Feb. 22, 1949. J. HERTRICH 2,462,098

CONTINUOUS CENTRIFUGAL MACHINE

Filed Jan. 7, 1944 3 Sheets-Sheet 1

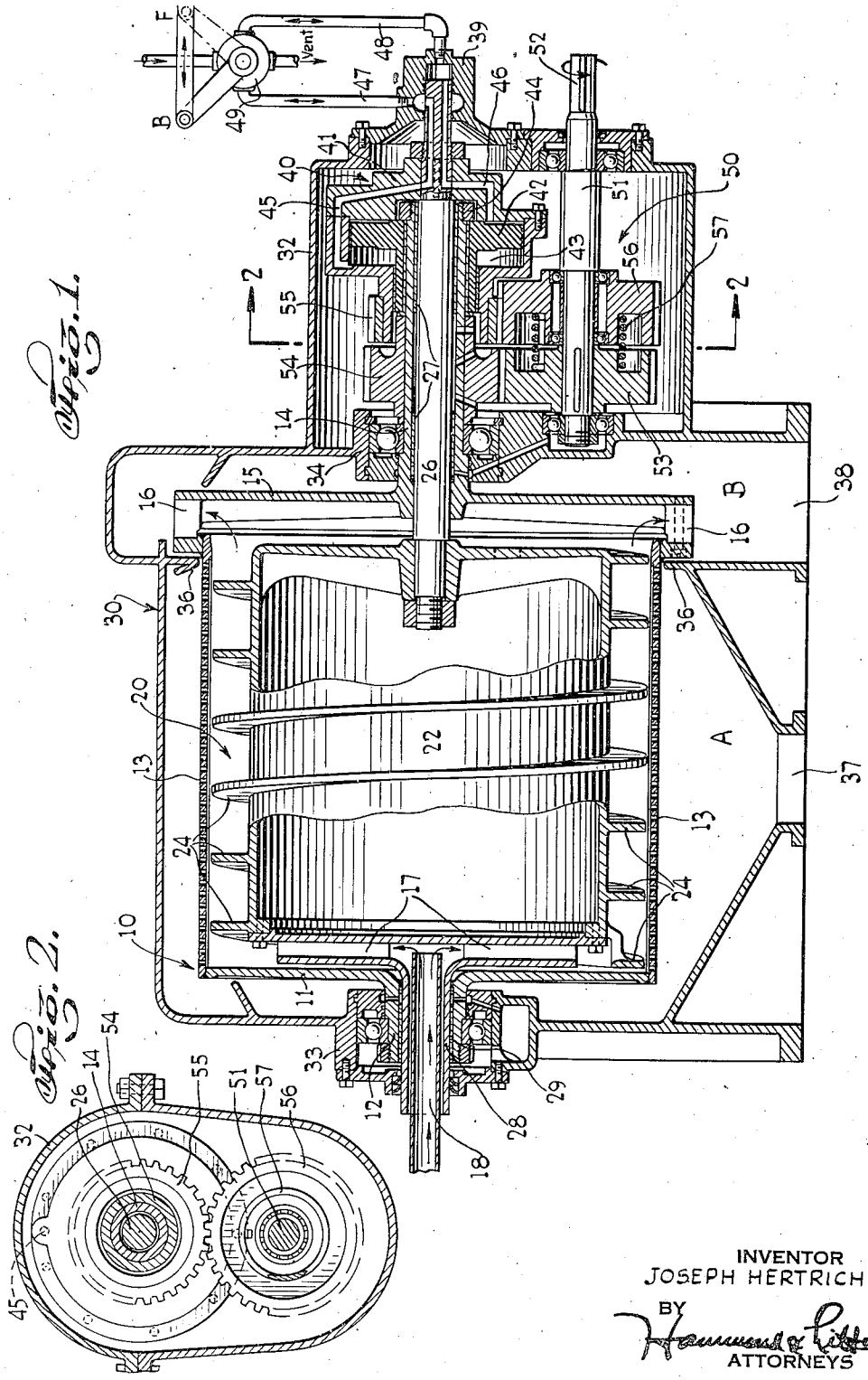


Fig. 1.

Fig. 2.

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CONTINUOUS CENTRIFUGAL MACHINE

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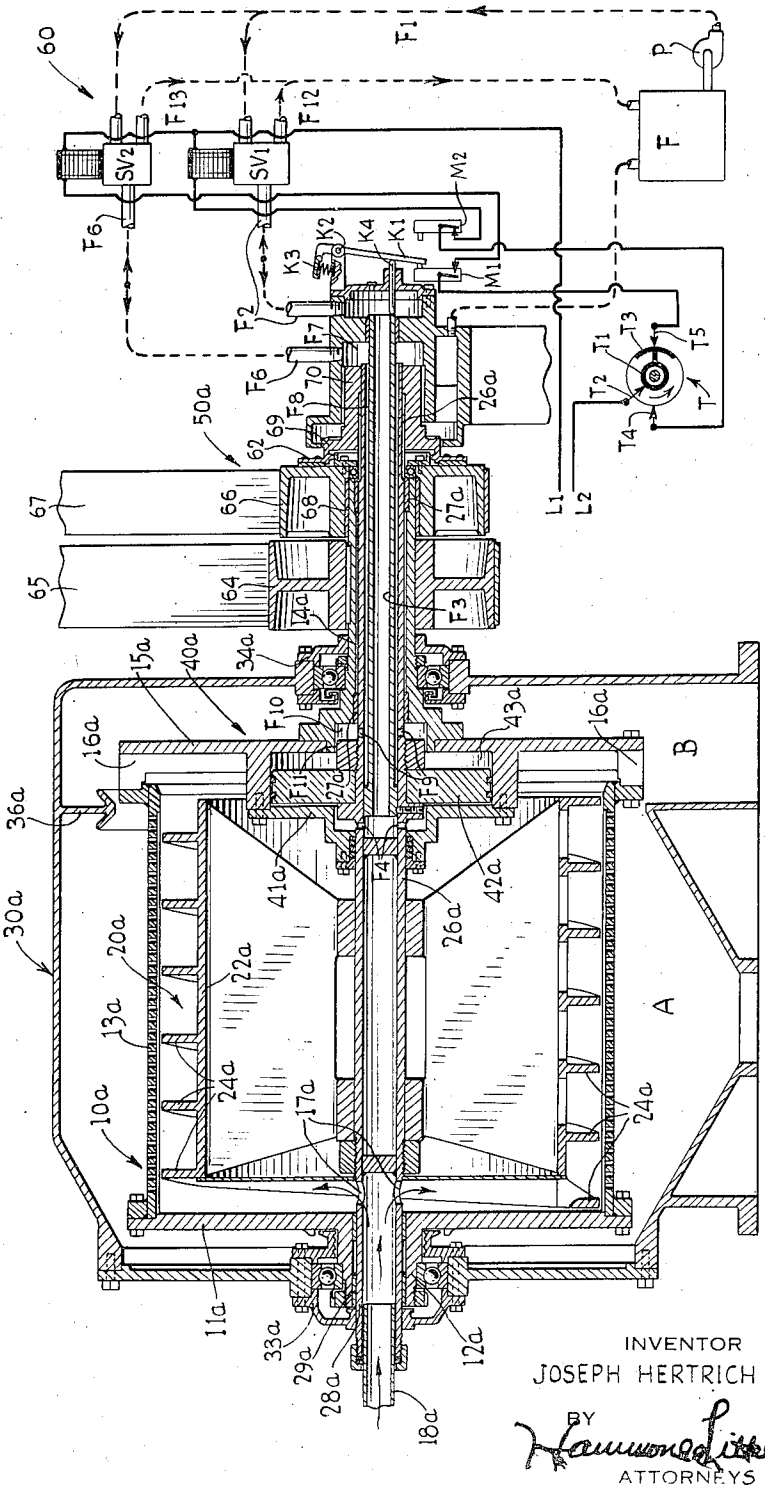


Fig. 3.

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CONTINUOUS CENTRIFUGAL MACHINE

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Fig. 5.

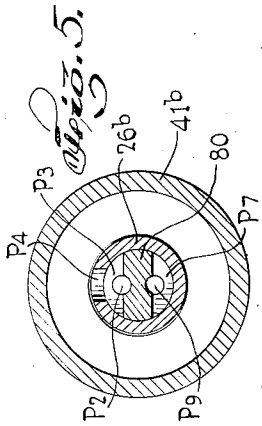


Fig. 6.

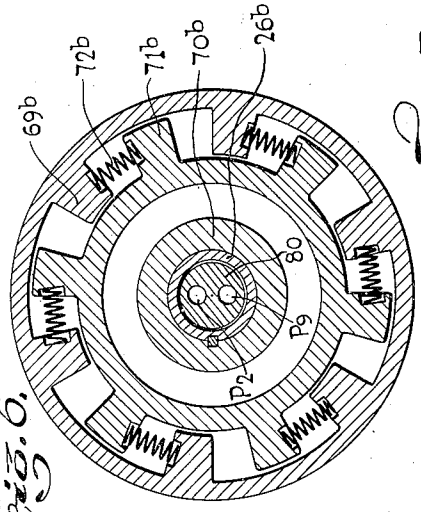


Fig. 7.

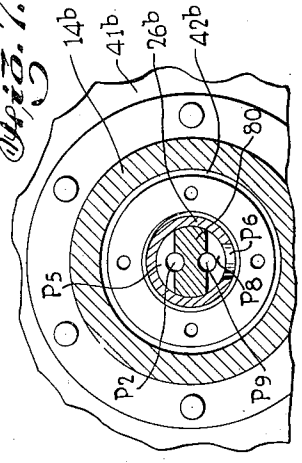
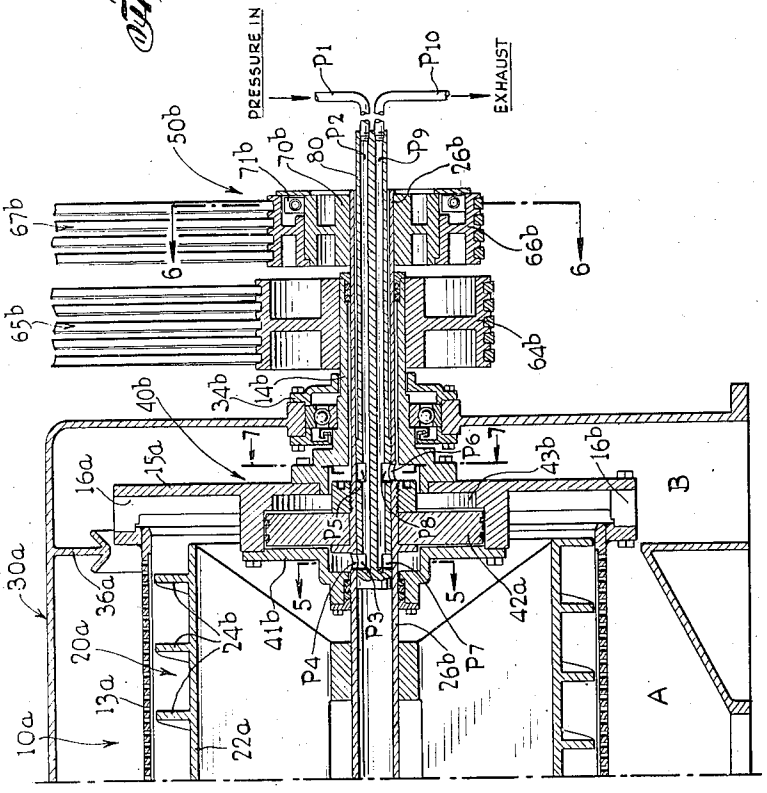


Fig. 4.



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UNITED STATES PATENT OFFICE

2,462,098

CONTINUOUS CENTRIFUGAL MACHINE

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Application January 7, 1944, Serial No. 517,309

17 Claims. (Cl. 210—69)

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This invention relates to new and useful improvements in continuous centrifugal machines.

In a continuous centrifugal machine the centrifugal basket is kept rotating continuously and is charged continually with the material to be treated while treated material leaves the basket continually at a suitable point of discharge. One known type of such machines comprises a horizontal feed screw inside a horizontal cylindrical basket, together with means for rotating the basket and the screw continuously at different speeds. The resulting differential rotation between the basket and the screw advances material through the basket to the discharge point.

In another type a reciprocating plunger is used to push the charge along a cylindrical basket wall, and after each plunger stroke the gap between the plunger and the charge is filled with fresh material. Such machines have only a limited utility because the charge tends to be crushed and to bulge and pile up next to the plunger.

Machines of the type first mentioned have been used for the treatment of various chemicals and suspensions, but where the solids to be treated are comparatively heavy and easily crushed, or are quite hard to move, or require high centrifugal forces for effective treatment, as is the case with sugar and many other crystalline or granular materials, there appears to have been little or no successful use of continuous centrifugal machines. Many inventors have failed in efforts to make continuous centrifugals suitable for such work, mainly because of the resistance of the charge against being moved bodily through the centrifugal basket. Even when treating materials much less difficult to treat than sugar, this resistance sometimes imposes a wearing load as high as several hundred horsepower on the rotary driving means for the machine, necessitating a very heavy and costly machine construction. The known continuous centrifugals also are severely limited in the speeds at which they may be operated safely and in the efficiency with which they perform the work they can do.

An object of this invention is to provide a continuous centrifugal machine capable of more efficient operation and of producing better results than known continuous centrifugal machines.

Another object is to provide a continuous centrifugal machine which can be used for the processing of crystalline or granular materials that cannot be treated satisfactorily in known continuous centrifugal machines.

Further objects of this invention are to provide new and improved systems for feeding charge

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materials through continuously operated centrifugal machines, and to provide such systems which utilize a feed screw inside a cylindrical centrifugal basket and yet avoid excessive torques or wearing loads on the driving means for the feed screw.

The continuous centrifugal machines of my invention are characterized by a novel compound periodic motion of a rotary feed screw, in relation to a coaxial continuously rotating centrifugal basket, that advances material step by step along the basket wall from a charging point near the back end of the screw to a discharge point near the forward end of the screw and does so without either imposing excessive torque loads on the machine or tending unduly to crush or pile up the charge. This compound motion comprises periodic axial reciprocations and synchronous periodic rotations of the rotating basket and screw in relation one to the other.

By the forward stroke of each reciprocation the screw shifts the charge bodily one step toward the discharge point, and during this stroke the screw is allowed or caused to rotate at substantially the same rate as the basket. It therefore acts like a plunger, except that its convolutions extend helically through the charge material, with each convolution pushing only a fraction of a full charge. After each forward stroke a relative backward motion between the screw and the basket takes place, to complete a reciprocation, and during this backward stroke the basket and screw rotations take place at different rates so that the screw has not only a relative axial motion but also a turning motion with respect to the basket and charge. During this differential rotation the screw or the basket is rotated the faster, according to whether the basket rotates against or with the lead of the screw convolutions. In either case, the differential rotation serves, in effect, partially to unscrew the screw convolutions from material in the basket during the backward axial movement of the screw relative to the basket, so that the backward stroke occurs without being obstructed by the charge and without shifting the charge back to its original position. Also, the screw convolutions are kept in continuous contact with the charge and in readiness to advance the charge another step toward the discharge point whenever the next forward stroke takes place.

My invention thus combines a rotary basket and a coaxial rotary feed screw with means to produce relative reciprocations between them in axial direction and with periodically operative means to produce a relative rotation between the

basket and the screw during the backward strokes of reciprocation. In this way, the work of moving a heavy charge through a continuously rotating centrifugal basket may be performed effectively by the reciprocation means alone, which may be of a simple yet strong contruction and capable of producing an axial thrust far greater than the thrust obtainable in practice from rotary driving means of economical construction. For example, I preferably use a pressure cylinder actuated by fluid or hydraulic pressure, with the cylinder itself or a piston inside the same shiftable axially by the pressure fluid and connected with the shaft of the feed screw to shift the screw axially with respect to the basket. The basket and the screw may be rotated by driving means of any suitable type adapted to produce a periodic differential rotation between the basket and the screw and combined with means for interrupting this differential rotation during each forward movement of the charge, or at other times if desired in the continuous operation of the machine.

A further feature of some embodiments of my invention resides in using the extra resistance against relative rotation of the basket and screw, that exists when feeding the charge along the basket, as the means for periodically interrupting the differential rotation of the basket and screw. This automatically synchronizes the periods of such interruption, i. e., the periods of rotation of the basket and screw at the same speed, with the forward strokes of reciprocation. In such embodiments, for example, the basket and the screw may be driven from a common power source through connections which would keep them rotating at predetermined different speeds when not subject to the extra resistance of feeding the charge, and angularly yieldable means such as a torque spring may be provided to permit a limited angular slippage in one of the drive connections under such extra resistance. This slippage permits the basket and the screw to rotate at the same speed during each forward stroke, and the differential motion of the drive at that time is taken up by the torque spring. During the backward stroke which follows the extra resistance against relative rotation is released, and the spring unlashes to produce a corresponding relative rotation of the basket and screw. This relative rotation, together with that produced in the same period by the differential drive, unscrews the screw in relation to the charge enough to compensate for their relative axial motion during the backward stroke.

According to another embodiment of my invention, a clutch may be provided in the differential driving means under an automatic control synchronized with the relative axial motions of the basket and screw, such that the clutch will be engaged during the backward strokes to produce the desired relative rotation between the screw and the charge and will be inactive during the forward strokes to interrupt the relative rotation.

The frequency and amplitude of the periodic relative motions between the basket and the screw may be selected as desired and to give any desired period of treatment for material in the machine. In some embodiments these frequencies may be so high as to approximate vibratory motions.

Because the rotation of my machine is not limited by the speed at which a feed screw is able, by rotating, to push material through a centrifugal basket, the machines herein disclosed may be operated safely at higher speeds and greater centrifugal forces than known continuous centrifugal machines.

Because of the strong feeding thrust obtainable with my machines, and because the convolutions of the feed screw extend helically through the entire charge in the basket and distribute this thrust uniformly over a large area of the charge, the machines herein disclosed may be used for the treatment of heavy granular or crystalline materials that cannot be treated satisfactorily in known continuous centrifugal machines, as well as for the more efficient treatment of materials that can be so treated.

My machines may be used with various known types of centrifugal basket construction, with or without various known accessories thereto, depending upon the material to be processed and the process operations to be carried out in the machines. The baskets used are generally cylindrical in form and preferably have their axes disposed horizontally, though other arrangements can be used. The feed screw comprises a cylindrical body or shaft inside the basket having a helical flange or vanes defining the screw convolutions, which project radially to a location near the inner face of the cylindrical basket wall or the basket screens. A stationary housing surrounding the basket assembly may be provided with separate compartments for collecting different materials produced in the operation of the machine. The material to be treated may be charged into the basket either continuously or intermittently, such as through an axial port at the charging end. The treated solids fed to the forward end of the screw may be discharged by centrifugal force through suitable outlets in the basket structure.

The foregoing and other objects, features and advantages of my invention will become more apparent from the following detailed description of preferred embodiments thereof and by consideration of the accompanying drawings illustrating such embodiments. The new features of construction and operation which I claim as my invention are set forth more particularly in the appended claims and are not limited to the illustrative forms or instrumentalities of the specification or the drawings except as may be required by a fair interpretation of the terms of the claims.

In the drawings:

Figure 1 is a vertical longitudinal section showing an assembly of one embodiment of my invention;

Figure 2 is a vertical cross-section taken approximately along line 2—2 of Figure 1;

Figure 3 is a vertical longitudinal section showing an assembly of another embodiment, wherein automatic control means for the periodic motions of the feed screw are shown in diagrammatic form;

Figure 4 is a vertical longitudinal section showing a third embodiment of the invention, with parts of the basket, feed screw and housing structures broken away, and

Figures 5, 6 and 7 are vertical cross-sections taken approximately along lines 5—5, 6—6 and 7—7, respectively, of Figure 4.

Referring first to the embodiment of Figures 1 and 2, the centrifugal there shown comprises, in general, a horizontal centrifugal basket 10, a feed screw 20 inside the basket, a stationary housing 30 which encloses the basket and screw

assembly, and reciprocating means 40 and rotary driving means 50 to produce the desired movements of the basket and screw. A casing 32 on housing 30 encloses the motivating means 40 and 50. Bearing boxes 33 and 34 at opposite ends of the housing contain bearings in which back and front hollow basket shafts 12 and 14, respectively, are journalled. Shaft 12 extends from a back wall 11 of the basket. Shaft 14 extends from a front wall 15. A cylindrical perforated wall 13 extends from wall 11 toward wall 15 but terminates short of the latter to provide radial outlets 16 for the discharge of treated solids from the basket in the operation of the machine.

The housing 30 is formed with a circular partition 36 between the perforated area of wall 13 and the discharge outlets 16, which partition divides the housing into a compartment A, to receive liquid spun by centrifugal force from material in the basket, and a compartment B to receive solids discharged from the basket. Outlets 37 and 38, respectively, may be provided for removing liquids and solids from the respective compartments.

The feed screw 20, as shown, comprises a drum 22 having an integral radial flange or vane 24 which extends in helical convolutions from the back to the front of the drum. The periphery of the helix lies near the inner face of perforated wall 13. A shaft 26 projects from the front of drum 22 through hollow basket shaft 14 to a point beyond the latter where the end of 26 is slidably disposed in a boss 39 at the front of casing 32. Bearings 27 between screw shaft 26 and basket shaft 14 allow these parts to have both a relative turning motion and a relative axial motion.

A hollow shaft 28 projects from the back of drum 22 through hollow basket shaft 12, where it rests on a bearing 29 for relative axial and turning motions. Between shaft 28 and drum 22 radial conduits 17 may be provided for the charging of material to be treated into the centrifugal basket, and an axial tube 18 may extend through shaft 28 to deliver the material either continuously or intermittently to the passages in 17.

In this embodiment the basket 10 is rotated continuously in a fixed axial position; the screw 20 is reciprocated axially with respect to the basket; and the screw normally is rotated somewhat faster than the basket but is provided with a torsion spring in its driving connections to allow a certain period of rotation at the same rate as the basket when the screw is moving a heavy charge forward in the basket, i. e., during the forward strokes of reciprocation.

The means for rotating the basket include a shaft 51 having a hub 52 to be driven by any suitable means, a gear 53 fixed to shaft 51 and a gear 54 meshing with gear 53 and fixed to the basket shaft 14.

The means for reciprocating the feed screw include a pressure cylinder 41 fixed to shaft 26 beyond the end of shaft 14 and a piston 42 inside pressure chamber 43 of the cylinder. The piston 42 is fixed against axial movement, being secured to the end portion of basket shaft 14 between the hub of gear 54 and a lock collar 44. The cylinder 41 is movable axially with shaft 26 and the feed screw. A fluid passage 45 in the cylinder opens into chamber 43 on the left-hand side of piston 42, and another fluid passage 46 opens into the pressure chamber on the right-hand side of the piston. These passages communicate, through ducts in shaft 26 and in hub 39, with conduits 47 and 48, respectively, to which fluid under pressure may be admitted alternately by movement of a valve 49. When the valve is moved to the B position pressure enters chamber 43 at the left-hand side of piston 42 and causes cylinder 41 and the feed screw to move axially to the left, producing the backward stroke of the screw. When the valve is moved to the F position, pressure enters the righthand side of chamber 43 and causes the cylinder and feed screw to move to the right, producing the forward stroke of the screw. When either side of the piston is under pressure, the other is vented through the control valve.

It will be evident that the valve 49 may be actuated by any suitable means at regular intervals of predetermined frequency to keep the screw reciprocating during the operation of the machine. The amplitude and frequency of the reciprocations are selected so as to control the time of feeding material from the charging point at 17 to the discharge point at 16, thus determining the period of treatment of material in the basket 10.

The means provided for rotating the feed screw 20 include a ring gear 55 fixed to cylinder 41, which in turn is fixed to the screw shaft 26, together with a meshing gear 56 mounted for free rotation on shaft 51 and a torsion spring 57 connecting gear 56 with gear 53. Extra width of the gear 56 permits gear 55 to slide axially with the screw without falling out of mesh.

A higher gear ratio is provided between gears 56 and 55 driving the feed screw, than between gears 53 and 54 driving the basket. The screw therefore must rotate at an average speed faster than the basket. Under normal operating conditions, however, the torsion spring 57 is not completely wound up and can be wound further if the resistance against relative rotation between the basket and the screw is increased. This increased resistance occurs during the feeding strokes of the screw, when its convolutions press strongly against the charge inside the basket, and at that time gears 53 and 56 turn in relation one to the other, further winding the spring, while the screw, the basket and the charge in the basket may all rotate at the same speed. At the end of each feeding stroke, when the screw is shifted backward again, the increased resistance against relative rotation is released, so that the extra energy stored in the torsion spring also is released and produces an increased rotation of the screw. This together with the normal differential rotation produced by the drive causes the screw to be simultaneously unscrewed and moved axially with respect to the charge during the backward stroke.

This embodiment may be further explained as follows: The average screw rotation is faster than the basket rotation, so that the screw normally would tend to advance the charge by it differential rotation, in the manner of known continuous centrifugals, were it not for the resistance of the charge, the torsion spring and the axial reciprocations. The reciprocations occur at a frequency sufficient to compensate for the faster average rotation of the screw, and the torsion spring provides a sort of lost motion connection in the screw drive which periodically interrupts the faster rotation, i. e., which allows the forward strokes to take place without relative rotation between the basket and the screw and causes the backward

strokes to take place with an actual screw rotation faster than the average.

For example, if the machine should be designed to drive the basket at 1000 R. P. M. and to drive the screw at an average speed of 1010 R. P. M., there would be 10 extra rotations of the screw per minute, and if the pitch of the screw convolutions were 6" the charge would be advanced along the basket at the rate of 6×10=60" per minute, or 1" per second. To produce this axial travel of the charge with a 1" axial stroke of the screw, at least 60 reciprocations would be used per minute, and perhaps a larger number to provide a safety factor. Assuming 60 reciprocations per minute and a heavily loaded basket, during each forward stroke the screw would rotate with the basket and charge, at 1000 R. P. M., for ½ second, and the spring would be wound up a fraction of a turn equal to the ratio of gear 55 to gear 56 times 10/120, or slightly less than one-twelfth of a turn. During each backward stroke, when the strong resistance of the charge against relative rotation of the screw is released, the spring would unlash to unscrew the screw from the charge by about $\frac{1}{12}$ of a turn, and the faster screw drive would produce a further extra screw rotation equal to about $\frac{1}{12}$ of a turn. Thus there would be a differential screw rotation of about ⅙ of a turn acting on a 6" pitch in ½ second to compensate for the 1" axial movement during the backward stroke and prevent backward movement of the charge; and the actual rotation of the screw during the backward stroke would be at the rate of approximately 1020 R. P. M.

The second embodiment of Figure 3 gives the same manner of continuous centrifugal operation as the embodiment of Figures 1 and 2, using equivalent basic combinations together with other new features now to be described. The reciprocations and periodic rotations of the feed screw relative to the basket are regulated and synchronized through the operation of automatic control means indicated diagrammatically at 60. These control means act upon a clutch 62 automatically to interrupt the differential rotation of the screw during its charge-feeding strokes.

The basket, screw and housing assembly is similar to that of Figure 1. Basket 10*a* has end walls 11*a* and 15*a*, a cylindrical perforated wall 13*a* and radial discharge outlets 16*a*. Its hollow shafts 12*a* and 14*a* run on bearings in bearing boxes 33*a* and 34*a*, respectively, of housing 30*a*. A partition 36*a* divides the housing into compartments A and B for liquids and solids separated in the basket. The screw 20*a* comprises a drum 22*a* inside the basket having helical flanges or convolutions 24*a* which project radially to a location near the inner face of the cylindrical basket wall, or near screens lying against the wall. Screw shaft 28*a* runs on bearings 29*a* inside of basket shaft 12*a*. The forward screw shaft 26*a* runs on bearings 27*a* inside of basket shaft 14*a*. An axial feed tube 18*a* delivers material to be processed to radial charging ports 17*a*.

A pressure cylinder is again used for reciprocating the screw, the cylinder 41*a* in this case being integral with the front end wall 15*a* of the basket, while the piston 42*a* is fixed to the screw shaft 26*a* and moves axially in pressure chamber 43*a* to reciprocate the screw. A suitable fluid, such as oil, may be admitted under pressure to the left-hand side of the piston from line F2 through a sleeve F3 located inside the screw shaft 26*a*, which is hollow, and through ports F4. This moves the piston and the feed screw to the right, producing the forward or feeding stroke. The pressure fluid is admitted to the right-hand side of the piston from line F6 through a chamber F7, a passage F8 between shaft 26*a* and sleeve F3, ports F9, chamber F10 and a restricted clearance or passage F11 leading into chamber 43*a*. The restriction of passage F11 enables a quick application of full pressure in chambers F7 and F10 without too rapid a leftward movement of piston 42*a*.

The driving means 50*a*, for rotating the basket and the screw, include belt pulleys 64 and 66 driven by belts 65 and 67, respectively, from a common driving shaft (not shown), together with the friction clutch 62. Pulley 64 is fixed to the basket shaft 14*a*. Pulley 66 turns freely on a bearing 68 surrounding the same shaft. Clutch 62 works against the end face of pulley 66 and has a spider 69 integral with a hub 70 that is fitted for axial movement in the structure defining chamber F7. Hub 70 is fixed to the forward end portion of screw shaft 26*a*, so that when clutch 62 is engaged with pulley 66 a connection is completed for driving the feed screw. Pulley 66 is smaller than pulley 64, so that the screw is driven through this connection at a speed greater than the speed of the basket.

An oil tank F connected with a pump P supplies oil under pressure to engage the clutch 62 and to reciprocate the piston and feed screw. The oil feed line F1 leads from the pump to two three-way solenoid valves SV1 and SV2 which, when energized, deliver oil into the lines F2 and F6, respectively. When deenergized each valve releases the pressure in its respective line F2 or F6, allowing excess oil on the left-hand or the right-hand side of piston 42*a*, as the case may be, to be discharged back to tank F through the respective vent line F12 or F13.

From the foregoing, it will be evident that when SV1 is energized and SV2 is deenergized the feed screw will be moved straight to the right without being driven at a speed faster than the basket, since there will be no pressure in chamber F7 to engage clutch 62. The screw therefore will rotate with the charge during each feeding stroke. On the other hand, when SV2 is energized and SV1 is deenergized pressure will be released from the left-hand side of piston 42*a* and pressure will be applied in chambers F7 and F10. The pressure in F7 pushes clutch 62 against pulley 66 so as to drive the screw faster than the basket, the screw convolutions then tending, were it not for what follows, to be moved farther against the charge in the basket. At the same time, however, the pressure in F10 bleeds through F11 to the right-hand side of piston 42*a* and shifts the screw axially to the left, on its backward stroke. By the compound motions the screw assumes a new position at the rear of the basket, without correspondingly moving the charge, and becomes ready to move the charge another step forward when SV2 is deenergized and SV1 is energized again.

To avoid undue stresses on the centrifugal, the friction clutch and the driving belts, it is important that SV1 and SV2 never be energized at the same time and that the valve which is energized during each stroke be deenergized immediately upon the completion of that stroke. It is also advantageous to regulate the number of reciprocations per minute in order to regulate the rate of travel of the charge material through the machine. These functions may be obtained with various types of automatic control means,

one suitable system being shown schematically at 60a in Figure 3.

A continuously rotating timer T is provided, having a collector ring T1 in contact with a brush T2 connected with one side L2 of an electrical power line. A collector segment T3 of the timer is connected with ring T1 and arranged to make alternating contacts with brushes T4 and T5. Two micro switches M1 and M2 are connected respectively with the brushes T4 and T5. These micro switches are arranged to be operated by a lever K1, which is pivoted at K2, biased by a spring K3 toward a position where it opens the contact of switch M1, and adapted to be moved by a plunger K4 to a position where it opens the contact of switch M2. The plunger K4 contacts the end of sleeve F3 and therefore moves back and forth in axial direction with screw shaft 26a and the feed screw, producing a corresponding swinging motion of lever K1.

The solenoid valves SV1 and SV2 have direct connections with power line L1 and are connected with line L2 through timer T and the contacts of micro switches M2 and M1, respectively. The timer preferably is driven by a variable speed motor, so that its speed and the frequency of screw reciprocations may be selected as desired.

The control system operates as follows: Piston 42a and the feed screw are in their left-hand position, as seen in Figure 3; switch M1 has been opened by lever K1; segment T3 contacts brush T5; both valves are deenergized; there is no oil pressure on either side of the piston; and the timer is revolving counterclockwise. Segment T3 then leaves brush T5 and shortly afterwards contacts brush T4. Power flows from L2 through brush T4 and switch M2 to valve SV1, which opens and admits pressure to line F2 and the left-hand side of piston 42a. The piston, the feed screw and plunger K4 then move to the right until lever K1 opens switch M2 at which time valve SV1 is deenergized and the plunger stays momentarily in its right-hand position. Meanwhile, the timer continues to rotate and segment T3 again contacts brush T5, and when this occurs valve SV2 is energized through switch M1 and pressure is applied to line F6 and chambers F7 and F10. The friction clutch 62 is thus engaged; the feed screw turns relatively to the basket; and the piston and screw are shifted axially to the left, until lever K1 again opens switch M1. At this time valve SV2 is again deenergized, so that the pressure in line F6 is released and clutch 62 becomes inactive for lack of operating pressure.

These described actions take place continuously, and the number of reciprocations of the feed screw per minute is controlled by the number of revolutions per minute of the timer.

Assuming the basket to be 36" long and the pitch of the screw to be 6", six complete turns of the screw relative to the basket are needed to convey charge material the full length of the basket. Assuming further that the material should be subjected to centrifugal force for a period of 60 seconds, the average speed of the screw would need to be 6 R. P. M. greater than the speed of the basket. If the axial motion of the screw is 1½", twenty-four reciprocations per minute are needed to secure the desired period of treatment for the material.

The length of the screw stroke can be reduced and the frequency of reciprocation increased, as may be desired, until a practical limit is reached, which would be a vibrating motion. For example, if the basket were rotated at 1400 R. P. M. and the screw reciprocated once per basket revolution, there would be 1400 reciprocations per minute. The length of the stroke required for a basket 36" long would then be about .027". With 1400 reciprocations per minute and six extra screw revolutions per minute, the screw would make 6/1400 = .0043 extra revolutions per minute, and the angular travel of the screw in relation to the basket during the backward stroke of each reciprocation would be about 1.55°.

A high frequency motion of this nature may be obtained according to a third embodiment of my invention, as illustrated in Figures 4 to 7, inclusive, where many of the parts correspond substantially to parts of Figure 3 and are numbered correspondingly. The variations from Figure 3 will be apparent from the drawings and the following.

Piston 42a is fixed to the screw shaft 26b and has a limited axial travel in cylinder 41b, which is integral with the front basket wall 15a. A fluid feed shaft 80 extends into the hollow screw shaft 26b and has two axial passages P2 and P9. Liquid or air under pressure is supplied to passage P2 through line P1. Feed slots P3 and P5 in the feed shaft 80 open into passage P2 and register alternately, during rotation of the screw 20a, with respective inlets P4 and P6 which lead into the pressure chamber 42b on the left-hand and right-hand sides, respectively, of piston 42a. The feed shaft has similar exhaust slots P7 and P8 communicating with axial passage P9 and disposed opposite to slots P3 and P5, respectively, so as to register alternately with the inlets P4 and P6. Passage P9 connects with an exhaust line P10.

The feed shaft being held stationary during rotation of the machine, fluid pressure from P1 is applied alternately to the left-hand side and then to the right-hand side of piston 42a through the openings P4 and P6, and whenever pressure is being admitted to one side of the piston through one of these openings the other opening is connected through one of the exhaust slots P7 or P8 with the exhaust line P10. In the position shown, pressure is applied at P4 and P6 is connected through P8 to the exhaust. When the screw has made another half revolution, pressure will be applied, through P5 and P6, to the right-hand side of the piston, and P4 will be connected through P7 to the exhaust. Consequently, each revolution of the screw is accompanied by a complete axial reciprocation, so that the frequency of reciprocations is equal to the R. P. M. of the screw. This frequency can be changed in various ways if desired, for example, by rotating the feed shaft 80 synchronously with the machine.

The use of very short axial strokes at high frequencies permits simplification of the rotary driving means. For example, the basket and the screw may be driven by a differential V-belt drive 50b from a common drive shaft (not shown). The sheave 64b, driven by V-belts 65b is keyed to the basket shaft 14b. The sheave 66b, driven by V-belts 67b, is free to turn to a limited extent on a hub 70b keyed to the screw shaft 26b. Sheave 66b is made slightly smaller than sheave 64b to secure the desired differential speed. Sheave 66b, carries inwardly projecting radial ribs 69b which register with outwardly projecting radial ribs 71b on the hub 70b. See Figure 6. Compression or torque springs 72b are interposed between the respective ribs 69b and 71b, so that the power for driving the feed screw is transmitted through these springs.

The periodically interrupted differential rota-

tion between the basket and screw therefore is obtained and synchronized with the axial reciprocations in substantially the same way as in the embodiment of Figure 1. When piston 42*a* and the feed screw 20*a* move to the right, conveying material along the basket, the screw rotates at the same rate as the basket and the charge, and the springs 72*b* acquire a little extra compression. When the piston and screw move again to the left, on the backward stroke, the screw becomes free to turn differentially, and an extra relative rotation is imparted thereto by expansion of the springs, in addition to the relative rotation produced at the same time by the differential screw drive.

Various other arrangements and forms of apparatus may be devised by skilled engineers and various other instrumentalities may be used to embody the new principles of combination and operation disclosed in this application. I therefore desire that my invention be accorded a scope commensurate with its novel contributions to the art without restriction to details or forms of constructions except as may be required by a fair interpretation of the appended claims.

I claim:

1. In combination, a centrifugal basket having a substantially cylindrical wall to hold material for centrifugal treatment, means to rotate the basket, a rotary feed screw coaxial with and having a helical member adjacent the inside of said basket wall to engage material therein, means for charging material into the basket, means for relatively reciprocating the basket and the screw in axial direction to advance material in the basket a step therealong on one stroke of each reciprocation, periodically operative means for relatively rotating the basket and the screw to unscrew said helical member with respect to such advanced material, said periodically operative means including means movable to interrupt said relative rotation during said one stroke and acting to cause said relative rotation during the other stroke of each reciprocation, and an outlet in the basket adjacent an end of said helical member for discharging centrifuged material.

2. A continuous centrifugal machine comprising a centrifugal basket to hold material for centrifugal treatment and means to rotate the same, means for charging material into the basket, a rotary helical feed member inside and coaxial with the basket to engage material held therein, means to reciprocate said member in axial direction to advance such material a step along the basket on the forward stroke of each reciprocation, means to rotate said member including means to turn the same relative to the basket during only the backward stroke of each reciprocation so that said member then may screw backward in such material, the basket having an outlet for the discharge of material advanced by said member.

3. In combination, a centrifugal basket, means to rotate the basket, a coaxial rotary feed screw inside the basket to engage material therein, means to charge material into the rotating basket near the back of the screw, an outlet in the basket near the front of the screw for the discharge of centrifuged material, means to reciprocate the screw axially within the basket, means to rotate the screw faster than the basket, and means to interrupt the operation of the last-recited means during movements of material in the basket toward said outlet by forward strokes of the screw.

4. In combination, a centrifugal basket to hold material for centrifugal treatment, continuously operative means to rotate the basket, a coaxial rotary feed screw inside the basket to engage and feed material therein, means for continuously charging material into the basket adjacent one end of said screw, an outlet in the basket for centrifuged material adjacent the other end of said screw, means to reciprocate the screw axially with respect to the basket, and continuously operative means for rotating the screw in the same direction as but at an average speed faster than the basket, the last recited means including torque transmitting means yieldable angularly to a limited extent under resistance imposed by material in the basket against relative rotation of the screw to permit interruption of such faster rotation.

5. In combination, a centrifugal basket to hold material for centrifugal treatment, means for charging material into the basket, a coaxial feed screw inside the basket to engage material therein, means for relatively reciprocating the basket and the screw in axial direction to advance such material step by step along the basket by the forward strokes of reciprocation, continuously operating means for rotating the basket and the screw including means normally operative to impart a differential rotation thereto, and means for interrupting such differential rotation during said forward strokes, the basket having a discharge outlet for material advanced thereto by the screw.

6. In combination, a centrifugal basket, means to rotate the basket, means for continuously charging material into the basket, a coaxial rotary feed screw inside the basket to engage material therein, means to reciprocate the screw axially with respect to the basket, means to rotate the screw faster than the basket, and means for alternately interrupting and establishing the faster rotation of the screw in synchronism with the forward and backward strokes of reciprocation, respectively, and means for discharging from the basket centrifuged material fed by the screw.

7. In combination, a centrifugal basket, means to rotate the basket, means for charging material into the basket, a coaxial rotary feed screw inside the basket to engage material therein, means to reciprocate the screw axially with respect to the basket, means to rotate the screw faster than the basket, and torque-responsive spring means in the last-recited means to interrupt the faster screw rotation under a certain resistance of material in the basket against relative rotation of the screw, the basket having a discharge outlet for centrifuged material fed by the screw.

8. In a driving system for a continuous centrifugal machine or the like including two coaxial driven shafts, fluid pressure responsive means for relatively reciprocating the shafts in axial direction, comprising a pressure cylinder connected with one shaft and a piston within the cylinder connected with the other shaft, a differential drive connected with said shafts to rotate the same normally at different speeds, and means connected in said drive for interrupting the differential rotation of the two shafts during one stroke of each reciprocation.

9. In combination, a centrifugal basket, a coaxial rotary feed screw inside the basket to engage material therein, means for charging material into the basket adjacent one end of the screw, fluid pressure responsive means including

a pressure cylinder and a piston within the same movable relatively to reciprocate the screw axially with respect to the basket, driving means for continuously rotating the basket, means connecting the screw with said driving means to rotate the screw at an average speed faster than the basket, and a torque-responsive spring in said connecting means for alternately interrupting and increasing the faster rotation of the screw during the forward and backward strokes of the screw, respectively, while there is material under treatment in the basket, the basket having an outlet for centrifuged material adjacent the other end of the screw.

10. In combination, a centrifugal basket, a coaxial rotary feed screw inside the basket, fluid pressure responsive means including a pressure cylinder and a piston within the same movable relatively to reciprocate the screw axially with respect to the basket, driving means for continuously rotating the basket, driving means including a clutch responsive to fluid pressure to connect the screw for rotation faster than the basket, means to admit fluid under pressure simultaneously to said clutch and to one side of said piston to produce a simultaneous backward axial motion and faster rotation of the screw relative to the basket, and means operative at the limit of such backward motion to release fluid pressure from said clutch and said one side and to apply fluid pressure to the other side of said piston to produce a forward axial motion of the screw without driving the same faster than the basket.

11. In combination, a centrifugal basket, a coaxial rotary feed screw inside the basket, driving means for continuously rotating the basket, driving means including normally inactive connecting means for rotating the screw faster than the basket, means to shift the screw forward in axial direction with respect to the basket, means to return the screw backward in axial direction with respect to the basket, control means acting alternately to activate said shifting means and thereafter to activate said returning means and said connecting means simultaneously, and timing means to determine the frequency of action of said control means.

12. In a continuous centrifugal machine comprising a cylindrical basket, means for charging material thereinto, and a coaxial rotary feed screw inside the basket to engage and feed material therein, fluid pressure responsive means including a pressure cylinder and a piston therewithin connected respectively with the basket and the screw to reciprocate the screw axially with respect to the basket, differential driving means connected with the basket and the screw, respectively, for rotating the same together but at different average speeds, a torque-responsive spring permitting limited angular motion in the connections between the screw and said driving means, and means operated by the rotation of the screw for admitting fluid pressure into said cylinder alternately on one side and then on the other side of said piston.

13. In a continuous centrifugal machine, the combination with a rotary centrifugal basket having a cylindrical side wall and coaxial rotary screw means therewithin for translating material from one point to another along the said side wall, of means to rotate the basket, means for rotating the screw means relative to the basket, means to produce relative reciprocations between the basket and the screw means in axial direction, and means connected with said means for rotating the screw means and operative in synchronism with such reciprocations to interrupt periodically the relative rotation between the basket and the screw means.

14. In a continuous centrifugal machine comprising a rotary basket, means for charging material thereinto and a coaxial rotary feed screw inside the basket to engage and feed material therein, means connected respectively with the basket and the screw to reciprocate the screw axially with respect to the basket, rotary driving means for rotating the basket and the screw respectively at different speeds, the screw driving means including means shiftable alternately to establish and to interrupt its power transmission to the screw, and control means connected with said reciprocating means and said shiftable means to cause and coordinate the actions thereof, said control means including a timer, switch means connected with the timer and means positioned according to the axial position of said screw for positioning said switch means so as to regulate the frequency of the screw reciprocations and synchronize their alternate strokes with alternate actions of said shiftable means.

15. 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 intermittently screwing a helical element into the material without substantial longitudinal displacement of the material and alternately moving said element longitudinally of the chamber without substantial relative rotation of the element and the material to advance the material bodily toward the discharge end of the chamber.

16. The method of separating the liquid and solid fractions of a material which comprises feeding the material into a substantially cylindrical chamber having perforated side walls and an open end for the discharge of material, rotating the chamber with material therein continuously to drive out liquid fractions by centrifugal force, rotating in the same direction as the chamber a helical element helically engaging material in the basket and periodically advancing such material toward and ejecting a portion of the same from said discharge end by intermittently moving said helical element bodily longitudinally of the chamber toward said discharge end while rotating the same with the material in the chamber at the same speed, and alternately screwing said helical element from material so advanced and into material meanwhile fed into the chamber by reverse longitudinal movement of said element accompanied by differential rotation therof with respect to said chamber and material.

17. In combination, a centrifugal basket to hold material for centrifugal treatment, a rotary feed member inside, coaxial with and reciprocable axially with respect to the basket, said member having helical vanes to engage material in the basket, means for charging material into the rotating basket near one end of said vanes, the basket having an outlet near the other end of said vanes for the discharge of treated material, the basket and feed member having respective rotary shafts in coaxial relation, driving means connected with the basket shaft for rotating it continuously, fluid pressure responsive means in-

cluding a rotary pressure chamber on one of said shafts and a rotary piston within said chamber to act upon the other of said shafts, said piston and chamber relatively movable in axial direction under fluid pressure to move the feed member axially with respect to the rotating basket, interruptable driving means for rotating the feed member in the direction of the basket rotation including a rotary driving clutch member and a companion driven clutch member carried by the feed member shaft, said clutch members being relatively movable to engaged and disengaged positions so that in their disengaged position the feed member can rotate free from their driving action, and means for synchronizing the relative movements of said clutch members with relative movements of said piston and chamber.

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