April 30, 1963 F. P. GOOCH 3,087,621

CENTRIFUGAL MACHINE

Filed July 16, 1958 3 Sheets-Sheet 1

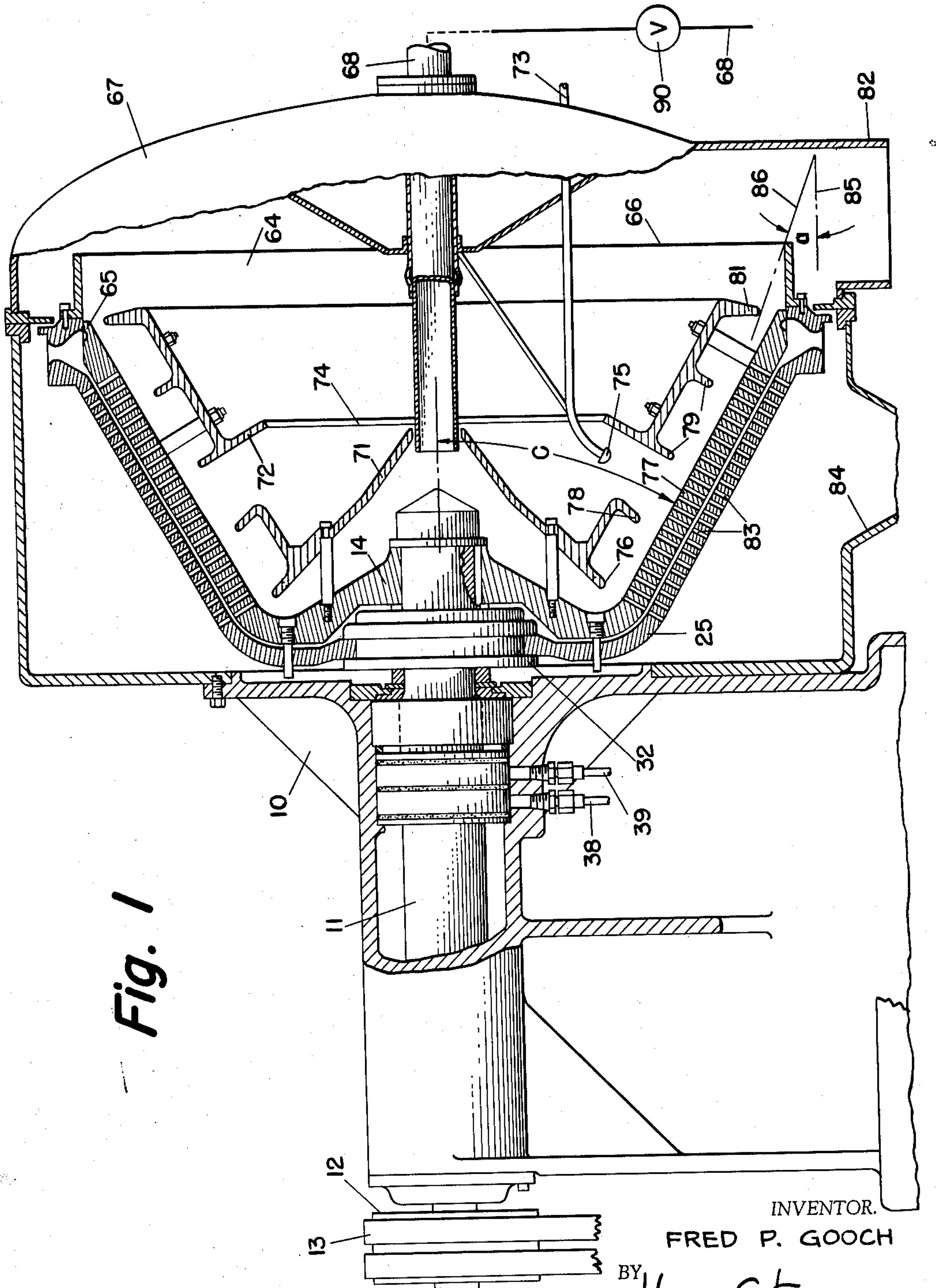

Fig. 1

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Fig. 2

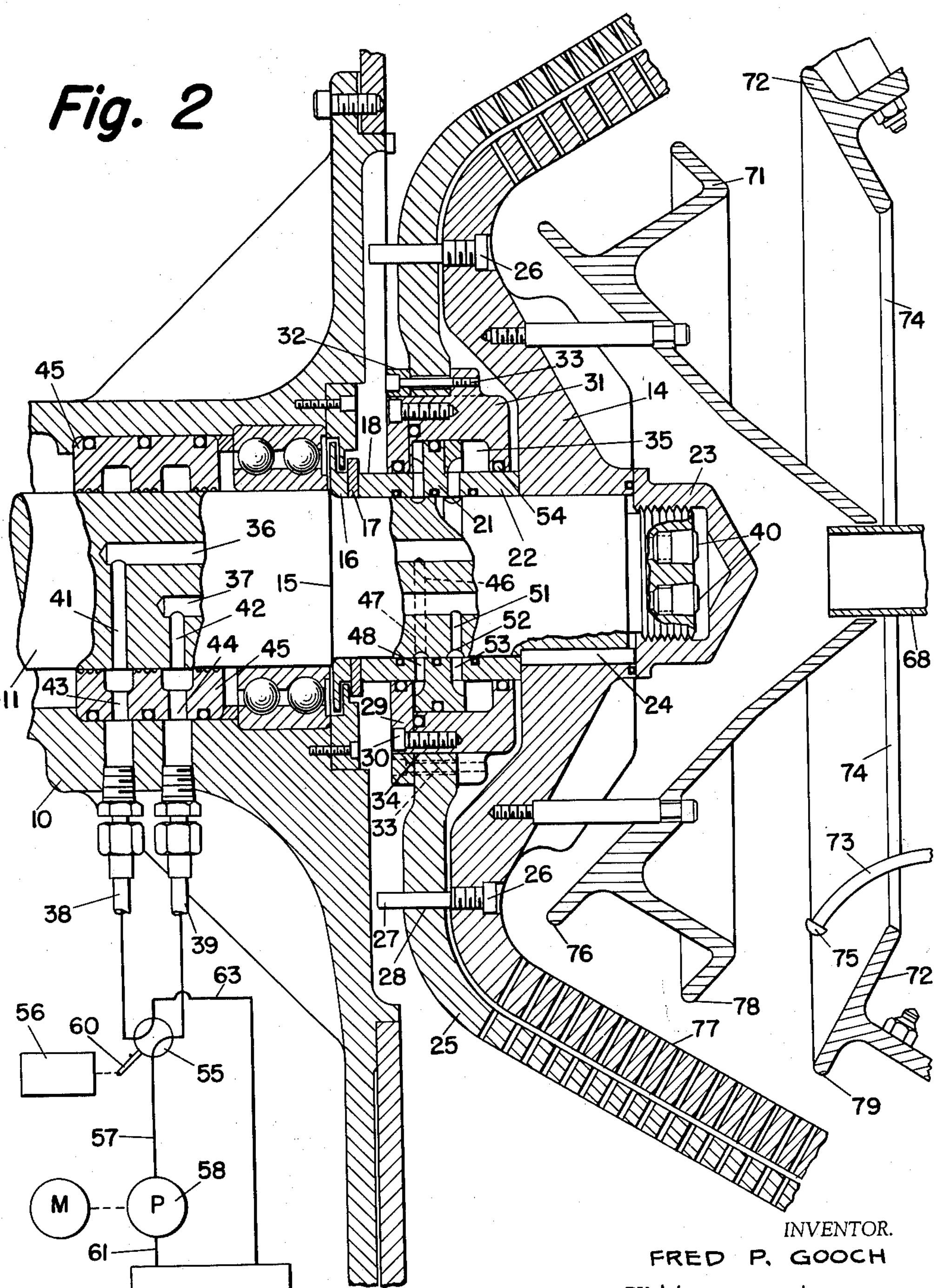

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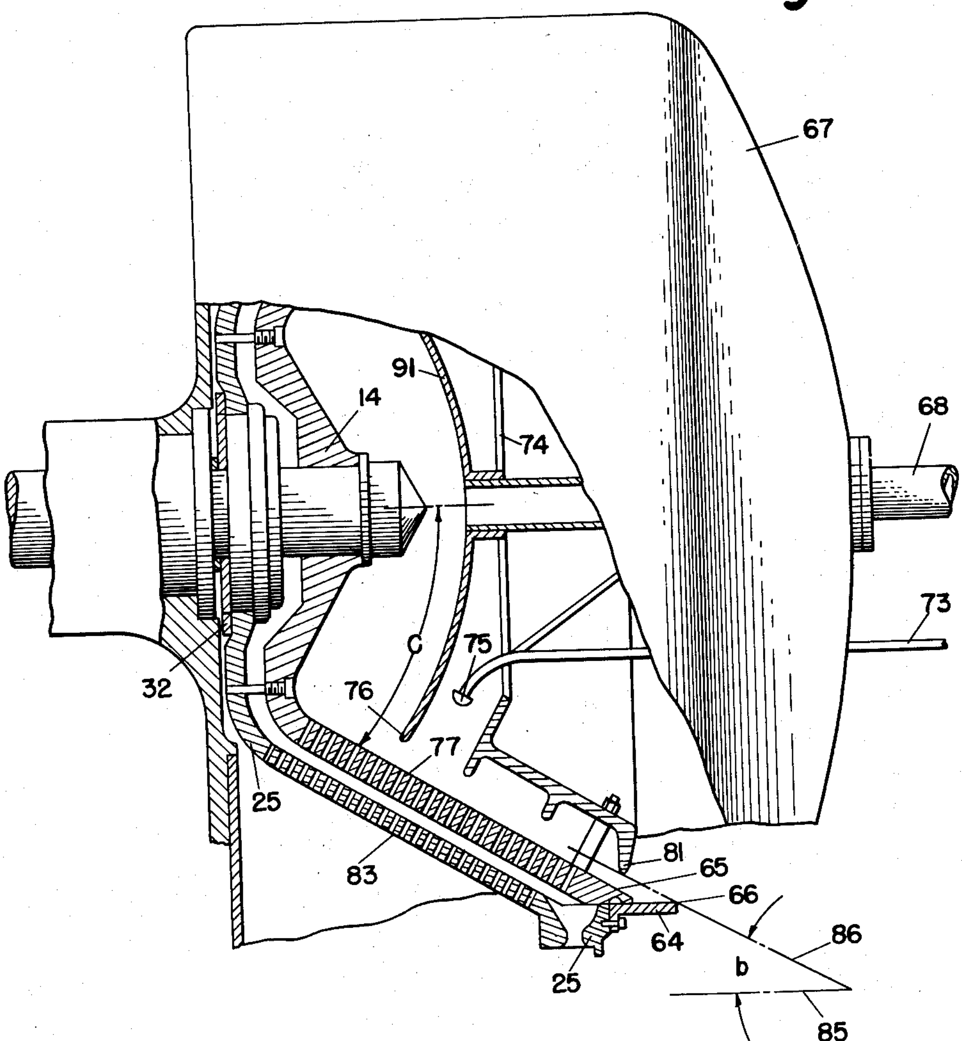
Fig. 3



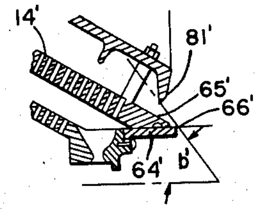


Fig. 3a

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3,087,621
CENTRIFUGAL MACHINE

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4 Claims. (Cl. 210—376)

This invention pertains to centrifugal machines of the type in which liquid and solid material are separated by centrifugal force. The invention pertains more particularly to centrifugal machines of this type that employ perforated rotors or baskets through the walls of which the liquid escapes during its separation from the solid material, and from which the solid material is discharged over a peripheral edge on the rotor.

In prior art centrifugal machines of this type, the rotors are variously shaped, and various forms of impeller mechanism are employed to advance the solid material longitudinally toward the discharge edge for solid material. When the rotor is frusto-conical in shape, such mechanism may function either to advance or to retard the flow of solid material over the perforated surface of the rotor, depending upon the relation between the angle of repose of the solid material, and the angle between the perforated surface and the axis of rotation.

The flow-control mechanism frequently takes the form of a worm or screw, a plow, a piston or pusher, or similar device positioned close to the inner perforated surface of the rotor, and movable relative to its perforations. As a result of such relative movement, a grating or comminuting action is set up between the movable member and the perforated surface of the rotor, which tends to reduce the size of the solid particles or crystal moving over the perforated surface, thus producing fines which either escape along with the liquid, or if not, then becoming intermixed with the dried solids of larger particle size, or causing plugging of the perforations.

To overcome these and other shortcomings inherent in centrifugal machines of the prior art, a centrifugal machine embodying a new and distinctly different principle for the advancement and discharge of solids is provided in the present invention, whereby the solid material flows over a perforated rotor surface without the need of impeller or like mechanism, with the rate of flow nevertheless under the positive control of the operator.

Further features of the invention will become apparent to persons skilled in the art as the specification proceeds, and upon reference to the accompanying drawings in which:

FIGURE 1 is an elevation partly in section of a centrifugal machine embodying the invention;

FIGURE 2 is an enlarged view mostly in section of a portion of FIGURE 1;

FIGURE 3 is a sectional elevation, shown broken, illustrating a different position of the solids discharge mechanism, as well as a modification of the feeding mechanism; and

FIGURE 3*a* is a fragmentary sectional view illustrating a possible relationship between elements in a further modified form of the apparatus.

Referring now more particularly to FIGURE 1, at **10** is shown a stationary housing. Journaled in housing **10** is a shaft **11** illustrated as being driven by means of pulleys **12** and belts **13** positioned at one end thereof.

Secured to the other end of shaft **11** is a perforated rotor **14** of frusto-conical shape. Means for securing rotor **14** to shaft **11** is illustrated in FIGURE 2, and, as shown, comprises a shoulder **15** on shaft **11**, annular rings **16** and **17**, which form a labyrinth seal, spacing collar **18**, a collar-shaped piston member **21**, a second spacing collar **22**, and member **23** which threadedly engages the end of

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shaft **11**, rotor **14** being positioned on shaft **11** between collar **22** and member **23**. Key **24** prevents relative rotary movement between rotor **14** and shaft **11**.

Mounted on shaft **11**, and slidable longitudinally with respect thereto, is a perforated frusto-conical member **25** which encloses the periphery of rotor **14**, and is of the same general shape. Member **25** is longitudinally movable relative to rotor **14**, and rotates therewith. Any means may be employed for the purpose, and as illustrated, rotor **14** is provided with a plurality of studs **26** having extensions **27** which pass through holes **28** in member **25** with a slidable fit.

The means for mounting member **25** on shaft **11** is illustrated as including annular members **31** and **32** which are secured together, such as by cap screws **33**, to engage the inner edge **34** of member **25**. Member **31** is so shaped as to form with anular member **29** an annular cylinder **35** surrounding annular piston **21**. Member **29** is secured to member **31** as by cap screws **30**.

Shaft **11** is provided with longitudinal bores or channels **36** and **37** which are connected at one end to fluid pressure lines **38** and **39**, respectively, through radial bores or channels **41** and **42** in shaft **11** and channels **43** and **44**, respectively, in stationary collar **45** in housing **10**. Bores **36** and **37** are sealed off at their other ends, as illustrated at **40**.

Bore **36** connects with a radial bore **46** in shaft **11**, which leads to a circumferential groove **47** on shaft **11**, groove **47** being connected to cylinder **35** on one side of piston **21**, through a plurality of circumferentially spaced radial channels in collar **18**, one channel being illustrated at **48**.

Bore **37**, on the other hand, is connected to cylinder **35** on the other side of piston **21**, through radial bore **51** in shaft **11**, circumferential groove **52** on shaft **11**, and a plurality of circumferentially spaced radial channels in collar **22**, one such channel being illustrated at **53**.

For fluid pressure sealing purposes, gaskets have been shown at various points throughout the structure illustrated, such as at **54**, but since their purpose and function will be well understood by persons skilled in the art, detailed description thereof, in the interest of brevity, will not be made.

As seen in FIGURE 2, member **25** has been moved to the right, this being caused by applying fluid pressure in line **39**, fluid pressure in line **38** being released. This in turn applied fluid pressure to the right hand end of cylinder **35**, causing member **25** to move to the right, since piston **21** is longitudinally fixed, and member **25** longitudinally movable.

To cause member **25** to move to the left, as seen in FIGURE 2, fluid pressure is applied in line **38**, fluid pressure in line **39** being released. The result is that fluid pressure is brought to bear in the left-hand end of cylinder **35**, which moves member **25** to the left.

Any means known in the art may be employed for alternately applying pressure in one of the fluid lines **38** and **39**, while releasing fluid pressure in the other. For purposes of illustration, lines **38** and **39** are shown connected to a four-way valve **55** which is actuated reciprocatingly by a timer **56**. Fluid pressure is delivered to valve **55** through line **57** and rotary pump **58** which in turn is connected through line **61** to fluid source **62**, such as of oil. Pressure release line **63** connects valve **55** with fluid source **62** for the return of released fluid to source **62**.

As illustrated, valve **55** is in a position connecting line **57** to line **39**, and line **38** to line **63**, the result being that member **25** is in its furthermost position to the right as seen in FIGURE 2. To move member **25** to the left, valve **55** is moved to connect line **57** to line **38**, and line **39** to line **63**, as will be obvious.

As will be well understood by persons skilled in the art, timer **56** operates valve **55** to alternately supply fluid under pressure to lines **38** and **39**, while at the same time releasing pressure in the other of the two lines, thus causing member **25** to reciprocate longitudinally with respect to rotor **14**.

Timers of the type shown at **56** are well known. If desired, valve **55** may be operated manually by disconnecting timer **56** from lever **60**, and reciprocating said lever **60** by hand.

Returning now to FIGURE 1, it will be noted that member **25** is provided with an annular lip **64** which extends beyond the edge **65** on rotor **14**. Edge **66** of annular lip **64** is shown in FIGURE 1 in its position of maximum distance from edge **65** on rotor **14**, whereas in FIGURE 3 edge **66** is illustrated in its position of minimum distance from edge **65**, these alternate positions of edge **66** with respect to edge **65** being the result of the reciprocating of member **25** relative to rotor **14**.

Housing **10** is shown as having a closed end **67** through which extends a stationary feed pipe **68**. Feed pipe **68** passes through the center of a frusto-conical feed distributing member **71** which is attached to rotor **14**. Another frusto-conical distributing member **72** also is shown attached to rotor **14**, feed pipe **68** passing through its central opening **74**.

Stationary spray pipe **73** is illustrated as passing through end **67** of housing **10**, and through central opening **74** in member **72**. Spray head **75** on spray pipe **73** is positioned between member **71** and **72**, and may be employed for applying a rinsing spray, if desired, to the solid material passing through rotor **14**.

The operation of the new centrifugal machine is as follows:

A slurry, such as of crystals in mother liquor, is fed into the centrifugal machine through line **68**, and enters the space or chamber between feed distributing member or wall **71** and rotor **14** wherein it is thrown outwardly by centrifugal force. The slurry passes around, i.e. over, annular edge or dam **76** which projects outwardly from member **71**, and slides along perforated surface **77** of rotor **14** toward the larger end thereof, the thickness of the layer of slurry on surface **77** preferably being regulated in any suitable manner, such as by outwardly projecting edges or dams **78** and **79** on distributing members **71** and **72**, respectively.

In order that the slurry may be caused to flow outwardly along the inclined perforated surface **77**, angle "*c*" between surface **77** and the axis of rotation should be of a magnitude greater than the angle of repose of the slurry undergoing treatment, it being understood, of course, that the line in FIGURE 1 representing surface **77** falls in a plane which passes through the axis of rotation.

By angle of repose is meant the maximum angle with the horizontal at which an object on an inclined plane will retain its position without tending to slide. In the case of a centrifugal machine the "horizontal" becomes the axis of rotation whether it is horizontal, vertical, or at some other angle. The term angle of repose is also used with the related meaning of the maximum angle with the horizontal (or axis of rotation) at which loose material, such as crystals, comminuted coal, or other finely or coarsely divided material, will retain its position without tending to slide. It is, of course, recognized that the moisture content, and the distribution of fine and coarse particle, have an effect on the value of this angle, as is well understood by persons skilled in the art. Generally speaking, the angle of repose of solid particles decreases with decrease in moisture content.

With the perforated surface **77** positioned at an angle with respect to the axis of rotation which is greater than the angle of repose of the slurry in its various states during the treatment, including, of course, that of the dried solids, the slurry slides along perforated surface **77** toward the discharge end of rotor **14**, being separated from liquid as it progresses. Since the rate of free travel of the slurry along surface **77** increases with increase in centrifugal force, and since the purpose of centrifuging is to apply centrifugal forces which are many times the force of gravity, it is found that when the angle "*c*" is greater than the angle of repose of the material in its various states while undergoing treatment, the material will pass through the rotor at a rate far too high for practicable separation purposes. Fow retarding mechanism is, therefore, an essential

In the prior art the necessary retarding action is accomplished either by making angle "*c*" less than the angle of repose, and resorting to impeller mechanism to advance the solids, or by making angle "*c*" greater than angle of repose, and resorting to a member similar to an impeller, such as for example, a scroll or screw, but which performs the reverse function of retarding the rate of flow of solids over the perforated surface. Both arrangements suffer from the shortcomings pointed out above.

In the present invention the rate of flow of the slurry across the reticulated frusto-conical peripheral wall **77** is controlled through the reciprocation of annular lip **64**, thus avoiding the mechanical grinding action of impeller or retarding mechanism functioning in association with the perforated surface. Annular lip **64** is preferably imperforate, although it may take the form of a screen or the like for additional draining purposes.

The solids sliding down perforated surface **77** eventually reach edge **65** of rotor **14**, at which point the solids pass around, i.e. over, outwardly projecting edge or dam **81** on distributing member **72**, and then onto the inner surface of annular member or lip **64**.

Annular lip **64** is shown for purposes of illustration as having an inner surface which is more or less parallel to the axis of rotation, and of a width such that the angle "*a*" between line **85**, drawn parallel to the axis of rotation, and line **86** which touches edge **66** and the outer edge of dam **81**, (both lines being in a plane passing through the axis of rotation), is less than the angle of repose of the discharging solids. As a consequence the flow of solids stops, and if annular edge **66** were to continue to occupy its position as illustrated in FIGURE 1, no solids would be discharged over edge **66**, the solids simply accumulating in rotor **14** to eventually stop the feed through pipe **68**. The angle between line **86** and the axis of rotation is, of course, the same as angle "*a*."

It will be recalled that annular edge **66** is illustrated in FIGURE 1 as occupying its position of maximum distance from edge **65** on rotor **14**. In one type of operation, when annular edge **66** is moved to its position of minimum distance from edge **65** as illustrated in FIGURE 3, the angle illustrated in FIGURE 3 by the letter "*b*" is still less than the angle of repose of the discharging solids, for it is not necessary, for purposes of discharging solids from rotor **14**, to move lip **64** to a position where the angle "*b*" equals or exceeds the angle of repose of the solids. This is because when lip **64** is moved to the left from the position shown in FIGURE 1, it slides out from under solids deposited thereon. Since such solids, due to friction, move only slightly but not appreciably to the left, which is actually uphill, any desired quantity thereof may be caused to discharge over edge **66**, the amount increasing with the distance that edge **66** is moved to the left. When lip **64** is returned to its original position to the right, such discharged solids are replaced by flow of further solids from rotor **14**, which is actually downhill, friction between the solids and lip **64** assisting in the forward movement of solids. Short frequent reciprocating movements of this character, such as at a rate between **20** and **200** times per minute, are found to be preferable to longer less frequent reciproating movements, for the former make it possible to more nearly simulate continuous movement of solids through the rotor.

Lip **64** may be of any desired greater width, and the solids need not necessarily be discharged over edge **66** as the result of a single reciprocation at the beginning of operations, for they in any event will eventually reach edge **66** due to the incremental advance resulting from each reciprocation cycle, thereafter to be discharged over edge **66** with each reciprocation.

Thus as a result of the reciprocation of reticulated member **25**, to which annular lip **64** is attached, solids are discharged intermittently at any desired frequency from the rotor **14**. Discharged solids are collected in housing **10**, and are removed therefrom through chute **82**. Liquid passing through perforated surface **77** of rotor **14** passes through the perforations shown at **83** in member **25**, and is withdrawn from housing **10** through chute **84**.

In another type of operation of the centrifugal machine of the invention, dimensional changes to the casing, reciprocating means, etc. which will be obvious to one skilled in the art, permit annular edge **66'** to be moved to a position of minimum distance from edge **65'** so that the angle "*b'*" having a ray tangent to edge **66'** and the edge of dam **81'** (FIG. 3*a*) becomes greater than the angle of repose of the discharging solids. This causes all of the solids in the rotor **14'** to be discharged therefrom at one time, particularly if suitably dried, and adapts the invention for cyclic operation, for example, in the following manner.

With annular lip **64'** in its outer position such as shown in FIGURE 1, rotor **14'** is charged with a slurry, the feed being discontinued after charging. After the solids have been suitably centrifuged for separation of liquid therefrom, annular lip **64'** is moved into a position as shown in FIGURE 3*a* whereat the angle illustrated at "*b'*" is greater than the angle of repose of the dried solids. The entire contents of rotor **14'** are thus discharged therefrom, and are removed from the housing, separately from the liquid, through segregated chutes comparable to chutes **82** and **84** of the FIGURE 1 representation. Annular lip **64'** is now returned to its original position such as illustrated in FIGURE 1, whereupon rotor **14'** is recharged with solids by opening a valve (not shown) comparable to valve **90**, and the cycle repeated.

Various other steps may be introduced into the cycle, as is common in the cyclic operation of centrifugal machines, for instance, as described in U.S. Patents 2,271,-493, 2,566,174, and 2,658,620.

Moreover, cyclic operation of the centrifugal machine of the invention lends itself to automatic control such as described in the foregoing patents.

It will be understood that in the first type of operation above described in which angle "*b*" does not exceed the angle of repose of solids discharging from rotor **14**, irrespective of the position of annular lip **64**, valve **90** normally will be continuously in open position.

While dam **81** is shown near the discharge end of rotor **14**, which is preferred, it obviously may occupy any other position between the inlet and outlet of rotor **14**, if desired for any reason, having in mind what has been said above with respect to angles "*a*" and "*b*," dam **81**, of course, being the outermost dam functioning in conjunction with lip **64**. The same applies to the spacing between dam **81** and the inner periphery of the rotor, which may be as desired, although a relatively thin layer of solids in rotor **14** is usually preferred. Dams **76**, **78** and **79** also regulate cake thickness, as will be obvious.

On the other hand, it is to be understood that the various dams, including dam **81**, may be dispensed with, if regulation of cake thickness, and a restricted width of annular member or lip **64** are not desired in the design of the centrifugal machine. For example, angle "*c*" may be made only slightly larger than the angle of repose of the particular slurry being treated, and lip **64** parallel to the axis and of sufficient width to avoid discharge of solids when in its outermost position, thus eliminating dam **81**, without departing from the spirit of the invention. It is preferred, however, to build the centrifugal machine with an angle "*c*" of sufficient size for the treatment of a large variety of slurries, for example, of 35°, and to employ a dam **81** so that the width of lip **64** may be held to a restricted width but sufficient for the controlled discharge of a wide variety of solids, it being understood, however, that lip **64** may be of any desired greater width, as pointed out above.

A modification of the feeding mechanism is illustrated in FIGURE 3, wherein a stationary feed distributing member or wall **91** mounted on the end of feed pipe **68** is substituted for a rotary feed distributing member, such as member **71**. The use of a stationary feed distributing members, such as member **91**, is found advantageous in certain instances, for example, when a slurry is sticky in character, in that a somewhat better distribution of the solids on the periphery of rotor **14** is obtained.

Also the radius of member **71**, or of member **91**, may be decreased or increased to decrease or increase, respectively, the centrifugal head at edge or dam **76**, as will be understood, the shape of the rotor being made to conform, if necessary, to obtain the desired spacing between dam **76** and surface **77**. In larger and/or high-speed machines, it may be desirable to limit the centrifugal head at edge or point **76**.

Usually, the hydrostatic pressure on the feed in pipe **68** is preferably held more or less constant and of nominal value, e.g, 5 or 6 feet, although, if desired, one or both may be departed from without departing from the spirit of the invention. A constant-head overflow device, for example, may be employed.

It will, of course, be understood that any other means may be provided for reciprocating annular lip **64**, accomplishing this purpose through a member **25** being merely illustrative. Moreover, it will be understood by persons skilled in the art that since the function of reciprocating member **25** is merely to reciprocate lip **64**, member **25** may have any other desired configuration and construction. Also it will be understood that any other means may be employed for reciprocating member **25**, the use of hydraulic means being illustrative.

For purposes of convenience in description, the periphery of rotor **14** has been shown with a plurality of closely spaced passages or holes of relatively small diameter, simulating a screen. It will, of course, be understood by persons skilled in the construction of centrifuges, that any other form of reticulated or liquid pervious surface may be substituted, for a rather wide variety are well known in the centrifuging art. Thus the term "reticulated," as used in the claims, is intended to define any type of construction which is pervious to liquid, that is which is capable of permitting liquid to pass therethrough while retaining solids, irrespective of its construction. The same applies to member **25** as will be obvious.

It will, of course, be understood that various refinements may be added, such as resilient bumper stops, e.g. of springs, rubber, or the like, to cushion the stopping of member **25** at each end of its reciprocating movement. Also it will be understood that the inner surface of annular lip **64** need not be parallel to the axis of rotation, but may form any other angle as long as angle "*a*" remains less than the angle of repose of the discharging solids.

Typical of crystals, or other solids, which may be dried, dehydrated and/or separated from mother liquor, in the apparatus of this invention, are the following: acetylsalicylic acid, ammonium persulphate, ammonium sulphate, borax, boric acid, copper sulphate, ferrous sulphate, hexamine, monochloracetic acid, naphthalene, paradichlorobenzene, polystyrene, potassium chloride, sodium bicarbonate, sodium carbonate, sodium chlorate, sodium chloride, sodium hydrosulphite, sodium sesquicarbonate, sodium sulphate, urea, zinc sulphate, coal, starch fiber and reclaimed rubber.

Having particularly described the invention, it is to be understood that this is by way of illustration, and that changes, omissions, additions, substitutions, and/or other modifications may be made without departing from the spirit thereof. Accordingly it is intended that the patent shall cover, by suitable expression in the claims, the various features of patentable novelty that reside in the invention.

I claim:

1. A centrifugal machine including a rotor with a single reticulated frusto-conical peripheral wall having a discharge outlet for solid material at its larger end, said wall terminating at its said larger end means to rotate said rotor, a feed distributing member positioned within the smaller end of said peripheral wall, means for feeding a slurry of liquid and solids into said centrifugal machine centrally of said distributing member, a dam positioned within said peripheral wall and adjacent said discharge outlet, said dam having a circular outer edge spaced from the inner surface of said wall, an imperforate annular end member positioned closely about and extending axially outwardly beyond said discharge outlet, means for rotating said annular end member with said rotor, means for continually reciprocating said annular end member axially relative to said discharge outlet, the inner surface of said peripheral wall defining an angle with the axis of rotation in a plane of said axis which is greater than the original angle of repose of said slurry and of said solids, and an imaginary straight line in a plane of the axis of rotation and touching the inner edge of the outer periphery of said annular end member when in outermost position and the outer edge of said dam defining an angle with the axis of rotation which is less than the angle of repose of the discharging solids.

2. The centrifugal machine of claim 1 having at least one additional dam between the dam of claim 1 and the distributing member.

3. The centrifugal machine of claim 1 wherein an imaginary straight line touching the inner edge of the outer periphery of said annular end member when in innermost position and the outer edge of said dam defines an angle with the axis of rotation which is less than the angle of repose of the discharging solids.

4. A centrifugal machine including a rotor with a single reticulated frusto-conical peripheral wall having a discharge outlet for solid material at its larger end, said wall terminating at its said large end, means to rotate said rotor, a feed distributing member positioned within the smaller end of said peripheral wall, means for feeding a slurry of liquid and solids into said centrifugal machine centrally of said distributing member, a dam of lesser radius than the larger end of said peripheral wall and positioned within said peripheral wall adjacent said discharge outlet, said dam having a circular outer edge spaced from the inner surface of said wall, an imperforate annular end member positioned closely about and extending axially outward beyond said discharge outlet, means for rotating said annular end member with said rotor, means for reciprocating said annular end member axially relative to said discharge outlet, the inner surface of said peripheral wall defining an angle with the axis of rotation in a plane of said axis which is greater than the original angle of repose of said slurry and of said solids, and an imaginary line in a plane of the axis of rotation and touching the inner edge of the outer periphery of said annular end member when in outermost position and the outer edge of said dam and defining an angle with the axis of rotation which is less than the angle of repose of the discharging solids, the imaginary line defining an angle greater than the angle of repose of the discharging solids when said annular end member is in innermost position.

References Cited in the file of this patent

UNITED STATES PATENTS

571,912	Abell	Nov. 24, 1896
1,342,743	Elmore	June 8, 1920
2,315,036	Bailly	Mar. 30, 1943
2,755,934	Ruegg	July 24, 1956
2,828,021	Ruegg	Mar. 25, 1958
2,982,411	Fontein	May 2, 1961

FOREIGN PATENTS

22,190	Great Britain	1912
34,197	Austria	Aug. 25, 1908
217,585	Germany	Jan. 5, 1910