

[54] CENTRIFUGE AND METHOD

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UNITED STATES PATENTS

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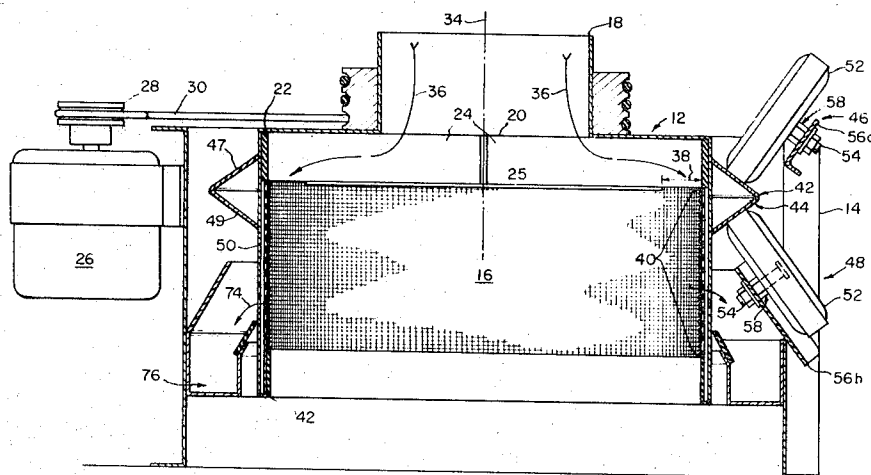
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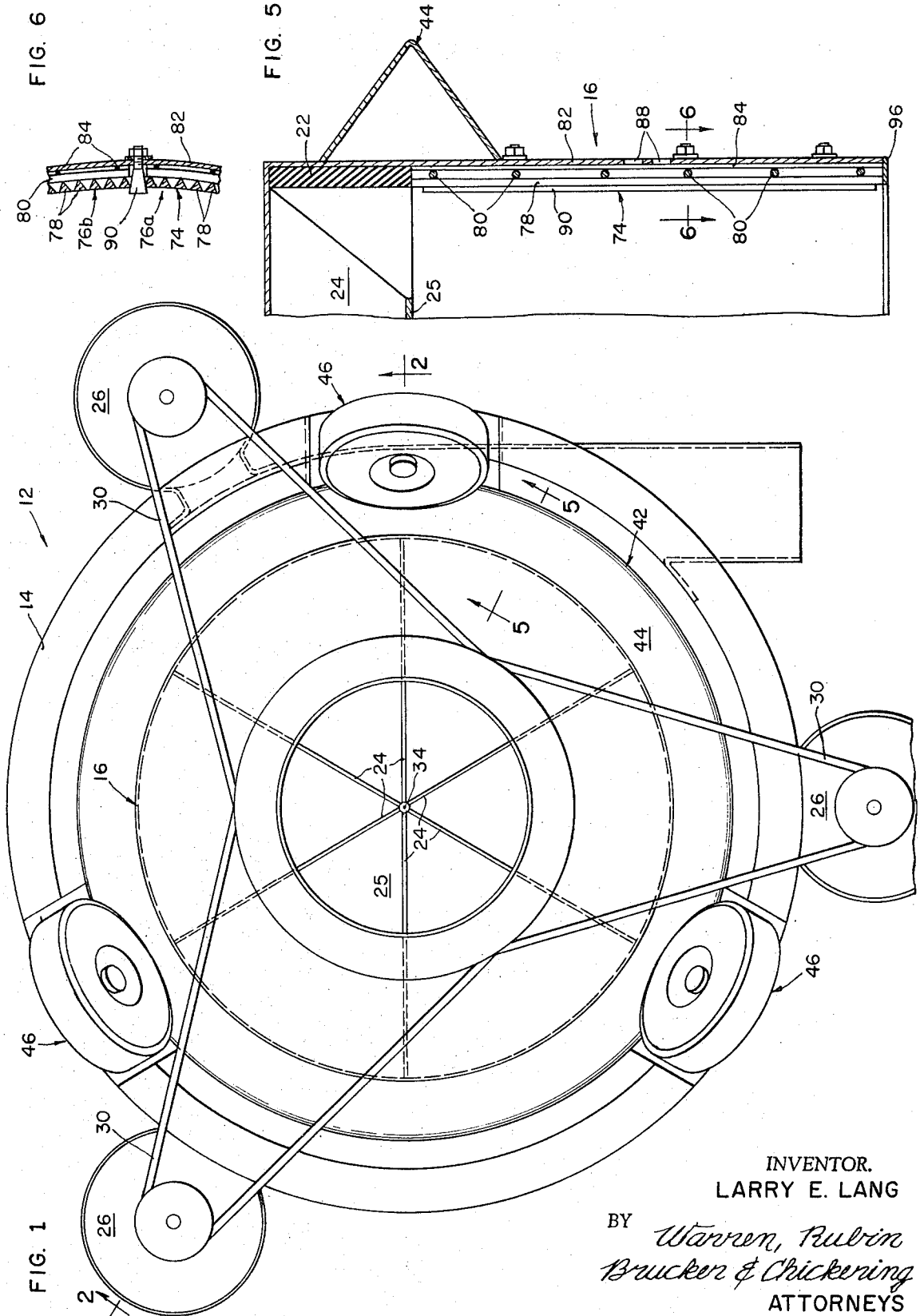
[57] ABSTRACT

In a centrifuge having a basket rotatably mounted in a fixed frame for the separation of the liquid fraction from a mixture thereof with a particulate material, the improvement of providing such basket with a cam as-

sembly including a flange extending radially outwardly therefrom and rollers secured to the fixed frame for rolling contact with the flange, such rollers and flange controlling the position of the basket in respect to the frame as the basket is rotated about its central longitudinal axis, the flange surface circumjacent to the basket being inclined so that as the basket and mixture contents therein rotate through a portion of each revolution, the basket is advanced axially in the direction of its discharge end, and thereafter, through an alternate portion of each revolution of rotation due to an abrupt change formed in the inclination of the flange, the basket and its contents are abruptly axially displaced in the opposite direction, so that the liquid-particulate material mixture within the basket is displaced relative to the wall thereof in the direction of the discharge end for eventual discharge therefrom in relatively liquid-free condition after passage through the centrifuge; and the method of transporting a liquid-particulate material mixture through a centrifuge embracing the steps of gradual axial advancement in one direction of a centrifuge basket so that the material clinging to the walls thereof is displaced in respect to such walls and repositioned thereon thereby advancing the mixture with the basket toward the discharge end thereof.

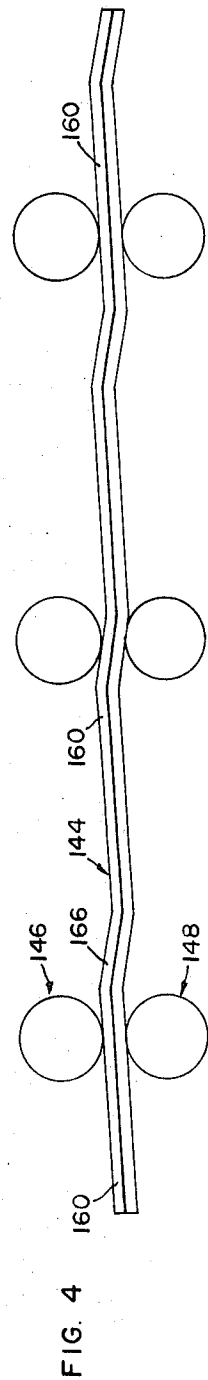
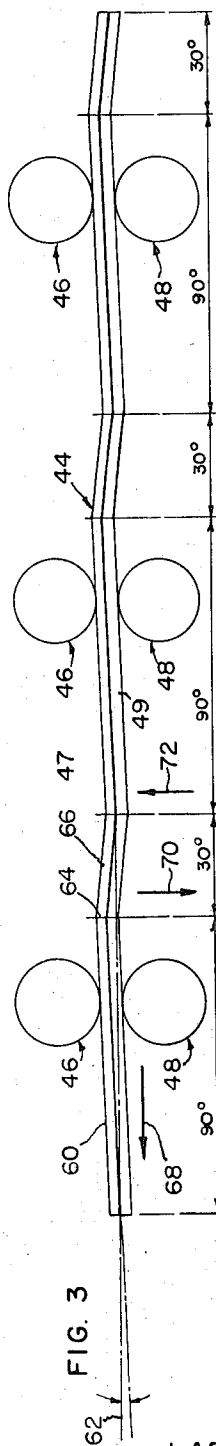
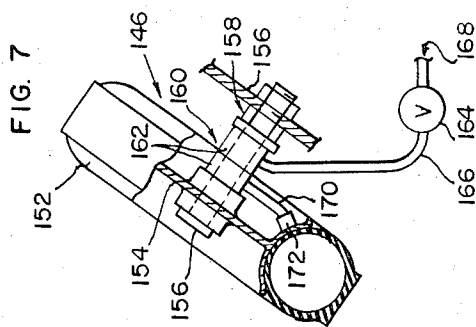
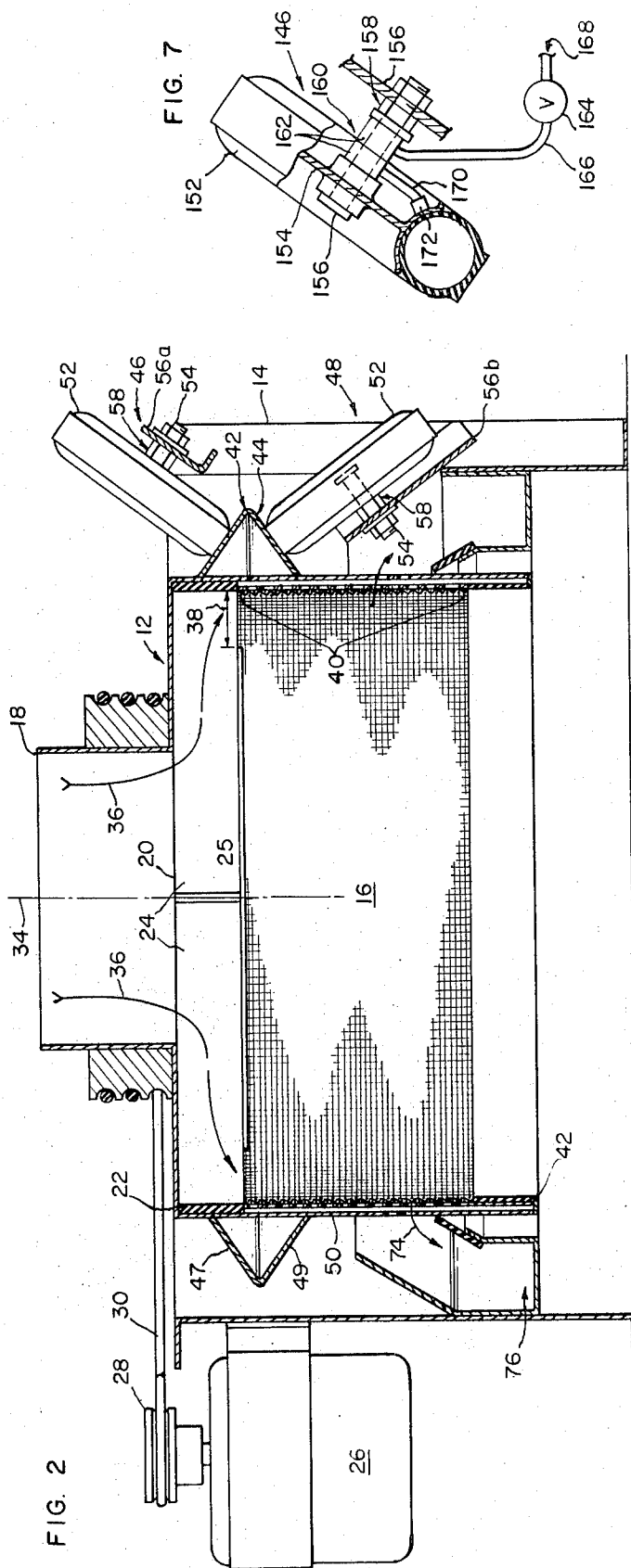
10 Claims, 7 Drawing Figures





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CENTRIFUGE AND METHOD

This invention relates to improvements in centrifugal separators generally employed to separate the liquid fraction of mixtures of such liquid with particulate material, common examples of the latter being water with sand, gravel, coal, and other mineral substances, although it is to be understood that my invention may be applied to separation of any liquid, be it water or other liquid carrier, from a mixture of the latter with a particulate material capable of being restrained by a screen or other mechanical barrier which is permeable to the liquid carrier and relatively impermeable to the particulate matter.

Centrifugal separation by means of a centrifuge is well established. In general, such devices employ a rotatably mounted chamber having liquid-permeable walls and feed means to deliver a mixture of liquid and particulate material into one end of the chamber. The chamber, often referred to as a "basket" because of the construction of its outermost element, is rotated at a suitable angular velocity which causes the liquid fraction of the mixture to be centrifugally driven through the liquid-permeable walls leaving within the basket a relatively liquid-free particulate material to be recovered for further use.

One of the prime problems encountered in such centrifugal separation is that of achieving continuous passage through the centrifuge basket of a mixture from which liquid is being centrifugally separated. This is so because the mixture under centrifugal treatment is carried within the centrifuge basket in rotation about the latter's central longitudinal axis, whereby the liquid fraction is driven through the permeable walls of the basket; but the particulate material therein, subject to the centrifugal action imposed on the entire system, is thrown radially outwardly and thus tends to cling to the inside of the basket walls. In this way, a relatively stationary stable "cake" of particulate material forms and remains within the basket in contradiction to the desired result of having the material discharged at one end thereof.

To overcome the aforementioned problem, a number of solutions have been proposed as exemplified in the prior art with which I am familiar. Generally, these involve some form of vibratory action which tends to loosen the cake from the inside wall surface of the basket, and the utilization of a cone-shaped basket having the large diameter at the discharge end. The combined action of vibration, which loosens the particles, and centrifugal action, which tends to throw the particles radially outwardly, results in a constant displacement of particulate material to sections of larger diameters longitudinally along the wall of the conical basket, thereby causing the particulate material to advance through the centrifuge basket to its discharge end as the mixture of liquid and particulate material are being centrifugally separated. Examples of this type of centrifuge are disclosed in the U.S. Pats. to W. G. J. Heckman, et al., No. 3,338,417, issued Aug. 29, 1967; and G. Linke, et al., No. 2,861,691, issued Nov. 25, 1958; as well as in numerous technical publications.

The aforescribed expedient for enhancing advancement of material through a centrifuge has several disadvantages which the industry has long sought to overcome. For example, the conical, or frusto-conical, basket assembly must generally be arranged so that ro-

tation occurs about a horizontal axis; because, if the cone is aligned vertically, the material being de-liquified could advance too rapidly through the cone for proper liquid separation. While some vertical conical basket assemblies are available, these generally require relatively complex inner cone assemblies or extremely high operating speeds, or both; all of which may be relatively costly or be prohibited altogether for certain types of liquid-particulate material mixture separations.

In addition, where horizontal conical baskets are employed, an inner acceleration cone is normally required to deliver the material to be de-liquified to the wall of the separator basket. Such inner cone, generally, accelerates the mixture so that the liquid fraction is first driven to the cake surface which thereafter is positioned away from the basket wall when actual separation treatment occurs—see for example FIG. 1 of the Linke et al U.S. Pat.—so that most of the liquid must be driven through the entire cake being treated, thus substantially reducing the overall system efficiency.

Moreover, the slope of a conical basket, be it horizontal or vertical, tends generally to be critical as a function of the material being separated; and vibration amplitude in relation to cone slope speed of rotation is subject to critical selection in this type of design. Also, as the material being treated progresses to the larger cone section diameters, as it moves to discharge, the cake is spread thinner within the conical basket, and the loss of fine particles is increased.

In the case of horizontal conical separators, the material being treated is subject to differential centrifugal forces, that at the top of the cone being subjected to the negative effect of the earth's gravitational force, while that at the bottom of the cone is subjected to the additional force of the earth's pull. Consequently, the de-liquifying effect is always partially nullified by the change in separation force magnitude. Moreover, since the input of mixture to be separated is by gravity drop, the feeder system, usually a pipe or conduit, must change direction of the material flow by about 90°, thus causing abnormal wear especially where abrasive particulate material is to be separated.

Still further disadvantages of conical centrifuge baskets include the difficulty and attendant relatively high cost of fabricating a conically shaped centrifuge basket, which term as used herein includes the entire basket assembly comprising an inner screen to restrain passage of the particulate material while allowing passage of liquid; an outer basket to reinforce and hold the inner screen; and spacer elements between the screen and basket necessary to maintain clearance at the interface of the former so that liquid may freely communicate from the mixture being separated to and through the outer basket. A conically shaped basket also imposes limitations on the size of centrifuge basket as a practical matter due to the relative precision required in the fabrication of the composite conical basket assembly, and the relative difficulty in achieving and maintaining the necessary dynamic balance of such a device when utilized as a centrifuge element. Moreover, the vibrational forces imposed on the entire conical rotating basket is tough on supporting bearings and other mechanical components.

Prior art attempts with which I am familiar to utilize a cylindrical basket and overcome at least some of the foregoing problems have been hampered by the basic

problem sought to be solved by the conical basket design, i.e., that of advancing the cake within the basket to eventual discharge after de-liquifying. Some attempts have been made to provide a cylindrical basket with a device sometimes referred to as a "plough," a helically shaped blade-like element, mounted within the basket and usually rotated in respect thereto at an angular velocity slightly different, generally lower, from that of the basket. In this manner the material being treated is advanced to discharge after a term within the basket. However, such ploughs require safe clearance from the walls of the basket which then become clogged with residual material; and in any event, the entire plough assembly greatly complicates the centrifuge assembly and adds seriously to initial costs and long-range maintenance.

Thus, it is an object of the present invention to provide an improvement in centrifuges for the transporting and advancing therethrough of a mixture of liquid and particulate material while such mixture is subject to centrifugal action and separation of the liquid and particulate fractions.

More particularly, it is an object of my invention to provide an improvement in centrifuges wherein the centrifuge basket may be of constant, uniform diameter, such as a cylinder, and mountable about a vertical axis without the need of relatively complex and costly auxiliary components.

A feature and advantage of my invention is eliminating the need for generally conically, or frusto-conically, shaped centrifuge baskets, so that a centrifuge employing the improvement of my invention may be fabricated more easily, less expensively, and be placed and maintained in operation more easily, while at the same time avoiding the many inherent disadvantages of conical basket construction discussed more fully hereinabove, or cylindrical baskets requiring internal ploughs.

A further advantage of my invention is that by eliminating the need for generally conically shaped centrifuge baskets, baskets of much larger size physically may be employed than have heretofore been practicable by way of the prior art.

Another object of my invention is to provide a method for the separation of liquid from a mixture of liquid and particulate material within a centrifuge basket wherein the steps of such method involve predetermined displacement of such mixture, alternately, of a gradual and then abrupt character, in a direction axial to the centrifuge basket, so as to cause advancement of the mixture along a zone defined by the centrifuge basket.

Numerous other objects, features, and advantages of my invention will be apparent to one of ordinary skill in the art upon a reading of the following specification in conjunction with the accompanying drawings wherein the same reference character refers to the same or corresponding elements in each of the several figures.

Turning first to the drawings, FIG. 1 is a plan view of a centrifuge employing the improvement of my invention;

FIG. 2 is a cross-sectional elevation thereof taken along line 2—2 of FIG. 1;

FIG. 3 is a schematic development of a portion of my invention shown in FIG. 2;

FIG. 4 is a schematic development of a portion of an alternate embodiment of my invention, similar to that portion shown in the plane development of FIG. 3;

FIG. 5 is a fragmentary cross-sectional view taken along line 5—5 of FIG. 1;

FIG. 6 is a fragmentary cross-sectional view taken along line 6—6 in FIG. 5; and

FIG. 7 is a sectional view of a portion of the apparatus of my invention showing an optional device in accordance therewith.

The present invention is best understood by turning first to FIGS. 1 and 2 wherein I show a centrifuge 12 including a fixed outer frame housing 14 to which basket assembly 16 is rotatably mounted in a manner explained in greater detail below. Input conduit 18 communicates directly into input end 20 of basket assembly 16 for the delivery therethrough of a liquid-particulate material mixture from which the liquid fraction is to be removed, such mixture being flung against upper basket wall section 22 by the deflective action of acceleration vanes 24 with which the mixture comes into contact when delivered through conduit 20 and blocked from central axial advancement through the basket assembly by acceleration plate 25. The entire basket assembly, including the acceleration vanes and plate, are rotated during operation of the particular embodiment shown by means of motors 26 drivably connected to the basket assembly by driver pulleys 28, power transmission belts 30, and driven pulley hub 32, the latter being secured to the basket assembly and located concentric to input conduit 18 and the basket assembly longitudinal axis 34.

The path of a mixture introduced into the centrifuge up to contact with wall section 22 is indicated by arrow 36 in FIG. 2.

It is to be noted that acceleration vanes 24 are formed to define a diagonal profile at the outer end thereof which, at their inboard edge, coterminate with the outer periphery of acceleration plate 25, thus forming an annular opening or annulus 38 proximate that portion of the basket assembly defined by liquid-permeable wall section 40. Thus, a mixture delivered to the centrifuge for separation of the liquid fraction therefrom during rotational movement of the entire basket assembly initially travels the path indicated by arrow 36; and then, for the most part, remains poised at annular opening 38, the mixture generally clinging to upper wall section 22 due to the force exerted by the mixture against the wall as a result of the acceleration induced therein by vanes 24 rotating at the centrifuge's operating angular velocity W.

It is essential, of course, to commence and maintain movement of the liquid-particulate mixture through annulus 38, and thereafter through basket assembly 16 along liquid-permeable wall section 40 in a direction parallel to the longitudinal axis of the basket assembly in a direction toward discharge end 42, to achieve continuous delivery of a relatively liquid-free mixture from the input end of the basket assembly to discharge end 42. During such delivery the liquid fraction is centrifugally driven from the mixture through the liquid-permeable wall section 40, due to the influence of the centrifugal action induced by the rotational movement of the basket assembly, as the mixture passes therealong.

Such movement of the mixture through annulus 38 and along wall section 40 is accomplished according to the present invention by means of cam assembly 42.

More particularly, cam assembly 42 comprises cam flange 44, upper roller assembly 46, and lower roller assembly 48, assemblies 46 and 48 being secured to fixed outer frame housing 14. Cam flange 44, in the embodiment shown, is fabricated to provide flange surfaces 46 and 48 that extend radially outwardly from basket assembly 16, flange 44 being welded or otherwise suitably secured to perforated reinforcing shield 50 which, like the cam flange, may be made of steel or other suitable material. In addition to the particular roller assemblies shown in the cross-sectional view of FIG. 2, two additional such assemblies are provided in the embodiment shown at 120° intervals, as can be seen by reference to the plan view of FIG. 1. Each roller assembly includes a wheel 52 rotatably journaled to pin 54 and secured thereto by conventional means such as a lock ring or the like (not shown), the pin being fixed to brackets 56a and 56b by means of conventional nut and lock washer assemblies 58, the aforesaid brackets being connected to fixed outer frame housing 14.

To appreciate an essential feature of my invention, that is the action by which a cake of material is transported through rotating basket 16 from the input end thereof to the discharge end, particular attention is directed again to flange surfaces 47 and 49 which are shown in a horizontal projection in FIG. 3. More specifically, FIG. 3 is a side elevation of the entire cam flange 14 in its circumjacent relationship about the girth of basket assembly 16. First section 60 of the cam flange is fabricated to be inclined at an angle of 1½° with respect to a plane transverse to the longitudinal axis of the basket assembly, the line of such plane being represented by line 62 in FIG. 3. Inclined portion 60 extends circumjacent to the basket for a circumferential distance equivalent to 90° of arc along the periphery of the basket. Immediately adjacent to flange section 60, commencing at intersection line 64, a second flange section 66 is provided and fabricated to be abruptly inclined in a direction opposite to that of section 60, the incline of section 66 being at an angle of 1¾° in respect to line 62. Flange section 66 extends along a circumferential arc distance of 30 degrees circumjacent to basket assembly 16. The foregoing described first and second flange sections are repeated circumjacent to the entire circumference of the basket assembly in the manner indicated in FIG. 3. As can be appreciated by observing the equidistant positioning of each of the pairs of roller assemblies 46, 48, the entire basket assembly is supported by lower roller assemblies 48 whose wheels 52 are in rolling contact with flange surface 49. Moreover, since the angular spacing between roller sets is 120°, and corresponding portions of the several flange sections are also 120 degrees apart, each pair of rollers engage similar flange portions. Thus, when drive motors 26 are energized and the entire basket assembly rotated about longitudinal axis 34 so that cam flange 44 is driven in the direction of arrow 68 with respect to relatively fixed upper and lower roller assemblies 46, 48, then, as each of flange sections 60 pass between the upper and lower roller assemblies, the entire basket assembly is gradually displaced axially in the direction indicated by arrow 70; and thereafter, during the subsequent portion of each revolution of rotation of the basket, as flange portions 66 each simultaneously pass be-

tween the several roller assemblies 46, 48, the entire basket assembly is abruptly displaced axially in the direction of arrow 72 away from the discharge end of the basket. Thus, when a liquid-particulate mixture is being centrifugally treated within the apparatus, whereby such mixture clings to the internal walls of basket assembly 16, entire cake travels axially with the basket during the aforescribed gradual displacement in the direction toward the discharge end of the basket.

Then, during the abrupt displacement portion caused by engagement of roller assemblies 46, 48, with flange portion 66, the cake, due to its own inertia and tendency to slip along the wall surface is sufficiently jarred, moves relative to wall section 40 in a direction opposite to the basket displacement, i.e., toward the discharge end thereof. In this way, upon repeated rotations of the basket assembly, the liquid and particulate mixture being centrifugally treated within the basket is caused to advance consistently along the walls thereof, from the time of introduction at annular opening 38 at the input end of the basket, to discharge end 42. At the same time, the liquid fraction being separated by centrifugal force from the cake passes through liquid permeable wall section 40 in the direction of arrow 74, thereafter to be collected in trough 76 for subsequent recycling or discard.

It is by means of the foregoing-described structure that my invention achieves numerous benefits heretofore unattained in accordance with the prior art device with which I am familiar. For example, I am able to achieve continuous transportation of a mixture of liquid and particulate material through the basket of a centrifuge wherein the structure therefor may take the form of a uniform cylindrical basket, rather than the commonly used cone-shaped arrangement whose inherent disadvantages have been discussed in greater detail hereinabove. Moreover, since the foregoing structure in accordance with my invention utilizes roller assemblies spaced about the periphery of the basket in contact with a radially extending flange secured to the basket to provide support thereof, the conventional central axial support with journal and bearings which tend to suffer severely under repeated vibrational forces, may be eliminated.

Moreover, my invention has the advantage of being able to utilize a cylindrical form for the basket assembly so that it is more practical to provide basket assemblies which may have diameters up to many feet, since the fabrication problems in providing a cylindrical form are substantially less than that of a conical form, particularly where a composite basket assembly is involved.

In addition, in the embodiment described above, a centrifuge embracing my invention may be vertically aligned further simplifying fabrication, eliminating the need for axial journal and bearing supports, and inherent unbalance which occurs in the case of horizontally disposed centrifuges. In addition, by being able to introduce the material to be separated by means of radially deflecting accelerator veins 24, rather than by the inner cone distribution exemplified by the Linke, et al., patent, my invention not only has the advantage of avoiding forcing liquid to the "wrong" side of the cake at the place of introduction to the separator, but may utilize a gravity feed intake which does not require a conduit having an abrasion-prone 90° change of direc-

tion for achieving feed to the input end of the separator basket.

As indicated hereinabove, the present invention may be adapted to various liquid-particulate material mixtures in accordance with certain operating parameters. For example, I have obtained satisfactory results for the separation of water from a mixture of 25 percent water and sand weighing 125 lbs. per cubic foot used with the following basic physical operating parameters:

Inside diameter of centrifuge basket	9 1/4 inches
R.P.M. of basket	225 rpm
Angle of inclination of first portion of flange	1 1/2°
Angle of inclination of second portion of flange	1 3/4°

The foregoing specific data applies, of course, to a particular inner wall basket surface and frictional characteristics thereof. The detailed construction of the entire basket assembly, including such inner wall surface, is shown in somewhat greater detail at FIGS. 5 and 6. With reference to these figures, basket assembly 16 comprises inner screen 74 fabricated in segments 76a, 76b, etc., each segment including spaced screen bars 78 welded or otherwise suitably secured to circumferential screen support rods 80 whose arc length defines the width of each of the screen segments. The segments in turn are held in spaced relationship to the perforated outer reinforcing plate 82 by means of longitudinally spaced rods 84 so as to define an effluent passage 86 whereby liquid, centrifugally flung from the material within the basket during rotation thereof, may pass between the screen bars and thence to the effluent passage for eventual discharge through perforations 88 in reinforcing shell 82 to effluent trough 76. Screen segment 76a, 76b, etc., are secured in position by means of screen expanding wedges 90 which are bolted to reinforcing shell 82, such wedges being of a continuous longitudinal construction with securing bolts 92 threadably connected to studs 94 located at necessary intervals therealong. The basket assembly is completed with circumferential liner 22 fabricated of a material such as rubber or the like suitably secured to the reinforcing shell and abutting the screen assemblies at the input end of the basket; and circumferential screenkeeper ring 96 at the discharge end thereof.

It will be appreciated that for any particular type of liquid-particulate material mixture, the amplitude of basket displacement at a given basket rotation speed may be relatively critical in order to achieve efficient separation and transportation through the centrifuge, just as with conically shaped baskets cone angle and amplitude of vibration is generally critical. It is a particular feature of the present invention that such basket displacement may be varied, even while basket rotation is in progress, so that a range of liquid-material mixtures may be efficiently separated and even adjusted therefor during actual operation.

The foregoing feature is achieved in a manner best understood by FIG. 7 wherein I show an alternative version of mounting one of the roller assemblies similar in most respects to that illustrated in FIG. 2. In the arrangement shown in FIG. 7, roller assembly 146 comprises pneumatically inflatable tire 152 mounted on a conventional rim and wheel 154 which in turn is rotatably journaled to pin 156, the latter being fixedly secured to the bracket 158 by means of lock bolt assembly 160. In addition, I provide a conventional rotating air lock assembly 160 having stationary ring 162 pneu-

matically interlocked to rotatable ring portion 162 which in turn is fixedly secured to the hub of wheel 154. A supply of air from an outside source (not shown) is entered through conventional valve 164 and tubing 166 in the direction of arrow 168 through fluid communicating passages within stationary portion 162, and thence to rotating portion 162 through valve feeder line 170 to conventional tire valving 172. The amount of air pressure in any of the roller tires equipped with the foregoing pneumatic assembly may be varied, hence making adjustments in the amount of air pressure in such tire and consequently the amount of displacement which will be imposed upon the basket during rotation. Thus, a determinative parameter of my invention may be controlled and varied even during operation to suit conditions of a particular separation phenomenon, an adjustment generally not even available in the prior art devices with which I am familiar.

Another alternative embodiment of my invention is illustrated in the cam flange layout of FIG. 4, which is similar to that shown in FIG. 3 except for those aspects here explained. In this alternative embodiment, I am able to accomplish an additional movement of the basket which in the case of certain materials being separated may be essential or at least desirable to increase the efficiency of separation of the system. The additional movement referred to is that of providing the centrifuge basket with relatively rapid wobbling motion in respect to its central longitudinal axis. This is achieved by providing sets of upper and lower roller assemblies 146, 148, different in total number, or in spacing, or both, from the indicated variations of flange section inclinations. That is, in the example shown in FIG. 4, roller assemblies 146, 148 at the far left of said FIG. 4 are shown engaging cam flange 144 at a zone somewhat near the beginning of the gradual inclination of first flange portion 160; while at the same time the second roller assemblies 146, 148 shown toward the center of said FIG. 4 are shown engaging the end portion of gradually inclined flange section 160; and third roller set 146, 148 shown at the far right of FIG. 4 is seen engaging at the very beginning of another gradually inclined flange portion 160 of cam flange 144. Consequently, as basket rotation occurs in a manner described hereinabove, the first mentioned roller assembly 146, 148, engages a different relative portion of the inclined flange section with which it is in rolling contact than that of either of the other two roller assemblies; hence the entire basket assembly is continually being tipped about longitudinal axis 34 while being rotated so that the entire basket wobbles. Yet, the relative positions of roller assemblies and flange sections are such that the axial movement—first gradual, then abrupt—of the basket is also achieved. However, the additional wobble movement of the basket tends to maintain a loosening of the cake which may be desirable if not essential to maintain continuous transport of a particularly sticky cake therethrough.

Another advantage of my invention is that the basket assembly support, i.e., cam assembly 42, which already has the advantage of being able to replace and eliminate the axle and bearing supports of the prior art, may be used to eliminate still another assembly, that of the drive belts and pulleys shown in FIGS. 1 and 2 and generally also employed in devices of the prior art with which I am familiar. This further improvement may be

accomplished by driving wheel 52 of one or more of lower roller assemblies 48. This is relatively easily accomplished by modifying the mounting arrangement of the wheel desired to be driven so that such wheel is mounted on what is commonly referred to by those skilled in the art as a "live" axle, that is one which is axially fixed to the wheel hub by means of a key and keyway, or some other suitable expedient; the live axle journally mounted to its support bracket; and a drive motor such as motor 26 coupled directly to one end of the aforementioned live axle by known expedients including any gearing as necessary to achieve the desired basket angular velocity. Such drive arrangement, in addition to minimizing and simplifying the mechanical aspects of the centrifuge, makes possible the application of my invention to units having large basket diameters, say 10 to 20 feet and longer, which generally cannot be driven by conventional pulley and transmission belt drives.

My invention may also be summarized as a method for achieving transportation of a liquid-particulate material mixture through a centrifuge basket assembly from one end thereof to the opposite or discharge end while being subjected to centrifugal separation therein by rotation of the centrifuge basket about its central longitudinal axis, said method comprising the steps of (1) displacing said basket gradually in the direction of the discharge end of the basket during a portion of a revolution of rotation of the basket, the rate of such displacement being selected so that the mixture within said basket being centrifugally treated remains relatively motionless with respect to the wall of said basket; (2) during an immediately subsequent portion of the revolution of rotation of said basket, abruptly displacing the basket in a direction opposite to said discharge end of the basket, the rate of such abrupt displacement being at least great enough to cause the mixture within said basket to slip or move along the wall in a direction so as to advance toward the discharge end of the basket; and (3) repeat steps (1) and (2) through subsequent rotations of said centrifuge basket so that as the liquid fraction of liquid-particulate mixture therein is centrifugally separated, the entire cake of material clinging to the inner wall of the centrifuge basket by virtue of the centrifugal force imposed upon it is continuously advanced and transported through the basket from one end thereof to the discharge end.

In addition to the foregoing process steps, and as an alternative embodiment of the method of my invention, a step may also be added of relatively rapidly wobbling the centrifuge basket about its central longitudinal axis, so as to enhance separation of the cake from the sides of the wall during the step of abruptly displacing the rotating centrifuge basket in the direction away from the discharge end thereof.

While the foregoing summary of the method of my invention is based upon the disclosure in respect to the specific embodiments set forth in the specification hereinabove, it is to be appreciated that the foregoing method could be practiced using apparatus of a modified character compared to the aforementioned specifications. For example, the method of my invention basically embraces the mode and rate of positioning of a centrifuge basket being rotated about its central longitudinal axis. This could be accomplished by reciprocally displacing a central shaft to which the basket is rotatably mounted but affixed thereto in the longitudi-

nal direction. While the cam flange assembly which comprises the fundamental mechanical innovation of the embodiment of the foregoing specification is preferred for the reasons discussed in greater detail hereinabove, other variations such as the assembly, including a reciprocating basket shaft, could be utilized.

I claim:

1. In a centrifuge of the type characterized by a stationary frame, a basket proximate to said frame having an input end, a discharge end opposite thereto, and liquid-permeable walls for the passage therethrough of liquid from a mixture of liquid and particulate material, feed means for delivering quantities of a mixture into said basket at the input end thereof, and power means interconnected to said basket for rotating the latter about its central longitudinal axis to cause the liquid of a liquid and particulate material within said basket to be centrifugally driven through the walls of said basket while the mixture retained within said basket clings to the walls thereof, the improvement for facilitating movement of a mixture within said basket from the input end thereof to the discharge end for discharge from said basket of relatively liquid-free particulate material, comprising:

cam means connected to said basket for gradually displacing the latter axially in a direction toward the discharge end of said basket during a portion of each revolution of rotation of said basket, and at a rate of displacement such that a liquid and particulate material mixture within said basket clinging to the walls thereof remains relatively motionless with respect to the walls and is displaced axially in the same direction as said basket, and, at an alternate portion of each revolution, abruptly displacing said basket axially in the direction away from the discharge end thereof at a rate such that a liquid and particulate material mixture within said basket is caused to be displaced relative to the wall of said basket in the direction toward said discharge end of said basket, causing a liquid and particulate mixture being centrifugally treated within said basket to advance consistently along the walls thereof from the input end to the discharge end of said basket for discharge of the mixture therefrom.

2. A centrifuge and the improvement therefor as defined in claim 1 and wherein further said cam means comprises:

a flange mounted on said basket and extending radially outwardly therefrom circumjacent to the entire girth of said basket, formed to define at least a first section circumjacent to said basket inclined at a relatively gradual helix angle with respect to a plane transverse to the longitudinal axis of said basket, and a second section of said flange inclined at a relatively steep angle with respect to a plane transverse to the longitudinal axis of said basket and in the opposite direction to the incline of said first section;

a pair of rollers; and

means mounting said rollers on said stationary base with the peripheral surfaces of said rollers in rolling contact with the surface of said flange, each of said rollers being positioned to contact opposite sides of the same portion of said flange.

3. A centrifuge in accordance with claim 2 wherein at least one of said rollers comprises an axle, a wheel rim and hub rotatably mounted on said axle, a tire

11

mounted on said wheel rim to form the peripheral surface of said roller, said tire being of the pneumatically inflatable type, and valve means secured to said tire and in fluid communication therewith to communicate varying amounts of air for selective inflation of said tire; and

means mounted on said axle in fluid communication with said valve means and an external source of air under pressure to selectively vary the amount of air communicated therethrough to said tire.

4. The centrifuge in accordance with claim 2 wherein said basket is of a generally cylindrical shape, and said flange is shaped to form alternate first and second sections, each of said first sections embracing an arc distance about said basket of 90° and inclined at a helix angle of 1½°, and each of said second sections adjacent to said first sections embracing an arc distance about said basket of 30° and inclined at a helix angle of 1¼°.

5. The centrifuge is accordance with claim 2 and additional pairs of said rollers and means for mounting same as set forth in said claim 2, each of said pairs of rollers being spaced apart from an adjacent one thereof by an arc distance of 120° in respect to the central longitudinal axis of said basket.

6. The centrifuge in accordance with claim 4 and additional pairs of said rollers and means for mounting same as set forth in claim 2, each of said pairs of rollers being spaced apart from an adjacent one thereof by an arc distance of 120° in respect to the central longitudinal axis of said basket.

7. The centrifuge in accordance with claim 4 and three additional pairs of said rollers and means for mounting same as set forth in claim 2, each of said pairs of rollers being spaced apart from an adjacent one thereof by an arc distance of 90° in respect to the central longitudinal axis of said basket.

12

8. The centrifuge in accordance with claim 2 wherein said basket is positioned with the central longitudinal axis thereof substantially vertical and said basket is of a generally cylindrical shape, and additional pairs of said rollers and means for mounting same as set forth in said claim 2, each of said pairs of rollers being spaced apart from an adjacent one thereof by an arc distance of 120° in respect to the central longitudinal axis of said basket.

9. The method of transporting a liquid-particulate mixture through the basket of a centrifuge, said mixture being subjected to centrifugal separation of the liquid fraction therefrom by relatively rapid rotation of said basket about its central longitudinal axis wherein the mixture, due to centrifugal action, tends to cling to the inside wall of said basket to form a relatively stationary cake, said method comprising the steps of:

1. gradually advancing said basket and the mixture therein in the axial direction in respect to the basket that the mixture is to be transported, the rate of such advancement being gradual enough so that the material tends to remain motionless with respect to the inside wall surface of the basket; and

2. abruptly displacing said basket in the axial direction opposite to that of the gradual displacement of said step 1, the rate of such abrupt displacement being rapid enough so that the material being treated within said basket slips with respect to the inside wall surface of the basket and moves relative thereto in the direction of the gradual advancement of said step 1.

10. The method in accordance with claim 9 and further the step of wobbling said basket about its central longitudinal axis during said steps 1. and 2.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,799,343 Dated March 26, 1974

Inventor(s) LARRY E. LANG

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 30, "in" is changed to --is--.

Column 2, line 40, "ususally" is corrected to --usually--.

Column 2, line 45, "attendent" is corrected to --attendant--.

Column 4, line 49, change "opening 88," to --opening 38,--.

Column 5, line 31, "14" is changed to --44--.

Column 6, line 13, correct "is" to --if--.

Column 6, line 29, "device" is changed to --devices--.

Column 11, line 20, "is" is changed to --in--.

Signed and sealed this 8th day of October 1974.

(SEAL)

Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents