P. F. PECK.

CENTRIFUGAL ORE SEPARATOR.

APPLICATION FILED MAR. 28, 1910.

981,679. **Patented Jan. 17, 1911.**

2 SHEETS—SHEET 1.

Fig. 1.

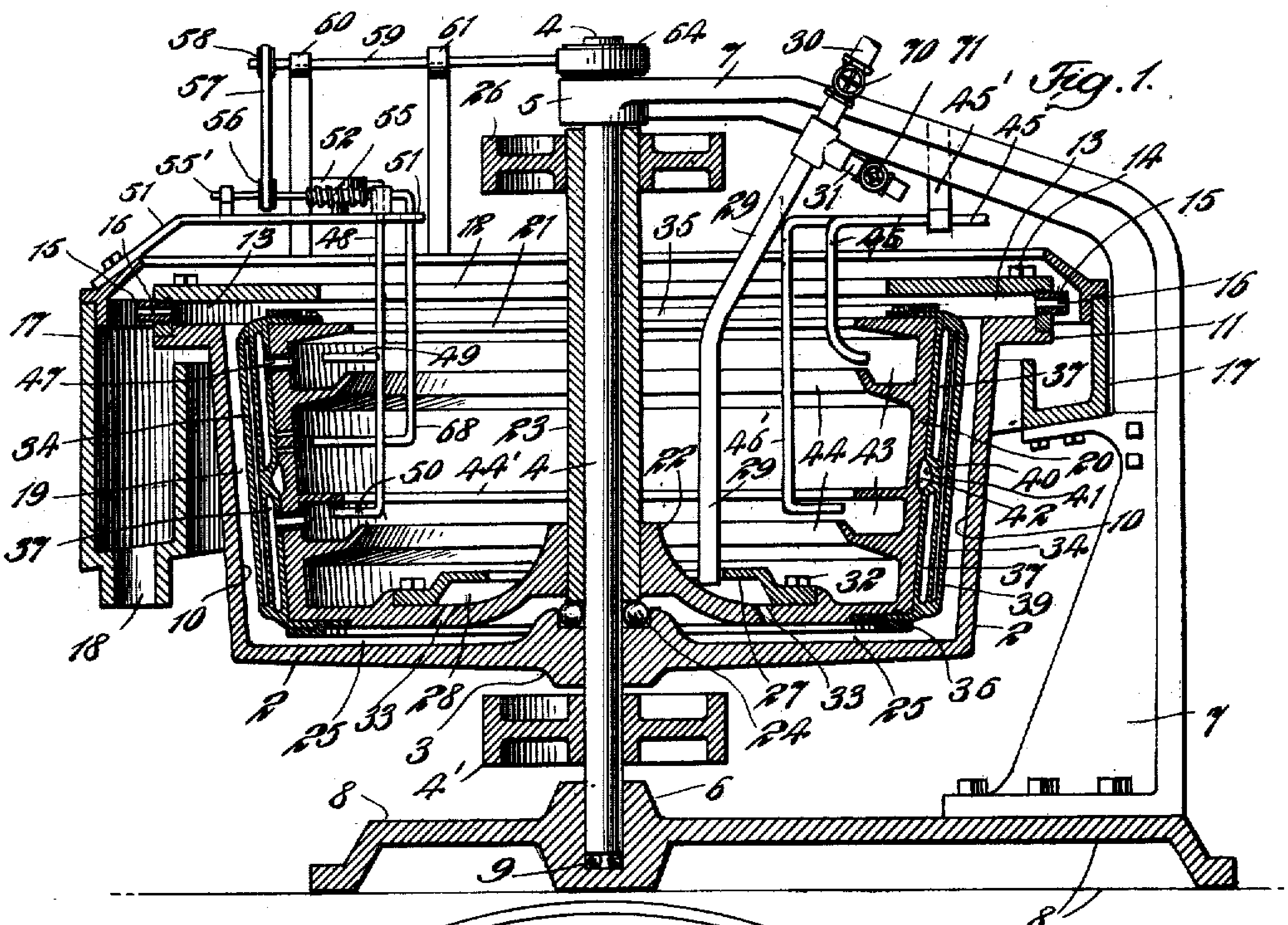
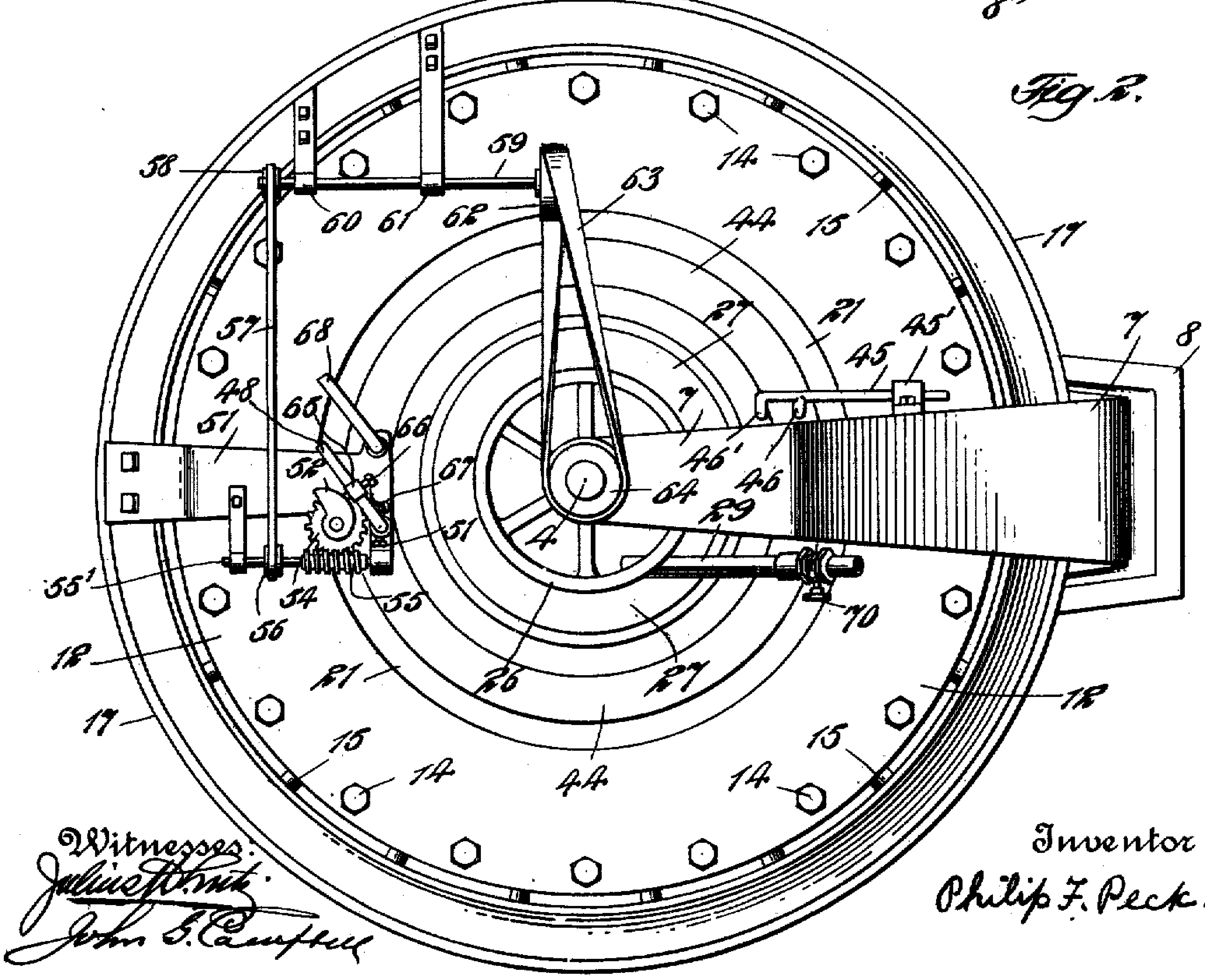


Fig. 2.



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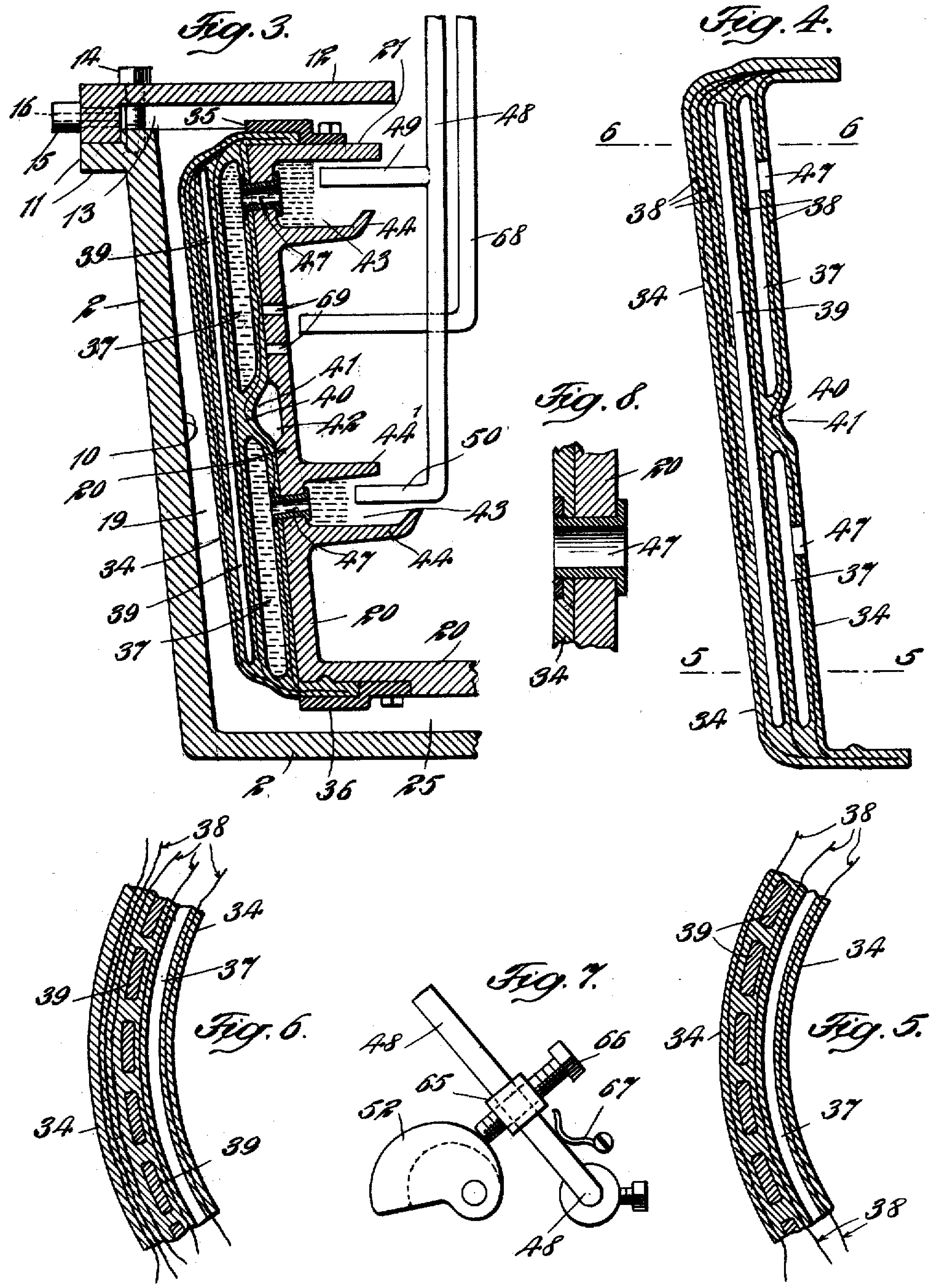
2 SHEETS—SHEET 2.



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CENTRIFUGAL ORE-SEPARATOR.

981,679. Specification of Letters Patent. Patented Jan. 17, 1911.

Application filed March 28, 1910. Serial No. 551,919.

To all whom it may concern:

Be it known that I, PHILIP F. PECK, a citizen of the United States, residing at Tacoma, State of Washington, have invented certain new and useful Improvements in Centrifugal Ore-Separators, of which the following is a specification.

The objects of my invention are to make an improved separator, employing centrifugal force and assisting agencies for separation of particles of waste and value in pulverized ores while mixed with liquid, of the general type employing a rotatable separating vessel and an expansible and contractible internal friction element, and my invention is more particularly directed to the expansible and contractible washing friction element, and its associated means for effecting expansion and contraction of the same.

In the drawings, Figure 1, is principally a vertical cross central section of my separator. Fig. 2, is a top plan of my separator, shown in Fig. 1. Fig. 3, is an enlarged detail of a vertical cross section of the left side of the wall of the separating vessel, the expansible element and deflector vessel, illustrated in Fig. 1, also showing some other parts, and showing the expansible element in a state of expansion, with expansion liquid illustrated in place. Fig. 4, is an enlarged vertical cross section of one wall of the expansible element, removed from the deflector vessel, showing more clearly its increased structural strength toward its large end, and with the expansion chambers in a state of partial expansion. Fig. 5, is a fragmentary detail cross section, on line 5—5, of Fig. 4. Fig. 6, is a fragmentary detail cross section on line 6—6, of Fig. 4. Fig. 7, is an enlarged detail top plan of the cam and some associated parts. Fig. 8, is a fragmentary enlarged sectional detail showing the water channel communicating device between the deflector vessel and expansible element.

In making my improved centrifugal ore separator, I provide a rotatable member 2, which is illustrated in the form of a vessel, and serves as a separating vessel, having a closed bottom and substantially open top. The bottom of the vessel has a central hub 3, that engages rigidly a shaft 4, which is mounted in journal boxes 5, and 6, respectively, to maintain it vertically, and carries a suitable drive pulley 4′. The journal box 5, is attached to the upper part of a suitable general supporting frame 7, and the box 6, is secured to the bed plate 8, of the separator; the lower end of the shaft is stepped on an anti-friction bearing 9, to carry its weight. The vessel 2, is turned smoothly and concentric to its shaft or axis, and on its inner peripheral wall is a separating surface 10, over which the substance to be separated passes, as hereinafter described.

The top edge or open end of the vessel is provided with an outwardly extended flange 11, as especially shown in Figs. 1 and 3, which flange has an annular recess as its outer top edge, into which the depending part of a wide ring 12, is seated, this depending part being some greater in width than the depth of the annular recess in the flange 11, there is left between the ring and the flange, when the two are seated together, an annular space 13. The main part of the ring is made wide enough to extend inward some distance toward the axis of the vessel as illustrated, thereby partly closing the opening in the top of the vessel.

The separating vessel is preferably made with its walls and the separating surface inclined outward from its bottom to its top or open end, making it of greater diameter at this end, which is the discharge end of the vessel, and the ring 12, extends a greater distance toward the axis than the extent of outward slant, or inclination of the wall of the vessel, so that the bore or opening of the ring is less in diameter than the inner diameter of the bottom of the vessel, enabling when desired, a sufficient body of liquid to be retained in the vessel to fill the separating passage and submerge the separating surface.

The ring 12, is held in place on the flange of the vessel by the screws 14, which pass through it and are threaded into the flange, as shown. This ring around its outer diameter, through its depending part is provided with a row of screw-threaded holes, communicating with the space 13, into which are removable screwed plugs or members 15, that are provided with small holes 16, of suitable size to permit of desired discharge of liquid and material, yet to retain a sufficient quantity of liquid in the vessel to fill the separating passage and submerge the separating surface, as above stated.

Surrounding the upper portion of the separating vessel and with an annular opening in circumferential alinement with the discharge holes in the plugs 15, is supported a suitable launder 17, adapted to catch the materials and water discharged from the vessel through the holes in the plugs 15, and to flow the same through a spout 18, to be diverted therefrom as may be desired.

Located inside of the separating vessel 2, and with said vessel formating a separating passage 19, is provided a member to serve as a deflector, which preferably embodies a substantial non-elastic supporting element or portion 20, which is illustrated in the form of a vessel, though this part may be any other suitable form of supporting structure. In most places in the specification I will refer to this supporting element, as the deflector vessel. The deflector vessel has a closed bottom, and an open top, except that at its top is a ring 21, flanged or extended a desired distance inward toward the axis of rotation. This vessel is somewhat smaller in diameter than the inside of the separating vessel 2, thereby leaving the separating passage 19, adjacent to the separating surface; it is also somewhat shorter than the inside of the separating vessel, and has a central hub 22, which securely and rigidly engages the lower portion of a sleeve 23, that is mounted in a rotatable manner around the central shaft 4.

Between the upper end of the hub 3, and the lower end of the sleeve 23, is provided a bearing 24, (Fig. 1,) which is preferably of an anti-friction type. This bearing is of sufficient thickness to hold the bottom of the vessels 2 and 20, apart, and leave a comparatively small space 25, between them, as shown.

The upper end of the sleeve 23, is provided with a pulley 26, by which the sleeve with the deflector may be revolved differentially to the separating vessel, by means of a suitable belt (not shown) from an appropriate source of power. Around the hub 22, of the deflector, I provide a ring 27, which rises above the bottom of the deflector vessel, and forms a feed chamber 28. This ring, which I will term a feed ring, has a central opening at its top, sufficiently larger than the outer diameter of the hub 22, to leave a suitable annular space around the hub, through which liquid and material, as well as concentrate-removing water may be introduced into the feed chamber 28, by means of a pipe 29, which has branch pipes 30 and 31, that connect respectively with suitable sources of pulp and concentrate-removing water supply.

The feed ring 27, has an outwardly extended flange at its lower edge, through which it is tightly secured to the deflector vessel by screws 32. Near the outer diameter of the feed chamber 28, are provided a number of holes 33, through the bottom of the deflector vessel 20, which serve as material and liquid passages from the feed chamber down into the space 25, whence such material and liquid, actuated by centrifugal force, is driven into the separating passage, where separation or concentration takes place.

The deflector member, in addition to the deflector vessel, which serves as the supporting part or element 20, embodies an expansible and contractible element 34, which I will term an expansible element, and is in the nature of a covering or jacket, secured to and supported by the deflector vessel. This latter element serves the office, as hereinafter described, of generating a frictional wash in the separating passage to assist in separation and in regulating the size of the separating passage. I have formed and illustrated the expansible element with its ends flanged in toward the axis a sufficient distance to pass under rings 35 and 36, respectively, which are clamped or securely held down over these flanged ends by suitable screws or by other ordinary means, engaging the ends of the deflector vessel. The expansible element is preferably made of the general form of the outer circumferential surface of the deflector vessel, and of size to closely fit over it,—and inasmuch as the deflector vessel is largest toward the top end, the expansible element is also largest in diameter toward its top end which is the discharged end of the vessel.

It is important that the exterior circumferential surface of the expansible element during operation, should substantially conform to the contour of the separating surface without arching or bulging longitudinally, so as not, during separation, to plow or gouge the bedding concentrates from the separating surface while operating in close washing frictional relation to such bed.

In the formation or structure of the expansible element, I prefer to make it with walls that are double, or comprise double or multiple layers, as illustrated, with multiple liquid expansion chambers 37, interposed between these double walls or layers, and for this purpose I have used layers 38, of suitable canvas, of weight and strength and of sufficiently yieldable weave to subserve the purposes desired, and have covered this canvas with rubber to render it water tight and better adapt it to desired usage. To prevent material arching or bulging lengthwise, I have provided the outer of said layers or walls with comparatively rigid longitudinal reinforcing means, preferably in the form of metal strips 39, made up between the layers of canvas, and have sufficiently covered the canvas and reinforcing means with rubber as above stated, to produce a smooth yieldable exterior friction surface.

As is illustrated, it is preferable not to make the inner layer or wall of the expansible element with reinforcing means,— this wall being adapted to fit around and rest against the exterior of the deflector vessel. To form divisions or partitions between the multiple expansion chambers between the walls or layers, the inner wall, at desired places, as illustrated at 40, is substantially secured to the outer wall or layer, preferably in a water tight circumferential course, by sewing and vulcanizing, or by other suitable means of fastening, so when the outer wall or layer with its reinforcing means is carried outward in expansion by liquid pressure in the expansion chambers, the inner wall or layer, being acted upon by this liquid, is tightly pressed against the outer surface of the deflector vessel, over which it fits, except within and adjacent to the zone of adhesion or anchorage to the outer wall. At and within these zones of anchorage the inner layer or wall is drawn and carried outward with the outer wall and reinforcing means, as illustrated at 41, and thereby the inner wall serves, around these zones as means for binding and assisting to hold or anchor the outer wall and reinforcing means, in place on the deflector vessel, and to assist in maintaining them against torsional movement caused by washing friction during operation of the separator. The reinforcing means in the outer wall, bridge or extend across these places or zones of fastening or anchorage, between the expansion chambers on a constant plane, and in so doing maintain a desirable even exterior frictional washing surface to the expansible element.

As the expansion element becomes contracted, there is something of a tendency to stretch a small portion or excess of the part of the inner wall around its zones of anchorage to the outer wall, into a wrinkle, and to accommodate this excess or wrinkled portion, so that it will not unduly press against the outer surface of the deflector vessel and tend to make an uneven place, or to wear rapidly, I provide a suitable recess or groove 42, in the outer walls of the deflector vessel into which it may recede.

On the inside of the deflector vessel, for each of the expansion chambers, I have provided an annular trough 43, which is formed by providing rings 44 and 44′, in the deflector vessel, extending a desired distance inward toward the axis of rotation. These troughs serve as facility for supplying liquid to the expansion chambers. To supply liquid to these annular troughs 43, I have provided a suitable pipe 45, held in place by a bracket 45′. This pipe has two branches 46 and 46′, each of which communicates with one of the troughs 43. Around in the bottom of these troughs, through the wall of the deflector vessel and through the inner wall or layer of the expansible element, are provided passages 47, communicating with the respective expansion chambers, so that water from the troughs 43, may pass into the expansion chambers during operation, and actuated by centrifugal force, become expansion liquid with sufficient pressure to expand the chambers and correspondingly enlarge the expansion element diametrically, as desired, carrying the outer surface to comparatively close proximity to the separating surface, and thereby rendering the separating passage of minimum desired sizes for commencement of concentration.

The pressure to which the liquid in the expansion chamber is subjected at a predetermined speed of rotation of the deflector vessel, mainly depends on the amount of liquid maintained in the troughs 43, from the fact that such liquid forms the column or body, which, acted upon by centrifugal force, effects a hydrostatic pressure substantially proportionate to its depth.

It is intended that the treatment vessel alternately accumulates a bed or load of concentrates of sufficient size to largely fill the separating channel with the expansible element fully contracted, and then to discontinue separation and to discharge such accumulated concentrates. To enable this result the separating vessel, during the concentrating period is rotated at a suitable high rate of speed to produce the requisite centrifugal force, and the deflector is rotated at a required different speed to produce frictional wash, through differential travel of the expansible element and separating surface, of intensity necessary to constantly move or wash the lighter or waste part of material from the separating surface, while permitting the heavier parts, or concentrates to lodge and bed on such surface.

It is necessary during concentration, in order to secure a condition to satisfactorily accomplish separation, to have and maintain the separating surface, or the surface of the bedding concentrates, and the frictional surface of the expansible element in comparatively close operative proximity, which is the condition obtained by expansion of the friction element, and this condition is maintained throughout the loading period by gradual contraction of this element, as hereinbelow described.

It is obvious that after being expanded to render the separating passage suitably small for concentration, at the beginning of the loading period, if this element was not of a nature that enabled progressive contraction during the loading period, the small passage initially produced for separation would soon become filled and prevent further concentration. To best enable gradual contraction of the expansible element to gradually and progressively provide space for the bedding concentrates after they become separated, and still maintain its necessary close operating relations to the surface on which concentration is effected, I have provided means for gradually removing the liquid from the annular troughs 43, in the deflector vessel, thereby gradually decreasing the expansion pressure within the expansion chamber. To remove this liquid, I provide a suitable pipe or conduit 48, with branch pipes 49 and 50, the branch 50, being formed by bending the lower end of the conduit pipe 48. These branch or scoop pipes are located with their scooping ends directly against the course of rotation, of the liquid in the troughs, to operate in contact with the surface of this liquid, so that such liquid is scooped out and removed to the extent that the ends of the scoop pipes are moved toward or from the axis of rotation of the vessel. This conduit pipe is suitably supported by the part 51, in a manner to permit of rotating movement, and its upper end extends out and over the top of the vessel, where it may connect with a hose, (not shown), or any other appropriate means of delivery of the liquid removed.

As means of changing the position of the scooping ends of the scoop pipes, and of traveling them toward and from the axis of the vessel, thereby governing the amount of liquid in the troughs 43, I provide a cam 52, rotatably supported on the bracket 51, and to the cam, have connected a worm wheel 54, engaging a worm 55, mounted on a shaft 55′, journaled in position to revolve the worm wheel. On the shaft 55′, of the worm I mount a pulley 56, in position to be driven by a belt 57, communicating with a pulley 58, which is carried by a shaft 59, supported in suitable journal boxes 60, and 61, which engage brackets from a part of the frame of the separator. The shaft 59, also carries a pulley 62, in position to be driven by a belt 63, engaging a pulley 64, on the shaft 4, of the separating vessel, so that through these several agencies the cam is rotated as the separating vessel is revolved.

The upper end or portion of the scoop pipe is crooked in position to carry a clamp 65, (best illustrated in Fig. 7), which is provided with an adjustable screw 66, the end of which contacts with the periphery of the cam 52, and the scoop pipe is consequently moved or swung in a rotary direction, as the cam is revolved, governed by the peripheral contour of the cam; the spring 67, which is fixed in a manner to press against the bent end of the scoop conduit or pipe, serving to hold the end of the screw 66, against the peripheral surface of the cam.

The scooping ends of the scoop pipes are shaped and in position with relation to the cam, and the peripheral contour of the cam is also formed so that removal of the liquid from the annular troughs 43, in the deflector vessel is suitably timed and proportioned during the loading period, to enable contraction of the expansible element, as desired, for maintaining suitable separating conditions and at the same time to accommodate the bedding concentrates in the separating passage, and also to effect desired expansion during the unloading period. The position of the scooping ends of the scoop pipes may be somewhat adjusted by the screw 66.

The resistance to expansion, and the contraction of the expansible element is principally effected by the pressure of liquid against its exterior, while such liquid is flowing through the separating passage, but is partly occasioned by the structural resistance to expansion or stretching of the expansible element.

The pressure of the liquid within and flowing through the separating passage is the greatest near the feeding end of the vessel, and gradually decreases toward the discharge end, from the fact that the distance of flow through the separating channel and consequent frictional resistance to such flow and the requisite static pressure to overcome such friction, decreases in that direction. It therefore follows that the resistance to expansion of the expansible element by outside pressure is less toward the discharge end of the vessel, and in order to assist in maintaining a uniform degree of expansion throughout the length of the expansible element under such decreasing pressure, I form such element of greater strength and having greater structural resistance to expansion toward the discharge end, which increased strength and structural resistance is intended to make up or compensate for the lesser external resistance or pressure toward the discharge end channel, and thereby facilitate uniform expansion. From the further fact that the separating vessel is larger in diameter toward the discharge end, and the deflector vessel, as well as the expansion element is correspondingly larger at this end, there is, at this end an additional centrifugal stress, because of the greater diameter, and a resultant increased tendency to expansion, and it is further desirable to here make the structure of the expansible element of greater strength on this account.

As is illustrated more clearly in Figs. 3, 4, 5, and 6, I have formed the outer wall or layer of the expansible element with progressively increasing strength toward the discharge end, which is also the larger end, by inserting additional layers of canvas within this wall. As illustrated in Figs. 4, and 5, at the lower end of the expansible element, there are but two layers of canvas made up in the outer wall, and at the discharge end there are four layers used, as shown in Figs. 3, and 6, which must increase the strength and its resistance to expansion at this end. One of the additional layers of the canvas is extended down below the center, and the second additional layer extends a considerable less distance downward, so that the increased strength is progressive toward the discharge end. In expansion of this element, its structural resistance becomes greater, as its stretching or distention increases and in such proportion there is required a progressively greater expanding liquid pressure within the expansion chambers, and a greater accumulation of liquid within the troughs 43, to effect such required increased pressure, and furthermore, in contraction of this element it follows that as contraction proceeds, the required resisting pressure to such contraction decreases progressively as the resistance to expansion decreases, therefore to obtain uniform speed of contraction, the expanding liquid within the troughs 43, should be removed at a constantly increasing rate, to effect such decreasing expansion pressure as the expansion element becomes less tense. To accomplish this variation in degree or speed of removal of liquid from the troughs 43, I have formed the contour or peripheral surface of the cam with an increasing degree or ratio of diversion in relation to its arc, throughout the portion of its circumference that operates to move the scooping pipes 49 and 50, for removal of the liquid in the troughs 43. I have illustrated the cam in Fig. 7, detached and enlarged in plan, and have indicated in dotted line, what would be a uniform or constant divergence of a part of its periphery with respect to its arc, which illustrates the contrast to my present structure of cam.

It will be understood that the movement or travel of the scooping end portions of the pipes 49 and 50, is adapted to be in a direction from the axis of the separating vessel at an increasing rate, and that the cam, having a peripheral contour of the form above described, serves as means for effecting such travel at an increasing rate, thereby removing the expanding liquid in such manner, which results in decreasing the expanding pressure in a similar ratio. This travel and its resultant effect is produced automatically and at a progressively increasing rate, being the sequence of the operation of the cam having the form described.

During operation, there may be accidentally, through breakage or leaking of the inner wall of the expansible element, some liquid between the outside of the deflector wall and the inner layer or wall of the expansible element, and to permit of its escape and removal I provide a fixed conduit 68, in the nature of a pipe, with one end crooked in close position to the inner wall of the deflector vessel, adapted to scoop any such liquid from the deflector vessel that may come through the passages 69. This pipe 68, is supported and held in place by the bracket 51, and its upper end is extended outside of the separating vessel.

In operation, the separating vessel is rotated at a sufficient speed to develop the high degree of centrifugal force required to retain the concentrates on the separating surface, and the deflector is rotated at a sufficiently different speed to enable the expansible element, through travel differential to the separating surface to create a washing or liquid scouring friction sufficient to wash and keep the waste substances moving to discharge while the concentrates accumulate in a bed on the separating surface. During this time pulp in a sufficiently dilute state, and in sufficient quantities to form a body in the separating vessel to fill the separating passage and submerge the separating surface, is introduced, and there is also sufficient liquid introduced into the troughs in the deflector vessel, to expand the expansible element as desired. As the operation proceeds the cam mechanism operates the conduit or main scoop pipe 48, swinging the latter's branch scoop pipes 49 and 50, which lessen the expanding pressure and enables the expansible element to be gradually forced inward, or contracted, affording space in the separating passage for bedding of concentrates, until the expansible element has become fully contracted. When the expansible element has become fully controlled, the flow of pulp for separation is stopped, through use of a valve 70; the speed of rotation of the vessel is lessened; preferably clean concentrate-removing liquid is introduced to the vessel, by opening the valve 71. The concentrate-removing liquid is enabled to remove the concentrates, because of the comparatively low speed at which the separating vessel is rotating and also because at this time expansion liquid is again in the troughs 43. This accumulation is again permitted by reason of the position which the scoop pipes have at this time assumed, through tolerance of the cam in its rotation, so the expansible element has become under full expanding pressure. As a result of these changed conditions from those prevailing for concentration, the accumulated bed or load of concentrates in the separating passage is quickly dislodged and driven to discharge, leaving the separating vessel free for another period of concentration. The concentrating speed of rotation of the separating vessel is restored; the flow of concentrate-removing liquid discontinued and the flow of pulp again restored for separation, and the operations are successively repeated.

What I regard as new and desire to secure by Letters Patent is:

1. In a centrifugal ore separator, the combination of a rotatable member forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an element with expansible and contractible walls adapted to increase in resistance to diametrical expansion toward the discharge end of the separating passage, substantially as described.

2. In a centrifugal ore separator, the combination of a rotatable member of greater diameter at one end, provided with a separating surface and forming one wall of a separating passage adapted to contain a body of liquid in operation and a member differentially rotatable thereto of greater diameter at one end in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an expansible and contractible element of greater diameter at one end adapted to increase in resistance to diametrical expansion toward said large end, substantially as described.

3. In a centrifugal ore separator, the combination of a rotatable member forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto, in part forming said separating passage, the second member embodying a comparatively rigid supporting element and a diametrically expansible and contractible element anchored to the supporting element adjacent to its end, and in part intermediate between said ends and containing comparatively non-elastic reinforcing means within said expansible and contractible wall, extending across the zone of said intermediate anchorage, substantially as described.

4. In a centrifugal ore separator, the combination of a rotatable member provided with a separating surface, forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto, in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an element with walls having multiple yieldable layers with an expansion chamber interposed between said layers, the outer of said layers structurally adapted to increase in resistance to diametrical expansion toward the discharge end of the separating passage, substantially as described.

5. In a centrifugal ore separator, the combination of a rotatable member forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an element with walls having multiple layers with multiple expansion chambers interposed between them, divided by anchorage zones of said multiple layers, the outer one of said layers being provided with comparatively non-elastic reinforcing means extending across said anchorage zones, substantially as described.

6. In a centrifugal ore separator, the combination of a rotatable member having a separating surface, forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto adapted to be expanded and contracted during operation increasing in diameter toward its discharge end, embodying yieldable layers with an expansion chamber interposed between said layers, the outer of said layers structurally adapted to increase in resistance to diametrical expansion toward the discharge end of the separating passage, substantially as described.

7. In a centrifugal ore separator, the combination of a rotatable member forming one wall of a separating passage adapted to contain a body of liquid while in operation and a member differentially rotatable thereto in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an element with walls having multiple layers with multiple expansion chambers interposed between them, divided by anchorage zones of said multiple layers, the outer one of said layers being provided with comparatively non-elastic reinforcing means extending across said zones of anchorage and the outer of said layers adapted to increase in resistance to diametrical expansion toward the discharge end of the separating surface, substantially as described.

8. In a centrifugal ore separator, the combination of a rotatable member forming one wall of a separating passage, adapted to contain a body of liquid while in operation, a member differentially rotatable thereto in part forming said separating passage, the second member embodying a comparatively rigid supporting element and an expansible element with walls having multiple layers

with an expansion chamber interposed between said layers, said supporting element provided with liquid containing chambers having liquid passages to said expansion chambers, and having liquid passages from between the exterior of said supporting element and the interior layer of said expansible element, gradually travelable means adapted to remove liquid during operation from said liquid chamber within the supporting element and comparatively fixed means adapted to remove liquid delivered from between the outer surface of the wall of the supporting element, and the inner layer of the expansible element, substantially as described.

9. In a centrifugal ore separating friction element adapted to be diametrically expanded and contracted during operation, the combination of walls having multiple layers with multiple expansion chambers interposed between said layers, the layers being anchored together at the zone of division between said chambers and comparatively rigid reinforcing means within the outer layer bridging across said zones of anchorage, on a comparatively constant plane during expansion and adapted to carry the inner layer outward within said zone while maintaining such constant plane, substantially as described.

10. In a centrifugal ore separating friction element adapted to be diametrically expanded and contracted during operation, the combination of walls having multiple layers with multiple expansion chambers interposed between said layers, the layers being anchored together at the zone of division between said chambers, the outer of said layers increasing in structural resistance to expansion toward its discharge end and comparatively non-elastic means adapted to reinforce the outer of said layers extending across the zone of said anchorage, substantially as described.

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