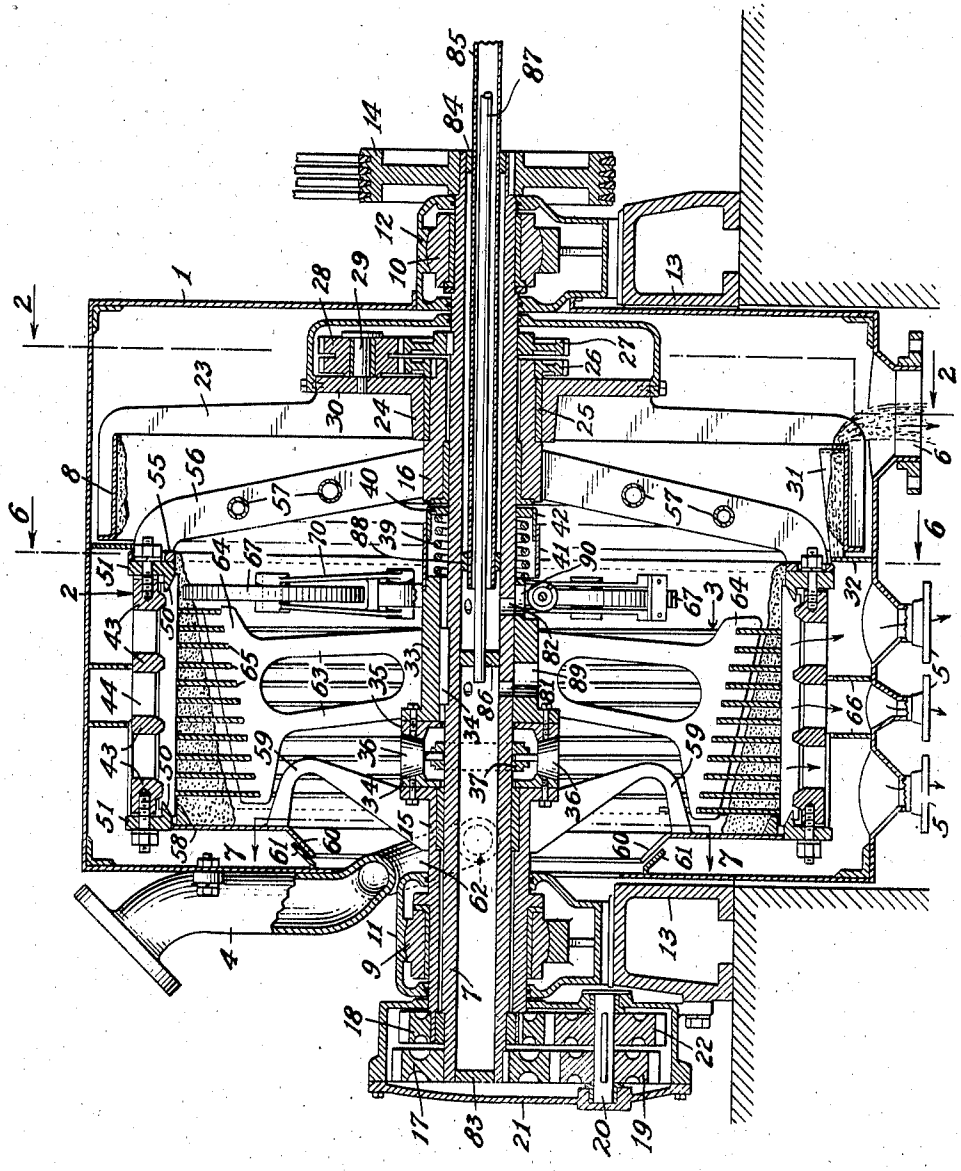
Aug. 11, 1942. H. G. CHATAIN 2,292,990

CENTRIFUGAL SEPARATOR

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Fig. 1.



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Fig. 2.

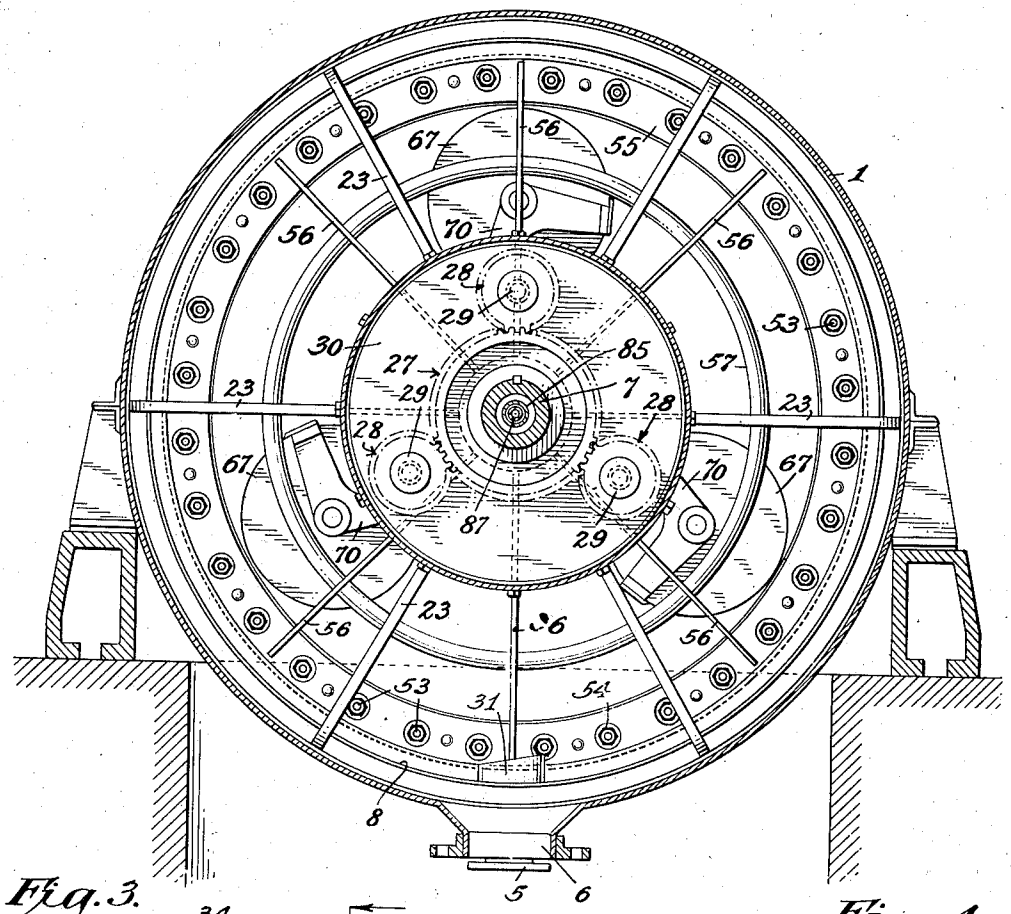


Fig. 3.

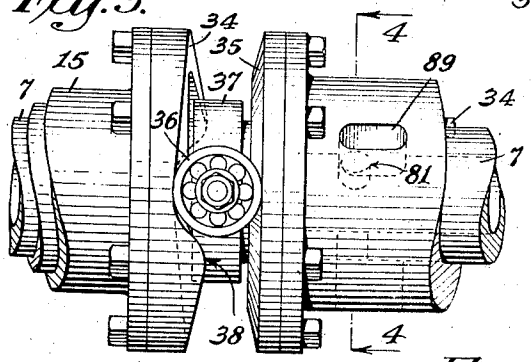


Fig. 4.

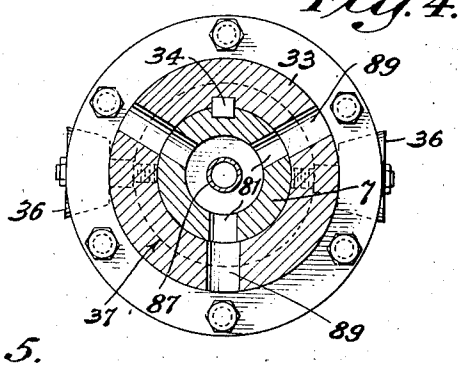
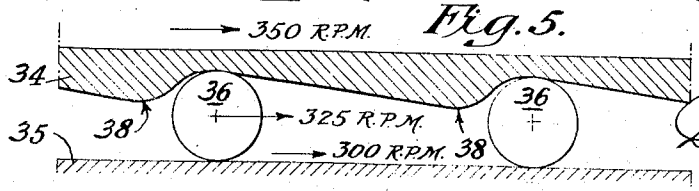


Fig. 5.



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Fig. 6.

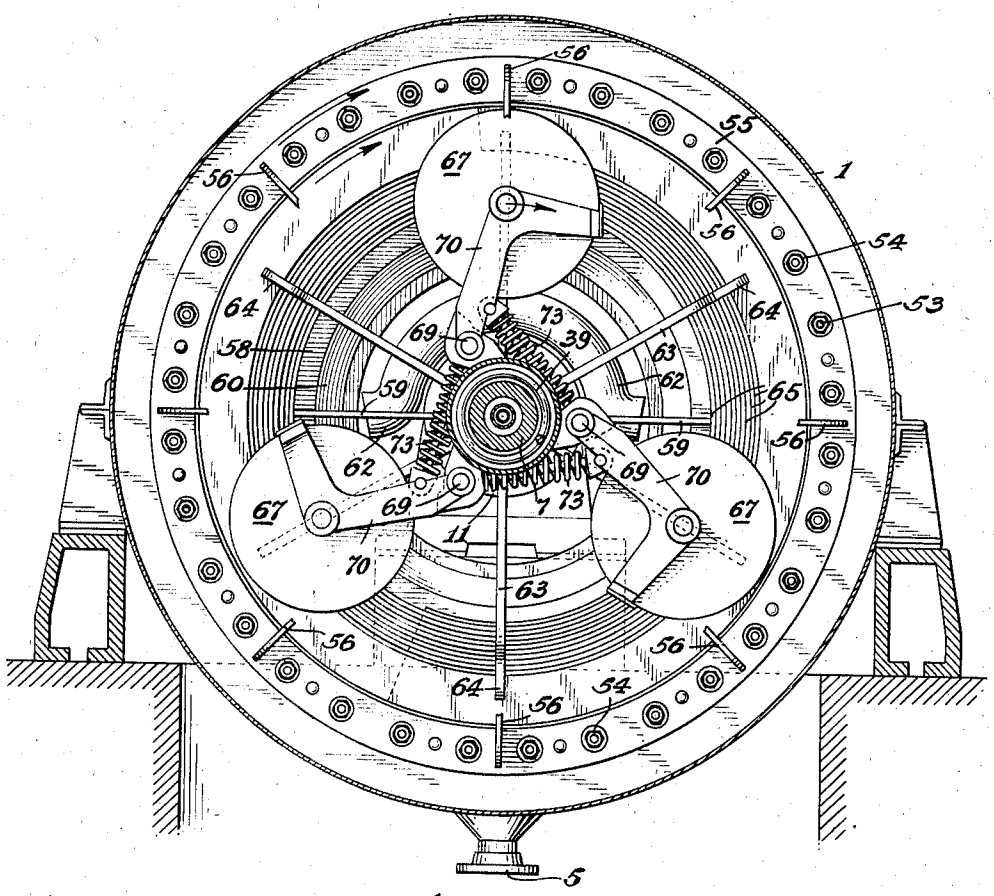
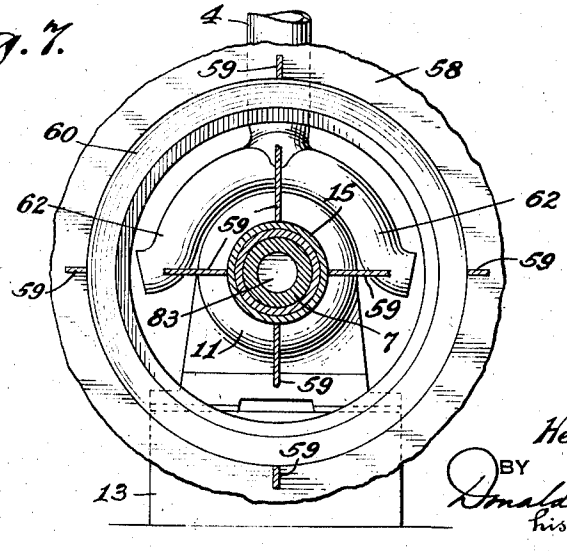


Fig. 7.



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Fig. 8.

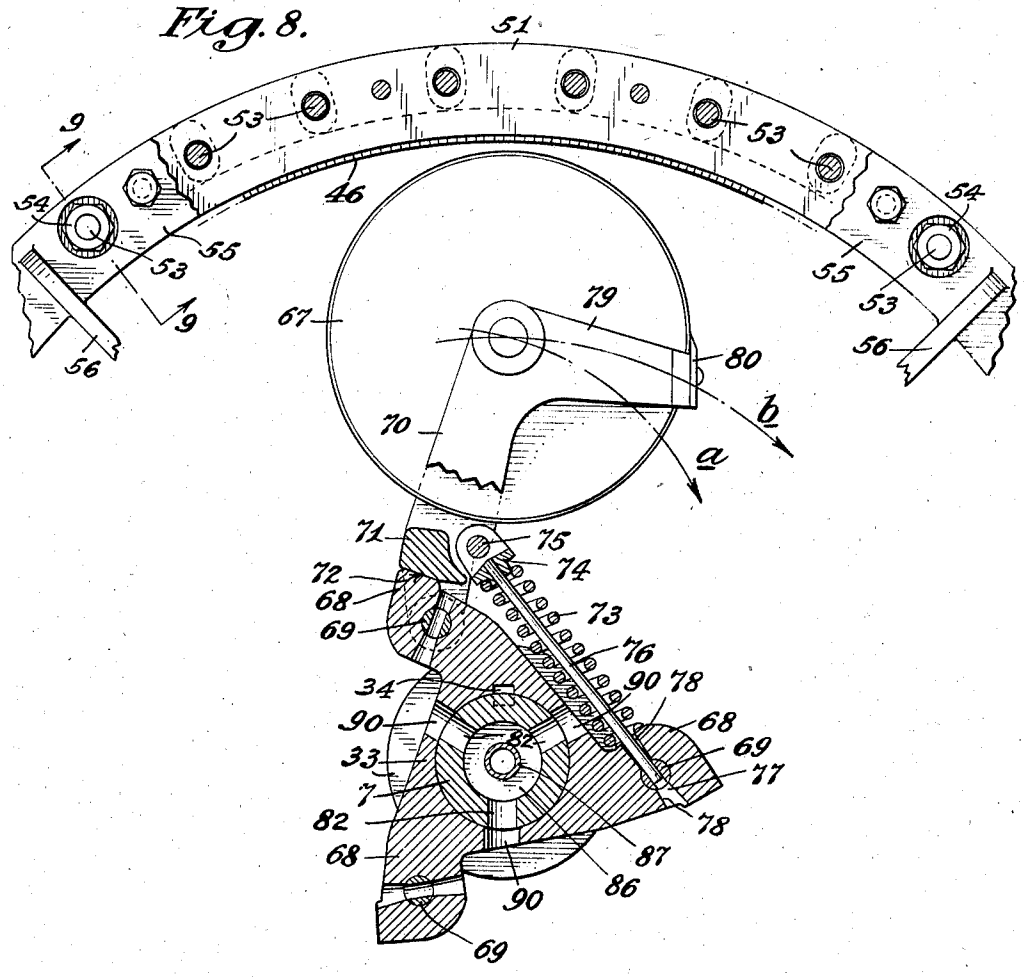


Fig. 9.

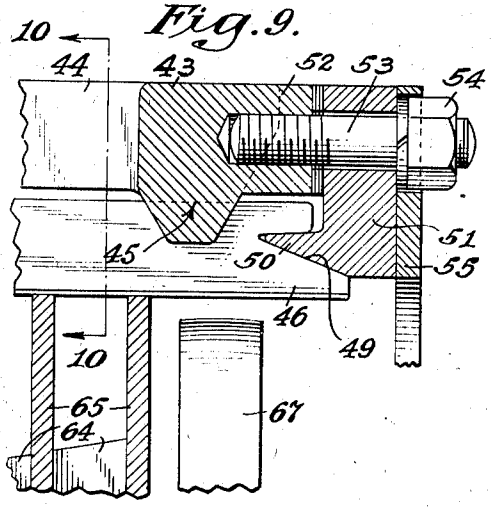
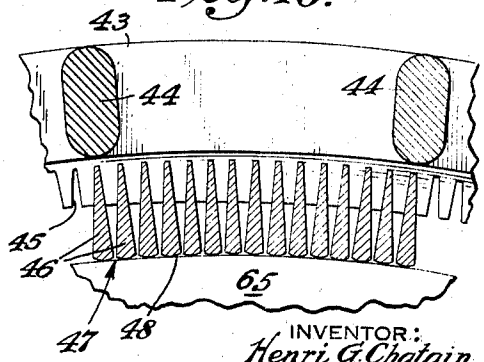


Fig. 10.



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Fig. 13.

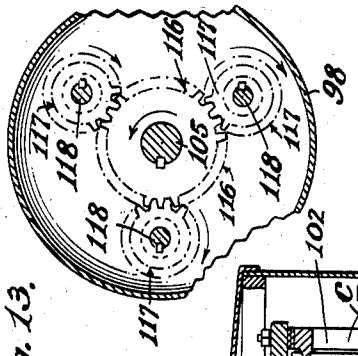
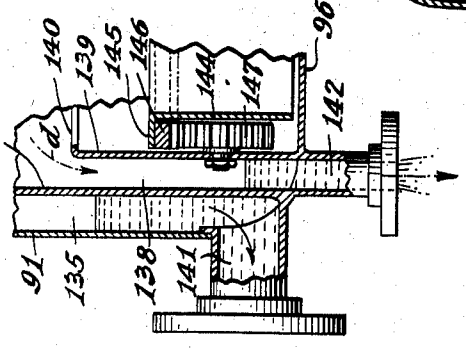


Fig 11.

Fig. 12.



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UNITED STATES PATENT OFFICE

2,292,990

CENTRIFUGAL SEPARATOR

Henri G. Chatain, Erie, Pa.

Application July 21, 1939, Serial No. 285,667

10 Claims. (Cl. 210—69)

The invention relates to method and means for filtering or extracting liquids from solids. More particularly it relates to improvements in centrifugal separators of the continuous type as distinguished from those designed for batch operation.

Centrifugal separators of the continuous type generally provide for continuous feeding of the stock at a controlled rate and for continuous discharge of the separated liquid fraction or fractions. Discharge of the solid fractions may be either continuous or intermittent. Attempts to provide for continuous discharge of the solid fraction have been attended with serious difficulties, particularly as applied to the treatment of fibrous materials or other materials yielding a solid fraction which does not flow readily. Movement of the solid fraction toward the point of discharge has been accomplished, or proposed to be accomplished, in many different ways. For example, it has been proposed to use helical conveyors; scrapers which exert a raking action on the material; disc harrows; or pistons which push the material toward the point of discharge. While such devices may have merit as applied to the separation of liquids from certain classes of material, they are not well adapted to the treatment of materials of a fibrous character such as paper pulp, fibrous cellulose, acetate, and nitrate, certain sludges from sewage and other materials in the sugar, rubber and fibrous board industries. The solid fraction of such materials tends to clog a helical conveyor; and rakes or scrapers which intermittently lift away from the surface of a centrifugal filter basket do not readily get down through the material on succeeding bites as the density of the solids increases during centrifuging. Again, pistons which push the material toward the point of discharge tend to distort the cake of solids, leading to lack of uniformity in extraction and adversely affecting the length of time required to achieve a given percentage of reduction in moisture content. With such a method the cake does not maintain a uniform thickness, but will frequently hump up, thereby increasing the difficulty of extracting the liquor. It is an object of my invention to provide a method and means for continuous centrifugal separation of solid and liquid fractions which overcomes these and other difficulties, and which is particularly advantageous in the centrifuging of fibrous materials.

A general object of the present invention is to provide means for continuously extracting liquids from moist solids more rapidly and efficiently than is possible with methods and apparatus heretofore known.

A specific object of my invention is to provide an improved method and means for causing solids to traverse the length of a centrifugal filter basket without clogging or humping.

A further specific object is to provide improved auxiliary pressure extracting means to supplement centrifugal extraction.

A further object is to provide an improved form of filter basket. Other objects and advantages of my invention will appear as the description proceeds.

As previously noted, one of the principal difficulties experienced in the centrifuging of fibrous materials, and materials possessing similar caking characteristics, resides in the problem of obtaining a uniform discharge of the cake without clogging or humping. Factors influencing removal of the cake in undistorted form are: (1) the density of the cake; (2) the width of the cake in advance of the pushing element; (3) the thickness of the cake; (4) the coefficient of friction between the cake and the surface of the filter basket; and (5) the centrifugal force developed by the machine. I have found that for a given material, centrifugal force and cake thickness, improved handling of the cake can be obtained by running ejector blades circumferentially into the cake at an acute angle to a plane normal to the axis of rotation of the filter basket, and intermittently advancing the ejector blades toward the discharge end of the basket, so that, in effect, the ejector is screwed into the cake from the discharge end and pulls the cake out like an annular cork. In order to have continuous operation this must take place while the basket and ejector are rotating. The "screwing-in" action is accomplished by having the ejector screw and basket rotate at somewhat different speeds. It is quite essential, in accordance with my preferred method, that the ejector screw enter the cake or advance its position into the cake, substantially without moving the cake axially of the filter basket. In this way very little resistance is offered to the action of the ejector even with a fibrous cake, or a cake of great density. Axial movement of the cake is performed intermittently by bodily movement of the ejector screw and not by a helical conveyor action.

In order that the nature and many advantages of my invention will be fully understood, I shall describe certain preferred embodiments thereof with reference to the accompanying drawings, in which

Fig. 1 is a vertical longitudinal sectional view of a centrifugal separator capable of operation in accordance with my novel method, and embodying novel features of construction to be described.

Fig. 2 is a transverse sectional view taken on the line 2—2 of Fig. 1.

Fig. 3 is a detail view of the cam mechanism for intermittently advancing the ejector blades toward the discharge end of the basket; and Fig. 4 is a transverse sectional view on the line 4—4 of Fig. 3.

Fig. 5 is a development layout of the cam surfaces of the mechanism shown in Figs. 3 and 4.

Fig. 6 is a transverse sectional view on the line 6—6 of Fig. 1; and Fig. 7 a detail sectional view on the line 7—7 of Fig. 1.

Fig. 8 is a detail transverse sectional view taken in the plane of the pressure rolls; and Fig. 9 is a detail sectional view to an enlarged scale on the line 9—9 of Fig. 8. Fig. 10 is a detail sectional view on the line 10—10 of Fig. 9.

Figs. 11 to 13 illustrate another embodiment of the invention in which the axis of the separator is vertical instead of horizontal; Fig. 11 being a central vertical sectional view; Fig. 12 a detail vertical sectional view showing the liquid discharge outlets; and Fig. 13 a sectional view on the line 13—13 of Fig. 11.

The apparatus comprises, in its general arrangement, a casing 1, within which are rotatably mounted a chamber or "basket" 2 and a helical ejector 3. The casing 1 is provided with an intake conduit, or alimentary pipe, 4, arranged to charge the separator with a slurry to be filtered, and is also provided with an outlet, or series of outlets, 5, for discharge of the liquid fractions, and an outlet 6 for discharge of the solids. The basket element 2 and ejector element 3 are mounted in association with a main shaft 7 and auxiliary shafts to be described, driven by a differential mechanism which causes one of said elements to rotate at a slightly higher speed than the other. Means are also provided to produce intermittent movement of one of said elements with respect to the other in an axial direction, i. e., parallel to the axis of the shaft 7.

As another element of the general combination there may also be provided a discharge ring 8 driven by a planetary transmission from the shaft 7.

The shafts for the rotating elements 2, 3, and 8 are supported on bearings 9 and 10, the supporting rings of which may have spherical surfaces for engagement with similar surfaces in the housings 11 and 12, respectively. These housings are carried on a suitable supporting frame, or base, 13. Keyed to one end of the shaft 7 is a pulley 14 driven from a suitable source of power. The basket 2 is supported on a pair of quill shafts 15, 16 surrounding the main shaft 7 and driven therefrom. The quill shaft 15 is driven from the main shaft 7 through suitable gearing. For this purpose I have shown gears 17 and 18 keyed respectively to the shafts 7 and 15, gear 17 meshing with a pinion 19 keyed to a shaft 20 conveniently carried in the housing 21 which surrounds the gearing. Also keyed to the shaft 20 is a pinion 22 which meshes with gear 18 previously referred to. In the embodiment illustrated the basket 2 is arranged to rotate at a speed which is somewhat greater than that of the helical ejector. This differential speed is produced by the transmission gearing just described. The purpose of the speed differential will be explained later.

Since the quill shaft 16 forms a part of the basket 2, it will be understood that the transmission gearing in the housing 21 serves to drive the shaft 16 as well as the shaft 15. The discharge ring 8 is driven through the shafts 7 and 16. The ring 8 is mounted on spokes 23 radiating from a hub 24 having a bearing portion 25 to receive a portion of the quill shaft 16 about which the ring is arranged to rotate. To drive the ring 8, gears 26 and 27 are keyed, respectively, to the shafts 16 and 7, and these gears mesh with planetary gears 28 mounted on stub shafts 29 secured to the flange 30 of the hub 24.

There are three sets of these planetary gears 28 as shown in Fig. 2. Inasmuch as the speed differential between the shafts 7 and 16, and therefore between the gears 26 and 27, is not great, the planetary gearing described causes the ring 8 to rotate much more slowly than the basket 2. Cooperating with the discharge ring 8 is a scraper 31 (Figs. 1 and 2), mounted on the flange 32 secured to the housing 1. The angular arrangement of the scraper 31 is such that the material collected on the discharge ring 8 is scraped off into the discharge outlet 6.

The helical ejector 3 is carried by a quill shaft 33, mounted on the main shaft 7 and keyed to it by a spline 34 in such a manner as to be slidable longitudinally of the shaft 7. Longitudinal movement of the ejector is positively controlled, as by cam action, at least during that portion of its cycle when it is moving to the right as viewed in Fig. 1. For this purpose I prefer to employ a cam or cams associated with one or both of the quill shafts 15 and 33. In the embodiment illustrated I have provided a pair of cams 34 and 35 secured, respectively, to the adjacent ends of the shafts 15 and 33, and cooperating cam rollers 36, of which there may conveniently be two, mounted on stub shafts for rotation in a ring 37 which, in turn, is rotatable with respect to the shaft 7 on which it has a bearing. One of the cams may have a plane surface, or both may be undulating or be provided with humps for controlling longitudinal movement of the quill shaft 33. As illustrated, the cam 35 has a plane surface serving as a race for the rollers 36, while cam 34 has a surface which, as developed, would appear substantially as shown in Fig. 5, having a pair of humps 38 located 180° apart to correspond with the spacing of the two rollers 36. The rollers 36 may be mounted on ball or roller bearings as indicated in Fig. 3. If desired, however, the rollers 36 can be omitted from the construction shown, and the two cams designed for direct engagement with one another. The form of the humps 38 is important in achieving certain of the objects of my invention, and will be described more particularly hereinbelow. If desired, a helical spring 39 may be provided between the end of the shaft 33 and a collar or flange 40 on the shaft 7 to insure that the ejector 2 will be correctly positioned when the apparatus is put into operation; also to assist in the screwing-in action to be described. Telescoping sleeves 41 and 42, attached, respectively, to shaft 33 and collar 40, provide a housing for the spring 39.

The preferred construction of the basket 2 will now be described with reference principally to Figures 1, 2, 9 and 10. The frame of the basket may conveniently be in the form of a casting of open cylindrical form having spaced circumferential rings 43 joined together by longitudinal members 44. The ring members 43 are provided with a series of longitudinally extending slots 45 (Fig. 10) to receive the wedge-shaped longitudinal bars 46 which form the inner surface of the basket. These bars 46 are so designed and spaced that their inner edges are spaced apart a suitable distance to permit escape of the liquid fraction of the material which is to be centrifuged. For paper pulp, fibrous cellulose, acetate and nitrate, certain sludges from sewage and other materials in the sugar, rubber, and fibrous board industries, I have found that spacings of

0.004 to 0.010 of an inch give good results. This refers to the spacing between adjacent bars at the point where they come closest together, as shown at 47 in Fig. 10. It will be understood that the spacing of the bars depends upon the nature of the materials to be separated and may be varied in accordance with this factor. In my preferred construction the inner edges 48 of the bars which are to form the inner surface of the basket are arcuate in cross section. I have found that this form of edge assists the liquid to find its way to the slots 47 under the action of centrifugal force. The bars 46 may be held in place in any convenient manner, and in my preferred construction the ends of these bars are slotted as at 49 to receive the peripheral flange 50 of a clamping ring 51 which is secured to a flange 52 formed on the end ring 43 of the basket frame by means of studs 53 and nuts 54 provided at intervals around the periphery of the frame. This construction is shown best in Fig. 9. At one end of the basket 2 the clamping ring 51 is secured to the rim 55 of the wheel which has the quill shaft 16 for a hub, and to which it is connected by radial spokes 56. The wheel thus formed may be strengthened by the provision of circumferential tubular elements 57 which may conveniently pass through suitable apertures in the spokes 56. An end plate 58 is secured to the clamping ring 51 at the other end of the basket, and this end plate forms the rim of a wheel of which the quill shaft 15 constitutes a hub, the plate 58 and shaft 15 being connected by a plurality of radial spokes 59. The end plate 58 is provided with a flange 60 which may be in the form of a truncated cone, and which cooperates with a flange 61 secured to the end of the casing 1 to insure that the material charged into the separator will be directed to the interior of the basket and not find its way between the end plate 58 of the basket and the wall of the casing 1.

The alimentary pipe 4, through which the material is charged into the apparatus, preferably is of the form shown in Fig. 7, having two branches 62 which extend in a generally circumferential direction from their point of connection with the pipe 4 so as to avoid interference with the spokes 59. The extremities of the branches 62 may be turned outwardly in a radial direction to direct the material toward the periphery of the rotating basket and ejector.

The construction of the ejector 3 will now be described principally with reference to Figs. 1 and 6. The quill shaft 33 forms the hub of the ejector wheel. Radial arms or spokes 63 extend outwardly from the shaft 33, six double spokes being shown in the embodiment selected for the purpose of illustration. The ends of the double spokes 63 are joined by a radial plate 64, the outer edge of which is inclined, as shown in Fig. 1. The plates 64 are cut to form a thread which receives the inner edges of a helical element 65 formed of a flat strip the width of which decreases in the direction of flow of material through the separator, i. e., from left to right as viewed in Fig. 1. The outer edges of the helical ejector thus formed lie approximately in the plane of a right circular cylinder. The inner edges of the helical element of the ejector lie approximately in the plane of a truncated cone. The reason for adopting this particular construction resides in the fact that the layer of material passing through the separator will be thicker at the entering side of the machine where its liquid content is greater, and progressively thinner as the "cake" approaches the discharge end of the machine, becoming more and more compressed and de-liquefied. The outer diameter of the ejector 3 is slightly smaller than the inner diameter of the basket 2.

In some instances it may be desirable to separate the liquids into selected fractions, in which event the casing 1 may be provided with a plurality of partitions 66 arranged circumferentially of the basket 2 and opposite intermediate circumferential rings 43 thereof, so as to effect a separation of the liquid which passes through the openings between successive rings 43. The partitions 66 thus cooperate with the separate discharge openings 5 previously described in separating the filtrate fractions.

It may be found desirable to apply pressure mechanically to the cake as it emerges at the discharge end of the ejector in order to obtain more complete extraction of liquid from certain materials which are so formed or of such a character as to require such auxiliary pressing. For this condition, it may be desirable to provide pressure rolls designed to squeeze the cake directly against the inside of the basket. In the embodiment illustrated, I have shown apparatus for this purpose, which apparatus will now be described principally with reference to Figs. 1 6 and 8. This apparatus consists essentially of one or more pressure rolls 67 which are pivotally and resiliently connected to the quill shaft 33. For this purpose, shaft 33 has formed thereon or secured thereto, lugs 68 (Fig. 8). In the embodiment illustrated, these lugs are formed integrally with the shaft 33. Pivotally secured to each lug 68 by a pin 69 is a bifurcated link 70 designed to pivotally receive the pressure roll 67 between the furcations thereof. The furcations of the link 70 are connected near their point of attachment to the lug 68 by a bridging element 71 having a surface 72 for engagement with the lug 68 to limit the movement of the link 70 about the pivot pin 69 in a counterclockwise direction as viewed in Fig. 8. In this limiting position it is preferable that there shall be a slight clearance between the roll 67 and the inner surface of the basket 2. The pressure roll is resiliently urged into this limiting position by means of a compression spring 73 which bears at one end against one of the lugs 68 of the quill shaft 33 and at its other end against a spring seat 74 which is pivotally connected to the link 70 by means of a pin 75. The spring 73 is further positioned and guided by a rod 76, one end of which is secured to the spring seat 74 and the other end of which projects through an aperture 77 which extends through the lug 68 and pin 69. In order to provide for angling of the rod 76 when the link 70 swings in a clockwise direction about the pivot 69 as indicated by the arrow *a* in Fig. 8, the aperture 77 is flared outwardly at each end as indicated at 78, 78. The rod 76 serves to hold the pin 69 against longitudinal movement, while the pin provides an angularly movable guide for the rod. The furcations of the link 70 may be extended angularly beyond the bearing for the pressure roll 67, as at 79, to provide a support for a knife 80, providing a scraper to keep the surface of the roll free from accumulations. It will be understood that as the pressure rolls 67 swing around the main shaft 7 in the direction indicated by the arrow *b* (Fig. 8), they may also swing about the pivots 69 against the action of centrifugal force, and of the spring 73, to pro-

vide greater or less clearance between the rolls and the basket as the thickness or compressibility of the material discharged from the ejector 3 varies. The rolls are constantly urged outwardly toward the limiting position shown in Figs. 6 and 8 by centrifugal force augmented by the action of the springs 73. The principal function of the springs 73 is to hold the rolls 67 in their outermost position as the machine is being put into operation.

If desired, means may be provided for introducing liquids into the interior of the basket for washing or impregnating the material during the process of centrifuging, or for such other purpose as may be contemplated. To this end I have made the shaft 7 of hollow form and provided it with a series of discharge openings 81 and 82. The ends of the shaft 7 are closed by plugs 83 and 84, the latter of which is apertured to receive an inlet pipe 85 for the liquid to be introduced. In the particular embodiment illustrated I have provided for the introduction of liquids from two sources and have shown a dam 86 dividing the hollow interior of the shaft into two compartments. Liquid from the pipe 85 enters the one compartment, and a pipe 87 extends through the interior of the pipe 85 and through an aperture in the dam 86 to discharge liquid into the other compartment. A second dam 88 may be placed around the inner end of the pipe 85 to confine the liquid in the first chamber. The quill shaft 33, which has been previously described, is longitudinally movable with respect to the shaft 7 which must be provided with elongated apertures 89 and 90. The apertures 81, 82, 89 and 90 may be arranged at several points around the periphery of the shafts 7 and 33 as shown in Fig. 8. In order to distribute the liquid uniformly over the contents of the basket, there may be as many series of outlets as desired, and these may be so arranged that the liquids will drain principally between selected partitions 43 of the basket and thence be discharged between partitions 66 and through selected outlets 5.

As previously mentioned, the drive for the basket and ejector elements is such that one of them rotates at a somewhat greater speed than the other. The actual speeds depend upon the character of the material which is to be processed, and upon other factors which have been mentioned. However, in describing the operation of the machine it will be convenient to assume that for a given material, the basket 2 is arranged to rotate at 350 R. P. M. and the ejector 3 at 300 R. P. M. Assuming further that the direction of rotation of the basket and ejector is clockwise as viewed in Fig. 6, the helical element 65 of the ejector will be in the form of a lefthand screw. Proceeding with these assumptions, I shall now describe the method of operation of the preferred embodiment of my apparatus illustrated in Figs. 1 to 10 of the drawings as follows:

The material to be de-watered is introduced continuously and at a suitable consistency through the alimentary pipe 4 from which it is discharged into the interior of the machine through the branch pipes 62. It has been explained that the ejector 3 is longitudinally movable along the main shaft 7 and with respect to the basket 2. As the separator is put into operation, the ejector will be at the limit of its movement to the left, as viewed in Fig. 1, under the action of the coil spring 39, the relative position of the cams 34 and 35 being as indicated in Figs. 3 and 5, in which the cam rollers 36 are in the troughs of the cam 34, permitting the cams to assume that position in which they are closest together. The cams 34 and 35 move the ejector 3 to the right against the action of the spring 39 a distance which is equal to the height of the humps 38 of the cam 34. In the embodiment illustrated, this distance is on the order of 1 inch and this dimension will be assumed in further discussion of the operation. This movement of the ejector to the right occurs—say—50 times per minute, which will give a discharge of material equivalent to a cylinder 50 inches long having an outside diameter equal to the inside diameter of the basket 2 and an inside diameter which will depend upon the thickness of the cake at the discharge end of the helical element 65.

With the basket 2 rotating in a clockwise direction at 350 R. P. M. and the ejector 3 rotating in the same direction of 300 R. P. M., the ejector is in effect rotating counterclockwise relative to the basket at a speed of 50 R. P. M. This means that the lefthand helical element 65 of the ejector screws into the material in the basket, moving from right to left as viewed in Fig. 1. The material entering the separator is thrown to the periphery of the basket by centrifugal force, where it forms a "cake" the thickness of which decreases progressively as the cake approaches the discharge end of the machine, becoming more and more compressed and de-liquefied. This condition is shown in Fig. 1. The pitch of the helical element 65 is such that it screws into the cake at a speed which brings it to its limit of travel to the left just at the point where the hump 38 of the cam 34 is ready to move the ejector bodily to the right. The longitudinally inclined portions of the cam 34 which lie beyond the humps 38 preferably are at such an angle as to permit the ejector to move to the left at exactly the speed produced by its action in screwing into the cake. Thus there will be substantially no movement of the cake with respect to the basket during the screwing-in action. In other words, the helical ejector does not act like a helical conveyor, but rather like a corkscrew which screws into the annular cake and is intermittently pulled toward the discharge opening to produce bodily movement of the cake in that direction.

If desired, the movement of the ejector to the left may be controlled entirely by the screwing-in action, independently of the cam. This might be accomplished, for example, by designing the cam 34 with a steep slope on both sides of the humps 38, in which case there would actually be a clearance between one of the cams and the rollers during the screwing-in action, and the spring 39 would be so designed as to be insufficiently strong to move the ejector to the left to take up this clearance (and yet sufficiently strong to take up this clearance at the beginning of operation when there is no cake in the basket). I prefer, however, to design the cam 34 in the manner first indicated so as to insure that the ejector will move to the left at a speed which is no greater than that produced by the screwing-in action, in which case the spring 39 can also be made sufficiently strong to insure that there will be no helical conveying action tending to produce bodily movement of the cake to the right during screwing-in action.

From the foregoing description of the operation of my apparatus, it will be understood that the helical ejector screws into the material a short distance to the left without exerting any helical

conveying action thereon, and is intermittently pushed to the right by the cam action a distance equal to the travel of the ejector during the screwing-in action. Therefore, considering the 1 inch travel of the ejector as postulated, it will be seen that the action of the ejector is to shift all of the material in the basket toward the discharge end, ejecting a cake of material in the form of a hollow cylinder 1 inch in length. Based on the assumptions previously made as to relative speeds of the basket and ejector, the action described occurs 50 times per minute and ejects 50 inches of material per minute. As each increment is discharged, it is thrown centrifugally to the discharge ring 8 from which it is removed by the scraper 31 which directs the material into the discharge opening 6. The liquid fractions are drawn off through the discharge ports 5, along with such wash water or impregnating liquid as may be introduced through the pipes 85 and 87.

It will be understood that the basket and ejector could be designed for counterclockwise rotation instead of clockwise rotation, in which case the helical ejector element 65 would be in the form of a right-hand screw instead of a left-hand screw as shown. Also, it would be possible to have the ejector rotate at a higher speed than the basket, remembering that the direction and pitch of the thread of the helical ejector must be such as to create the proper screwing-in action, as determined by the direction and magnitude of the speed differential.

Figs. 11–13 illustrate another embodiment of the invention as applied to a vertical separator. The casing 91 of this separator is provided at its lower end with brackets 92 disposed at convenient points around its periphery. The entire unit is supported from pedestals 93 by means of self-centering supports 94 which, as shown, consist of rods engaging rubber blocks 95 associated with the pedestals 93 and with the brackets 92. The bottom 96 of the casing 91 is provided with an opening to receive a bearing support 97 which, together with the housing 98 secured thereto, supports the shafts of the rotating elements of the machine and forms a housing for the gears and cams to be described. The shafts for said rotating elements are carried by bearings 99, 99 and 100. I find it convenient to employ tapered roller bearings at 99, 99 and a ball bearing at 100. The quill shaft 101 of the basket 102 is carried directly in the bearings 99, 99. The quill shaft 103 which drives the helical ejector 104 is rotatably and slidably carried within the quill shaft 101. The main shaft 105 is keyed to the quill shaft 103 at 106, and drives the quill shaft 103 through this key, while permitting the quill shaft to slide with respect thereto under the influence of the cam action and screwing-in action to be described.

The construction of the basket 102 and helical ejector 104 is substantially the same as has been described in connection with the embodiment illustrated in Figs. 1–11, so it is considered unnecessary to describe this construction in detail. The basket has a perforate surface formed by a series of parallel bars clamped together in the manner previously described. It is mounted on the spokes 107 attached to a hub 108 secured to the quill shaft 101. At its top it is provided with a plate or shield 109 which corresponds in its general function to the plate 58 of the horizontal separator previously described.

The material which is to be processed is introduced through the pipe 110 from which it is directed against a rotating guide plate 111 secured to the main shaft 105. The periphery of the guide plate 111 preferably is flanged upwardly as at 112 to guide the entering material toward the top of the helical ejector 104.

The main shaft is driven from any suitable source of power and for this purpose I have shown a motor 113 mounted on a bracket 114 bolted to the bottom 96 of the casing. This motor is connected by suitable belting to a pulley 115 secured to the main shaft 105. Also secured to the main shaft is a gear 116 which meshes with pinions 117, 117 keyed to shafts 118, 118, to the other ends of which are secured pinions 119, 119. The shafts 118, 118 are conveniently carried in the housing member 97, 98. The pinions 119 mesh with a gear 120 keyed to the quill shaft 101. The gear ratio between the gears and pinions 116, 117 is slightly different than the gear ratio between the pinions 119 and gear 120 so that the quill shaft 101 is driven from the main shaft 105 at a somewhat different speed than shaft 105. The construction which I have shown is designed to produce a higher speed of rotation of the basket than of the ejector, the basket and ejector being driven respectively at the speeds of the quill shaft 101 and main shaft 105. For example, the basket may be geared for rotation at 1000 R. P. M. and the ejector at 950 R. P. M.

In this embodiment of the invention the relative bodily movement between the basket and ejector is controlled by the cams 121 and 122, in cooperation with rollers 123 carried by a collar 124 rotatably mounted on the quill shaft 103. The construction and operation of these cams and rollers may be the same as has been described with reference to the cams 34 and 35 and rollers 36 of the horizontal machine. The cam 121 is keyed to the gear shaft 101 and the cam 122 is keyed to the quill shaft 103 so as to produce relative longitudinal movement between these two quill shafts. Since the ejector 104 is mounted on the quill shaft 103, and the basket on the quill shaft 101, these cams provide for intermittent longitudinal movement of the ejector with respect to the basket. As in the embodiment previously described, the movement of the ejector toward the discharge end of the basket (i. e., the lower end of this embodiment) is relatively rapid, whereas the return movement of the ejector is synchronized with the screwing-in action so as not to produce relative movement of the cake and basket during the return travel of the ejector. In other words, the ejector does not act as a spiral conveyor but merely screws into the material in the basket and pulls it downwardly at intervals by bodily longitudinal movement. A coil spring 125 is arranged within the main shaft 105 so as to bear at one end against the end of the hollow portion of the shaft and at the other end against the key 106 to urge the quill shaft 103 and therefore the ejector 104 upwardly toward its starting position, and to take up all clearance between the cams 121, 122 and rollers 123. This makes it possible to so design the cams as to positively control the speed of return of the ejector so as to synchronize it with the screwing-in action and avoid any tendency of the ejector to act as a helical conveyor. The shafts 118 may be three in number as shown in Fig. 13, each carrying a pair of gears 117, 119.

Mounted for rotation with the helical ejector

104 are two series of pipes 126 for distributing liquid to the cake in the basket 102. These pipes conveniently are attached to the hub 127 of the ejector, which hub in turn is secured to the shaft 103. Apertures 128 and 129, formed respectively in the shafts 103 and 105, provide communication between the interior of the pipes 126 and the interior of the shaft 105. Apertures 129 are elongated in order to provide for relative movement between the shafts 103 and 105 without closing off communication between the pipe 126 and interior of the shaft 105. Suitable liquids for flushing or impregnating the cake may be introduced in a manner similar to that which has been described in the embodiment of Figs. 1–11 inclusive. For this purpose, I have provided a series of dams 130 at spaced intervals along the interior of the shaft 105 in order to divide it into separate compartments. Concentric feed pipes 131 and 132 communicate respectively with the chambers 133 and 134 thus formed, so that liquids can be introduced while the machine is in operation. Liquid from the upper set of pipes 126, together with a liquid fraction separated from the material being treated, passes through the basket 102 as indicated by the arrows *c* into the chamber 135 formed between the casing 91 and a cylindrical wall 136 which is concentric therewith and is spaced therefrom. The wall 136 may be provided with a flange 137 at its upper end to assist in separating the liquid fractions. Liquid discharged from the lower set of pipes 126, together with a liquid fraction extracted from the material, passes through the basket 102 in the direction indicated by the arrows *d* into the chamber 138 formed between the cylindrical wall 136 and a second cylindrical wall 139 spaced therefrom and concentric therewith. The wall 139 may be provided with a flange 140 at its upper end to assist in guiding the discharged liquid fraction into the chamber 138. The liquid fractions are discharged from the chambers 135 and 138 through ports 141 and 142 respectively (Fig. 12). These ports may be provided with flanges, as shown, for connection to suitable pipe lines leading to vats or storage tanks as may be desired. If the basket 102 is rotating at 1000 R. P. M. and the ejector 104 at 950 R. P. M. this means that there will be a speed differential of 50 R. P. M. between the cake, which is moving at the same speed as the basket, and the pipes 126, which are moving at the same speed as the ejector. This differential of 50 R. P. M. gives a satisfactory speed for laying the liquids upon the cake. The arrangement shown is subject to modification in accordance with the nature of the separation to be effected and the liquids to be discharged from the pipes 126.

To assist the ejector 104 in the proper discharge of the solid fraction, the ends of the spokes 107 adjoining the cylindrical walls of the basket 102 are connected by a conical flange 143 which directs the solids, under the action of centrifugal force, against a discharge ring 144 which may be mounted in any convenient manner and arranged for rotation at a speed which is relatively low with respect to that of the basket 102. For this purpose I have provided the ring 144 with a supporting flange 145 to the under side of which is secured a ring gear 146 meshing with a series of pinions 147 carried on studs secured to the wall 139. One of the pinions 147 is keyed to a drive shaft 148 to which is secured a worm gear 149 driven from a worm 150 secured to the shaft of the motor 113. The discharge ring 144 may be supported and driven in any other manner which may be desired. For example, it would be possible to support the ring on friction wheels or discs instead of on the pinions 147. The solids discharged from the basket cling to the walls of the discharge ring 144 under the action of centrifugal force until they are removed therefrom by the action of a scraper 151 secured to the bottom 96 of the casing 91 adjacent the discharge outlet 152. The scraper 151 may be secured in place by means of a bracket 153 or it may be welded directly to the bottom of the casing. In the event that the material discharged from the basket is of such a character as to stick to the ring 144, auxiliary means may be provided for scraping the bottom 96 of the casing, such as radial planes or spokes extending inwardly from the ring.

It will be understood that the principle of operation of the vertical embodiment illustrated in Figs. 11, 12, and 13 is the same as has been described with reference to the horizontal type. With the speeds as previously assumed, the cams 121 and 122 are pushed apart approximately 50 times per minute. As in the case of the horizontal type, the direction of rotation of the basket and ejector may be either clockwise or counterclockwise (looking into the machine from the discharge end). If clockwise, the helical element of the ejector will be in the form of a left-hand screw; if counterclockwise, a right-hand screw. Also, the ejector may be geared to run faster, instead of slower, than the basket, always remembering that the pitch and direction of the screw should be so related to the magnitude and direction of the speed differential, and design of the cams, as to produce a screwing-in action which avoids any substantial displacement of the cake with respect to the basket except during the intermittent bodily longitudinal movement of the ejector. Other modifications will suggest themselves to those skilled in the art. The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention of excluding such equivalents of the invention set forth, or of portions thereof, as fall within the purview of the claims.

I claim:

1. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material without substantial displacement of the material and intermittently moving said element longitudinally of the chamber to advance the material bodily toward the discharge end of the chamber.

2. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material at a controlled rate of longitudinal movement such that for each revolution of the element relative to the chamber said element moves a longitudinal dis-

tance substantially equal to the pitch of the helix, and intermittently moving said element longitudinally of the chamber to advance the material toward the discharge end of the chamber.

3. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material and intermittently moving said element bodily longitudinally of the chamber to advance the material toward the discharge end of the chamber, and controlling the rate of longitudinal travel of the element during both the screwing and bodily movements.

4. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material and intermittently moving said element bodily longitudinally of the chamber to advance the material toward the discharge end of the chamber, and controlling the rate of longitudinal travel of the element during both the screwing and bodily movements so that said rate will be substantially greater during the bodily movement than during the screwing movement.

5. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material and intermittently moving said element bodily longitudinally of the chamber to advance the material toward the discharge end of the chamber, and controlling the rate of longitudinal travel of the element during both the screwing and bodily movements so that said rate will be synchronized with the pitch of the helix during the screwing movement.

6. The method of separating the liquid and solid fractions of a material which comprises feeding the material continuously into a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, rotating the chamber to drive out liquid fractions by centrifugal force, and periodically ejecting a portion of the solid fraction by screwing a helical element into the material and intermittently moving said element bodily longitudinally of the chamber to advance the material toward the discharge end of the chamber, and controlling the rate of longitudinal travel of the element during both the screwing and bodily movements so that said rate will be synchronized with the pitch of the helix during the screwing movement and will be much more rapid during the bodily movement.

7. Apparatus for separating the liquid and solid fractions of a material which comprises a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, means for feeding the material continuously into the chamber, a substantially cylindrical helical element disposed within the chamber and extending longitudinally thereof, said element comprising a helical portion extending at least for one turn about the longitudinal axis thereof, means for rotating the chamber to drive out liquid fractions by centrifugal force, and means for screwing the helical element into the material in the chamber without substantial displacement of the material and for intermittently moving the helical element longitudinally of the chamber to advance the material bodily toward the discharge end of the chamber.

8. Apparatus for separating the liquid and solid fractions of a material which comprises a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, means for feeding the material continuously into the chamber, a substantially cylindrical helical element disposed within the chamber and extending longitudinally thereof, said element comprising a helical portion extending at least for one turn about the longitudinal axis thereof, means for rotating the chamber to drive out liquid fractions by centrifugal force, means for screwing the helical element into the material in the chamber, means for controlling the rate of longitudinal movement of the helical element so that for each revolution of the element it moves a longitudinal distance substantially equal to the pitch of the helix of said element, and means for intermittently moving said element bodily longitudinally of the chamber to advance the material toward the discharge end of the chamber.

9. Apparatus for separating the liquid and solid fractions of a material which comprises a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, means for feeding the material continuously into the chamber, a substantially cylindrical helical element disposed within the chamber and extending longitudinally thereof, said element comprising a helical portion extending at least for one turn about the longitudinal axis thereof, means for rotating the chamber to drive out liquid fractions by centrifugal force, means for screwing the helical element into the material in the chamber in one direction, and means for moving said element bodily in the opposite direction.

10. Apparatus for separating the liquid and solid fractions of a material which comprises a substantially cylindrical chamber having perforated side walls and an end open for the discharge of material, means for feeding the material continuously into the chamber, a substantially cylindrical helical element disposed within the chamber and extending longitudinally thereof, said element comprising a helical portion extending at least for one turn about the longitudinal axis thereof, means for rotating the chamber to drive out liquid fractions by centrifugal force, means for rotating the helical element at a speed which is different than the speed of the chamber, means for reciprocating said element longitudinally of the chamber, and means for controlling the rate of reciprocation to avoid substantial displacement of the material when reciprocating in one direction and to produce substantial displacement of the material when reciprocating in the opposite direction.

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