this compact layer, however, causes a considerable amount of liquid to be retained by the material. It has been proposed heretofore to improve this situation by providing the centrifuge with an internal pusher, which moves the material supplied centrally at the bottom of the centrifuge in thrusts along the wall. With this arrangement, the part of the wall closest to the bottom is stripped each time of the sealing layer of material, so that the liquid gets a better chance of being flung out. As a matter of fact, this liquid also entrains fine particles. In a further stage, the centrifuge wall is divided into several steps. At each step that the layer passes, the material becomes looser in texture, so that the opportunity for the liquid to pass through it is improved. However, the original distribution of the liquid content in the layer, an increase from the inside towards the wall, is then completely or partially disturbed.

Furthermore, in the copending application, Fontein Serial No. 599,652, filed July 23, 1956, and now Patent No. 2,982,411, it has been proposed to equip the centrifuge with a non-perforated wall and to provide in this wall, close to its end, a circumferential slot, a plate rotating together with the centrifuge and being positioned around this slot, at some distance from it. The material flung out through the slot, which, naturally, has the highest liquid content, is checked by this plate and forms a bank on it the natural slope of which depends on the nature of the material and on its liquid content. If the part of the layer adjoining the wall is saturated with liquid, or if at least its liquid content is above a certain value, the material supported on the plate will behave like a liquid and flow away past the slot. If the saturation point or the critical liquid content is not reached, the material will remain stationary against the annular plate and the whole layer will continue its path on the wall past the slot. Hence, this centrifuge is self-controlling. The advantage obtained by the use of this centrifuge is that no costly perforated centrifuge wall need be used, which, depending on the nature of the material to be treated, is often liable to heavy wear or may get blocked, while the dehydrating effect is equally good as in perforated-wall centrifuges. In many cases, the dehydrating effect is even better, as in the case of a centrifuge with a perforated wall the liquid has to be removed through partly blocked openings, whereas if part of the layer is peeled off, the liquid is removed through the slot together with the peeled-off layer.

However, it is possible by the use of mechanical means to provide for the discharge of the wettest layer part

checked by the annular plate even if the above-mentioned critical liquid content is not reached, so that a separation into two layers, one having a higher mean liquid content and one with a lower mean liquid content, is yet effected. If necessary this treatment may be carried out in several stages.

Irrespective of whether the layer section closest to the wall, hereinafter to be called the outermost layer section, is separated off in one or more stages because of its flowing off as a result of its high-liquid content, or is removed by mechanical means, this outermost layer-section has a mean liquid content which is considerably higher than the liquid content of the material fed into the centrifuge. In the inner section of the layer, which continues its movement along the wall, the liquid is distributed as described before, and the maximum liquid content in it may be higher than the liquid content of the material supplied. Even though the mean liquid content of the above-mentioned inner layer section is lower than the liquid content of the material supplied, it may still be too high to make this section suited for direct delivery or further treatment, while thermal drying of temperature-sensitive substances, for example, basic materials for the preparation of polyamides, becomes rather costly. Naturally, the same observations hold for similar materials treated in a perforated-wall centrifuge whether or not they are equipped with a pusher and/or a stepped wall.

An object of the present invention is the provision of a process which will obviate these drawbacks in a simple way.

According to the invention the layer of material or the remaining part of the layer of material is divided, in a following stage, in the same, or in one or more following centrifuges, into two fractions, one forming a product having an admissible liquid content, the other having a higher content, which latter fraction is recycled to the same or to another centrifuge.

Where the separation in the following stage takes place in a centrifuge other than that in which the separation in the first phase took place, the fraction having the higher liquid content is preferably returned to a preceding centrifuge. Preferably, the separation in the following stage is carried out in such a way that the separated-off fraction of higher liquid content has a liquid content substantially equal to the mean liquid content of the material fed into the centrifuge to which the separated-off fraction is recycled.

The condition prior to the start of the above-mentioned following stage may be obtained by adjustment of either the speed of the centrifuge or the thickness of the outermost layer section to be peeled off which has a mean liquid content considerably higher than that of the material supplied, or this condition may be established by the use of a combination of these two measures. As part of the material is recycled, the capacity of the centrifuge is reduced, but, on the other hand, the advantage is obtained that the material leaving the centrifuge as final product has a mean liquid content which is considerably lower than that which could be reached before.

In the copending application, Serial No. 599,652, filed July 23, 1956, and now Patent No. 2,982,411, there is disclosed a centrifuge having at least one circumferential slot provided in its wall, to permit the passage of an outermost section of a layer of fine-grained material containing free liquid moving along the centrifuge wall. The liquid in the material travels towards the outermost layer section under the influence of the centrifugal force developed in the centrifuge. An annular plate is mounted in coaxial relation with the centrifuge wall at a position some distance outside the wall opposite the slot. This plate overlaps the slot and serves as a guide for the layer section that has passed through it. Of course, the cen-

trifuge also includes feed means for the material to be treated and discharge means for the layer sections to be separated.

The centrifuge described in the above mentioned application has a smooth, non-perforated wall and serves to effect the complete or partial dehydration of fine-grained material which, because of the fine size of the particles or of part of them, allows liquid to pass therethrough only slowly and with difficulty, and in which the centrifugal force has to overcome the capillary action of the interstices between the particles. The centrifugal action forces the free liquid gradually to the outside of the layer, i.e. the side adjoining the centrifuge wall, so that, in a cross section through the layer, the liquid content gradually rises from the inside to the outside. The outermost part of the layer may even be saturated or oversaturated with liquid.

When it reaches the slot the part of the layer which is the richest in liquid, is flung out through the slot and checked in its path by the annular plate provided around the slot. The plate is so dimensioned that the material flung out of the centrifuge can form a bank, the slope of which is dependent on the liquid content of the material. If the material is saturated with liquid it will flow away; if it contains less than a certain percentage of liquid it will be supported by the plate, so that no material is removed along the plate. Thus, the centrifuge disclosed in the above mentioned application has a self-regulating action.

It is possible that in border-line cases the automatic removal along the plate of the outermost section of the layer which is richest in liquid, cannot be controlled because of the vibration or shaking of the centrifuge. Also, it may be desirable in certain cases to remove the outermost layer richest in liquid, even if its liquid content is not so high as to enable the material to flow away. This case may be encountered where the material fed to the centrifuge does not contain or at least no longer contains sufficient liquid to make the previously described automatic flow-off possible. For example, in those cases where the centrifuge wall is perforated and therefore a certain quantity of liquid has been allowed to pass, or where the outermost layer richest in liquid has already been automatically removed previously. If the material does not easily permit the passage of water it may, on the one hand, contain too much liquid, but, on the other, not enough to enable the outermost section of the layer to be automatically discharged through the slot. As a result, the material leaving the centrifuge will often have too high a liquid content to be used in practice.

It has already been proposed to use centrifuges with a diameter increasing stepwise, in which the material loses its coherence each time it passes a step, while a rearrangement of the material takes place on the following part of the screen. (Cf., for instance, Schweizerische Bauzeitung, vol. 71, 11. 4. 1953, pp. 213-216.) However, centrifuges of this kind are costly. Without having recourse to this costly device, it is possible, when making use of the phenomenon that the outermost layer section has the highest liquid content, by separating off the outermost layer section to retain an inner layer section of considerably lower mean liquid content.

Accordingly, it is another object of the present invention to provide a process of the type described employing improved centrifuge means for removing part or all of the material flung out through the circumferential slot into the space between the centrifuge wall and an annular plate even if the liquid content of the material is below the critical value at which the material behaves like a liquid.

Another object of the present invention is the provision of a process of the type described employing improved centrifuge means for removing the material flung out through the centrifuge slot, which means is variable

to control the thickness of the layer peeled off at the slot.

Still another object of the present invention is the provision of a process of the type described employing improved centrifuge means movable axially with respect to the centrifuge slot for removing the material flung out through the centrifuge slot.

These and other objects of the present invention will become more apparent during the course of the following detailed description and appended claim.

The invention can best be understood with reference to the accompanying drawings wherein illustrative embodiments are shown.

In the drawings:

FIGURE 1a is a diagrammatic view of a longitudinal section through a layer moving along a non-perforated centrifuge wall, from which layer outer sections are cut off in two places;

FIGURE 1b is a diagrammatic view showing the liquid contents of the various sections of the layer corresponding to FIGURE 1a;

FIGURES 2a and 2b are view similar to FIGURES 1a and 1b of a layer moving along a perforated wall, from which layer an outer section is cut off near the end of the wall;

FIGURE 3 is a vertical sectional view of a centrifuge embodying the principles of the present invention;

FIGURE 4 is a diagrammatic view of an arrangement in which a centrifuge is combined with a device for pre-treating the material;

FIGURE 5 is a view similar to FIGURE 3 illustrating another form of centrifuge embodying the principles of the present invention;

FIGURE 6 is a cross-sectional view taken along the line 6-6 of FIGURE 5; and

FIGURE 7 is a view similar to FIGURE 3 illustrating still another form of centrifuge embodying the principles of the present invention.

Referring now more particularly to FIGURE 1a there is diagrammatically illustrated a layer of fine-grained material through which liquid can pass only with difficulty, which moves from A to B on a non-perforated centrifuge wall p_1, p_2, p_3 having peeling slots s_1 and s_2 provided therein. At A, where the layer is fed onto the centrifuge wall, it has a thickness which is equal to a . At this position the liquid content has the same value, v , as shown in FIGURE 1b, throughout the entire thickness of the layer. The total quantity of liquid contained in a cross-section of the layer is represented by I which is a times v . As the layer nears s_1 , the distribution of the liquid content will gradually change. The situation may even become such that when the layer reaches s_1 a section of it adjoining the wall p_1 is saturated or oversaturated, which liquid content is denoted by d . At s_1 a section of the layer, with thickness b and containing a quantity of liquid II is peeled off. The remaining layer contains a quantity of liquid III, which is equal to I minus II. The maximum liquid content in this remaining layer is e , the minimum content k . As the layer moves towards s_2 the distribution of the liquid content will undergo some further change as a result of the centrifugal force, the total quantity III remaining the same, however. When the slot s_2 is reached the maximum liquid content will be f , which is higher than e . The minimum value l will be smaller than the value k . At s_2 a layer of thickness c , containing a quantity of liquid IV, is cut off, the thickness being so chosen that the mean liquid content is substantially equal to the mean liquid content v of the material fed into the centrifuge. This layer is recycled to the centrifuge. The remaining part of the layer contains a quantity of liquid V; the mean value of this liquid content is considerably lower than the liquid content of the material obtained from a perforated-wall centrifuge.

FIGURE 2a illustrates a diagrammatical representation of the distribution of the liquid content in a layer

moving along an elongated perforated wall q_1 and short wall q_2 defining a slot r therebetween. When the layer reaches the slot r , the part of it next to the wall has a maximum liquid content m as shown in FIGURE 2b. This value, which depends in part on the permeability to liquid of the material, will in any event be lower than the value at which the material is saturated with liquid. Depending on the value m and the distribution of the liquid content in the layer at r , a part of the layer having a thickness n is peeled off, the value of n being so chosen that the mean liquid content of the layer separated off is, again, substantially equal to the liquid content v of the material fed into the centrifuge as at A_1 . The remaining part of the layer, which is discharged from the centrifuge at B_1 , also has a mean liquid content which is considerably lower than the mean liquid content of the layer at r .

Both FIGURE 1 and FIGURE 2 show the advantage inherent in the processes used, which is that the distribution of the liquid content of the layer as this moves along the wall (a gradual increase in liquid content from the axis of the centrifuge towards the wall) remains unaltered, so that in peeling off the outermost layer the part richest in liquid is removed. This procedure is in contrast with that observed in the centrifuge whose wall shows a stepwise increase in diameter.

The distribution of the liquid content in the moving layer depends first and foremost on the permeability to liquid of the material. This is determinative of the speed to be imparted to the centrifuge and is a decisive factor in the choice of the wall, whether this is to be perforated or non-perforated, the dimensions of the circumferential slots, the way in which the outermost layer or layers are to be discharged and the thickness of the layer or layers.

A further factor that may influence the choice of a perforated or non-perforated centrifuge wall is the wear exerted by the material to be treated.

Referring now to FIGURE 3 there is shown a centrifuge which embodies the principles of the present invention. In the centrifuge shown the wettest portions of the material are removed in two stages.

To this end, the centrifuge includes an imperforate centrifuge wall 21 having two axially spaced circumferential slots 22 and 23 formed therein. The centrifuge wall 21 is enclosed in a housing 24 which is supported by a frame 25. Any suitable means, such as plates 26, are provided for rigidly securing a wall 27 to the wall 21 in a position parallel to the axis of the centrifuge and at some distance from the slot 22 in overlapping relation thereto. Annular guides 28 and 29 are connected to the exterior of the wall 21 and the wall 27 forms therewith an annular space 30 of substantially rectangular cross section, into which the slot 22 opens. An annular body 31 is disposed in the annular space 30, with very little clearance and is mounted for axial movement with respect thereto by any suitable means such as rods 32 fixed to the body 31 and to a shaft 33.

Mounted in surrounding concentric relation to the shaft 33 is a hollow shaft 34, the upper end of which is fixed with respect to the centrifuge wall 21. To permit the axial motion of the body 31, the hollow shaft 34 is provided with slots 35 through which rods 32 are connected with shaft 33. The shaft 33 also serves to support a pulsating pusher 36 which is fixed to the upper end thereof within wall 21. A suitable drive means is connected to the shaft 33 for imparting movement thereto, there being shown diagrammatically a drive means 33a at the lower end of the shaft 33.

The wall 27 overlaps a fixed wall 37 which forms a part of the housing 24. The fixed wall 37, which slightly clears the wall 27, defines together with an outwardly spaced fixed wall 38 of the housing, a collecting space 39 for the fraction peeled off through slots 22. This fraction

may be removed through a discharge connection as indicated at 40.

The peeling off of the following layer section is done by means of the slot 23, which co-operates with an annular body 41 and a wall 42 similar to the body 31 and wall 27 previously described. The annular body 41 is connected to the rod system 32 through rods 48 while the wall 42 is fixed to the centrifuge wall 21. This fraction is collected in a chamber 43 of the housing and removed through a discharge connection 44. The remaining material, which has the lowest liquid content, is collected in a chamber 45 of the housing and removed through discharge connection 46. The supply of the material takes place through a central supply conduit 47.

The apparatus may be modified in various points without departing from the invention. For instance, the centrifuge may be disposed with its axis of rotation horizontal; the annular bodies 31 and 41 may be rotated and pulsated by different means. One or both annular bodies may be so disposed that they push the peeled-off layer or layers towards the bottom of the centrifuge.

The invention is not restricted to the use of the apparatus shown in FIGURE 3. The annular body 31 for the removal of the layer peeled off first may be omitted if the liquid content of the outermost layer section at the slot 22 is so high that an automatic removal of this section through the slot and along the plate 27 is ensured. The first part of the centrifuge wall may be perforated. In certain cases only one slot need then be used, as shown in FIGURE 2, through which slot the layer section that is recycled to the centrifuge, is discharged.

In the diagram shown in FIGURE 4, a centrifuge 1 has been arranged beyond a filter 2. The centrifuge has a centrifuge wall 3, joined to a bottom 4, which is rotated by a hollow shaft 5. The centrifuge wall is provided with axially spaced circumferential slots 6 and 7, through which two layers of material of comparatively high liquid content are successively peeled off from the layer moving along the centrifuge wall. The displacement of the layer is effected by means of pulsating pusher 8, which is mounted on a shaft 9 axially displaceable in the shaft 5 and capable of rotating together with this shaft. The material to be treated is axially supplied at 10. This material comes from a revolving suction drum filter 11, from which it is scraped off by the scraper 12, after which it passes through a conduit 13 into the centrifuge 1. Through the opening 6, an outermost layer section, having a liquid content which is considerably higher than the liquid content of the material coming from the filter drum 11, is peeled off in a manner not shown in the drawing, after which it is returned to the filter 2 through conduit 14.

Another outer layer section is peeled off by the slot 7. This section is chosen so that its mean liquid content is substantially equal to the liquid content of the material coming from the filter, and is recycled to the centrifuge through conduit 15 or in some other way. There remaining portion of the material, which has only a low liquid content, is discharged across the edge of the centrifuge wall at 16.

Example I

A fine-grained product having a liquid content of 22% is supplied to a centrifuge with a non-perforated wall, provided with two circumferential slots. At the first slot a layer section having a mean liquid content of 30% is automatically discharged and returned to the filter. The remaining layer section has a liquid content of about 13%. At the second slot a second outer layer section, having a mean liquid content of about 22%, is peeled off and returned to the centrifuge. The remaining layer portion has a mean liquid content of about 8% only. If a centrifuge with a perforated wall had been used the ultimate liquid content would not have been lower than 13-15%.

Example II

A fine-grained material having a liquid content of 22% is fed into a perforated-wall centrifuge with one circumferential slot. About $\frac{1}{3}$ of the liquid contained in the material is spun out through the perforations. The mean liquid content of the material is thus reduced to about 15%. From this material an outer layer section having a mean liquid content of about 22% is peeled off and recycled to the centrifuge. The remaining layer section has a liquid content of about 8%. The saving in energy required for heat production far outweighs the surplus cost involved in the use of bigger or series-connected centrifuges and the higher cost of the energy required to operate them.

Although in the example the treatment takes place in one centrifuge, the invention is by no means restricted thereto. Neither is it restricted to a separatory treatment in two stages. The treatment may be effected in several, series-connected centrifuges, with one or more stages of the treatment taking place in each centrifuge, or one stage being spread over several centrifuges.

It is also possible to arrange several centrifuges in parallel for carrying out any one stage.

In FIGURE 5 there is shown another form of centrifuge in which the material flung out through the centrifuge slot is removed toward the bottom of the apparatus. The centrifuge includes a bowl 51 providing a frusto-conical centrifuge wall and a bottom wall 52. Fixed to the central portion of the bottom wall 52 is a vertical shaft 53, which can be rotated by a driving gear (not shown) enclosed in a housing 54. The centrifuge is enclosed in a housing 55 supported by a frame 56. Formed in the upper portion of the centrifuge bowl, which may be either perforated or nonperforated, is a circumferential slot 57, interrupted by strips 58. Fixed to the outside of the bowl 51 is an annular plate 59 overlapping the slot 57 and so disposed that material flung out through the slot 57 can collect in the space between the wall 51 and the plate 59. One or more knives 60 project into the space between the plate 59 and the outside of the bowl 51. Each of the knives is individually hinged, as at 61, to a rod 62, which is fixed to a sleeve 63 concentric with shaft 53. The sleeve 63 is rotatable independently of shaft 53 by any suitable means (not shown). If necessary, ball races may be provided between the sleeve 63 and the shaft 53.

Mounted on the sleeve 63 for rotation with respect thereto is a sleeve 64 which is also axially movable thereon. As best shown in FIGURE 6, the axial displacement is preferably effected by means of a yoke 65 disposed in embracing relation with respect to an annular groove 66 formed in the peripheral surface of the sleeve 64. The yoke 65 has pins 67 extending inwardly from opposite ends thereof which engage within the groove 66. The central portion of the yoke has a rod 68 fixed thereto which is pivoted intermediate its ends on a pin 69 fixed in supports 70 carried by the housing 54.

The position of the knives 60 can be adjusted by means of a counterweight 71 slidably mounted on the rod 68. The sleeve 64 is provided with projections 72, one for each knife, which are provided with pins 73 fitting into the slots 74 in the lower ends of the arms of the knives 60. The position of the knives 60 may be altered by axial displacement of the sleeves 64. Preferably, the speed of rotation of the shaft 53 is made to differ from the speed of the sleeve 63, rods 62, and knives 60.

A collecting space 75 is provided by the housing 55 for the material that has passed through slot 57 and has been peeled off by the knives 60. To this end, it will be noted that the housing 55 includes an inner cylindrical plate 76 and a bottom plate 77. The material collected can be removed through a discharge opening 78. An outer wall 79 of the housing 55 encloses a collecting space 80 for material flung out across the edge of the centrifuge wall of the bowl 51, which material is discharged through

an opening 81. The material to be treated is centrally supplied through a tube 82. If necessary, the sleeve 63 with the knives may be axially displaceable. The housing of the centrifuge can be closed by means of a cover 83.

In the operation of the apparatus according to the FIGURE 5, wet, fine-grained material, which is highly impermeable to liquid and from which part of the liquid has to be removed, is supplied through feed tube 82 and moves along the bottom 52 to the centrifuge wall of the bowl 51, where it constitutes a layer of uniform thickness moving along the centrifuge wall. This movement of the material may, if necessary, be promoted by a pulsating pusher (such as shown in FIGURES 3 and 4) mounted in the centrifuge. Due to the centrifugal force, the liquid contained in the material moves towards the outside of the layer, that is, towards the centrifuge wall, so that the liquid content of the layer rises from the inside toward the outside. When the layer reaches the slot 57, its outermost part, having the highest liquid content, will be flung through this slot and against the plate 59. If the liquid content of this part of the layer is such that the material does not behave like a liquid it will remain stationary against the plate 59, if no knives are present. It is then impossible for any following material to flow through the slot 57, so that the entire layer will be discharged into the space 80 over the top of the centrifuge wall. This condition may arise if the material supplied contains too little liquid to form an outer layer section saturated or oversaturated with liquid, or if the part of the centrifuge wall adjoining the bottom 52 is wholly or partly perforated over its surface, so that liquid may already have been discharged through this part (which necessitates the use of a separate collecting chamber), or if ahead of the slot 57 there is another circumferential slot through which a liquid saturated or oversaturated layer section has been removed to a separate collecting space.

In the present construction, the knives 60 are provided to insure continuous removal so that the blockage noted above will not occur. Knives 60 project into the space between the plate 59 and the centrifuge wall of the bowl 51, so that during the rotation of the centrifuge the wettest portion of the material fed in is continuously discharged. In the most simple embodiment of the apparatus according to the invention the knives are stationary. However, in order to avoid undue wear, it is better to make them rotate at a speed differing from the speed of the centrifuge. By adjusting the position of the knives and/or their speed of revolution it is possible to control the amount of material to be discharged through slot 57 and hence the mean moisture content of the final product. The material peeled off may be returned to a processing apparatus from which it has come, or to the centrifuge, depending on its moisture content.

Referring now more particularly to the FIGURE 7 of the drawings, there is shown still another form of a centrifuge embodying the principles of the present invention which includes a generally frusto-conical centrifuge wall 101 having a bottom wall 102 formed at its lower end. The walls 101 and 102 are rotated about their axis by any suitable means such as a hollow shaft 111 having its upper end fixed to the apertured central portion of the bottom wall 102. An internal pusher 112 is mounted above the bottom wall 102 for axial reciprocatory movement by a shaft extending downwardly therefrom throughout the apertured central portion of the bottom wall a hollow shaft 111.

In FIGURE 7, the lower portion of the wall 101 is shown to be perforated. However, under certain conditions this perforation may be omitted. Moreover, the centrifuge wall may have a cylindrical configuration rather than the frusto-conical shape shown, particularly when the centrifuge is provided with an internal pusher 112 such as that shown, by which the material to be treated is displaced thrustwise along the wall 101.

Spaced some distance downwardly from the upper or free end of the wall 101, a circumferential slot 103 is formed therein. Disposed in surrounding relation to the slot 103 and in coaxial relation to the wall 101 at a position spaced therefrom is an annular plate 104, which is secured to the wall 101 by any suitable means, such as strips 107, fixed to the centrifuge wall 101 and to the plate so that the latter will rotate together with the wall. The plate 104 and the centrifuge wall 101 define therebetween an annular guiding space indicated at 115. The distance between the plate 104 and the wall 101 is so chosen that material flung out of the centrifuge owing to the centrifugal force is checked by the plate 104. An annular body 108 is disposed within the guiding space 115 with only a small clearance which permits relative axial movement therein. The body 108 is connected, as by rods 109, with the shaft 113 which serves to impart a rotating and pulsating motion to the annular body.

The space 115 or at least the part in which the annular body moves has a rectangular section. The plate 104 therefore is parallel to the axis of rotation at least for the length of the rectangular part. If the wall 101 is conical, annular guides 105 and 106 are therefore fixed to it on both sides of the slot 103. The annular body 108, which is preferably rectangular in cross section, is so disposed that in one of its extreme positions its upper face is substantially on a level with the edge of the slot 103 facing towards the bottom of the centrifuge.

The centrifuge has a central feeding device 110 for the material to be treated. The shaft 113 is provided with any suitable means (not shown in the drawing) for imparting to it a rotary and pulsating motion. The rotary motion may be obtained, for example, by providing one of the shafts with cams, and the other with axial slots in which these cams are guided. Fixed to the shaft 113 are the body supporting rods 109. The shaft 111 is, to this end, provided with longitudinal slots 114 through which the rods extend.

In operation, fine-grained material containing free liquid is supplied at A and moves in a layer, evenly distributed, to the centrifuge wall 101. In a centrifuge having a large apex angle the material will automatically move in a layer to the end of larger diameter.

In a centrifuge having a small apex angle or in a cylindrical centrifuge this movement is supported or caused, respectively, by the pusher 112. On account of the centrifugal force free liquid will move towards the outside, to the extent which the nature of the material permits, and if the wall 101 is perforated part of this free liquid will be flung out, so that it can be removed separately. However, owing to the poor permeability to liquid of the material, there will be created in the layer, irrespective of whether or not the wall is perforated, a situation in which the part of the layer closest to the axis is completely or partially free of liquid and the liquid content increases towards the wall. When the layer reaches the slot 103, a slice of the width of the opening constituted by the annular body 108 and the slot 103 will be peeled off. The thickness of this peeled-off layer will at the most be equal to the distance between the plate 104 and the wall 101, or the guides 105 and 106. Therefore, care should be taken to determine this distance in relation to the dimensions and the capacity of the centrifuge, so as to prevent the whole layer being flung out through the slot. In addition, the amount of material richest in liquid that is discharged can be controlled by adjustment of the stroke length and frequency.

Coupling the annular element 109 to the pusher 112 has the advantage that during the forward stroke of the pusher, when the layer of material is displaced, the slot 103 is closed, while during the reverse stroke, when the layer of material remains practically stationary, the slot is opened, so that at that time the layer section richest in

liquid can pass through the slot. In the following forward stroke this section is pushed to the discharge opening for the wettest fraction, at 116. The drier part of the layer is discharged at 117.

The advantage presented by the apparatus shown in FIGURE 7 is that only a short centrifuge bowl need be used. The removal, from the material originally supplied, of the amount of liquid contained in the peeled-off layer would, when carried out in any other way, require the use of a much longer centrifuge wall and a much longer retention time in the centrifuge, or the use of a costly thermal drier. True, the peeled-off section of the layer, which has a high liquid content has to be returned to a preceding plant for removing the liquid from it, which plant is arranged ahead of the centrifuge and consists, for example, of a filter installation, so that the centrifuge delivers only part of the material supplied in the required state, but the lower capacity far outweighs the much higher cost attending the abovementioned disadvantages.

It will thus be seen that the objects of this invention have been fully and effectively accomplished. It will be realized, however, that the foregoing specific embodiment has been shown and described only for the purpose of illustrating the principles of this invention and is subject to extensive change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claim.

We claim:

A process for continuously dehydrating fine-grained material containing free liquid which comprises the steps of: imparting sufficient rotary movement to a supply of material, while generally confining the rotary movement in a plane of revolution having an axis concentric with the axis of rotary movement, such that the material moves along the plane of general confinement as a layer which, in the direction of the thickness thereof toward the plane of confinement, increases in liquid content and, in the direction of material movement, the increase in moisture content toward the plane of confinement is progressively greater and the particle distribution is retained substantially the same; separating from the moving layer a first fraction having a mean liquid content greater than the liquid content of the supplied material; and then separating the remaining material into a second fraction having an admissible liquid content and a third fraction having a higher liquid content substantially equal to the liquid content of the supplied material by peeling off, from a moving layer of the remaining material similar to the moving layer of supplied material, a layer section thereof constituting said third fraction, and recycling said third fraction to form a part of the supplied material.

References Cited in the file of this patent

UNITED STATES PATENTS

739,081	Hicks	Sept. 15, 1903
1,373,743	Jones	Apr. 5, 1921
1,557,672	Doerner	Oct. 20, 1925
1,776,554	Gale	Sept. 23, 1930
2,370,999	Schutte	Mar. 6, 1945
2,387,276	Link	Oct. 23, 1945
2,628,021	Staaff	Feb. 10, 1953
2,644,583	Cannon et al.	July 7, 1953
2,752,089	Zachariassen	June 26, 1956
2,755,934	Ruegg	July 24, 1956
2,782,925	Morton	Feb. 26, 1957
2,860,776	Hays	Nov. 18, 1958
2,878,995	Dega	Mar. 24, 1959
2,899,065	Irving	Aug. 11, 1959
2,982,411	Fontein	May 2, 1961
2,991,887	Wirth et al.	July 11, 1961
3,087,621	Gooch	Apr. 30, 1963