J. J. BERRIGAN.

PROCESS OF SEPARATING LIQUIDS AND SOLIDS.

APPLICATION FILED MAY 11, 1908.

1,055,254. Patented Mar. 4, 1913.

2 SHEETS—SHEET 1.

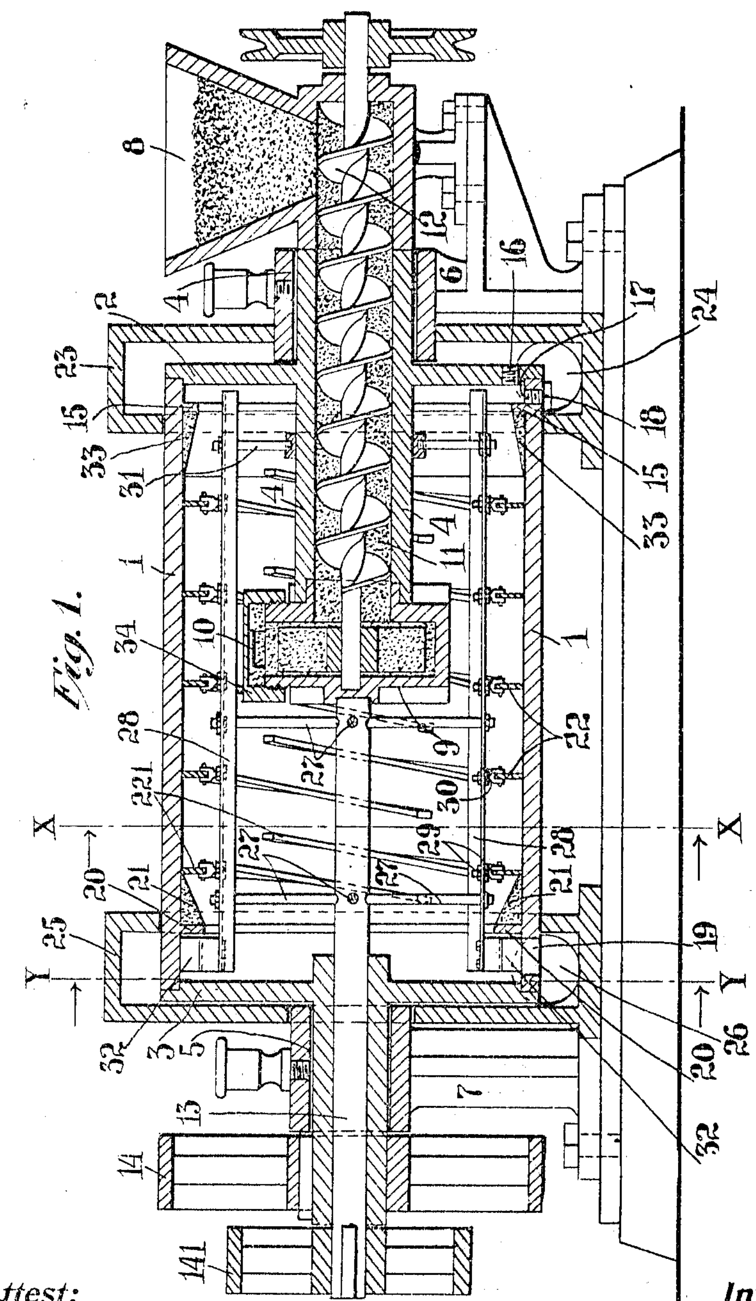

Fig. 1.

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2 SHEETS—SHEET 2.

Fig. 2.

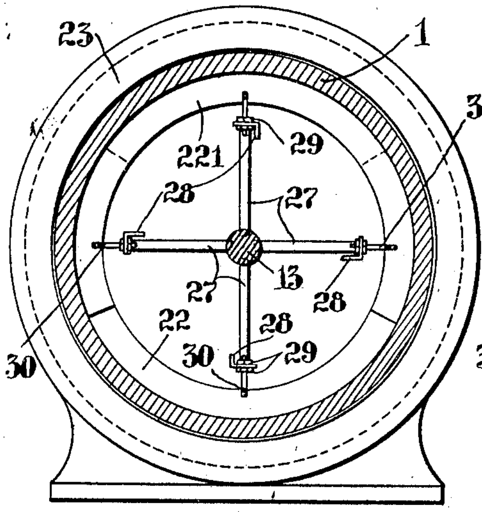


Fig. 3.

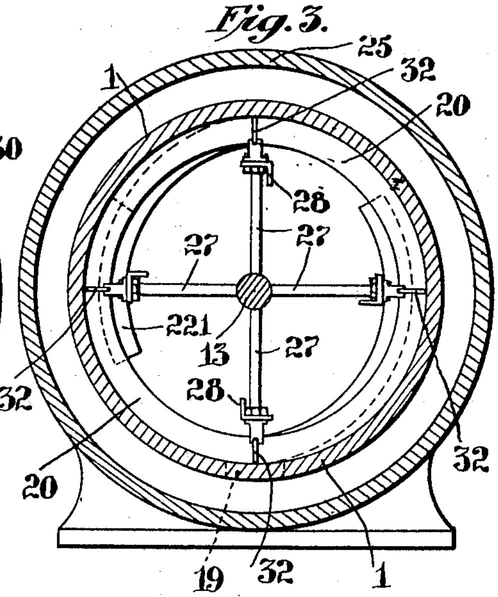


Fig. 4.

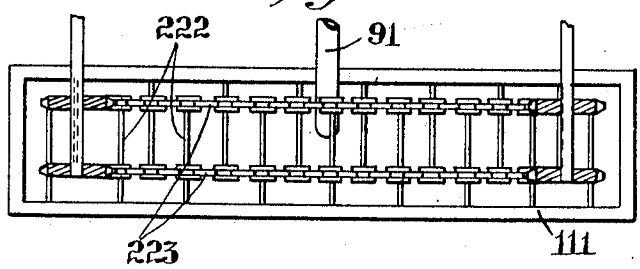
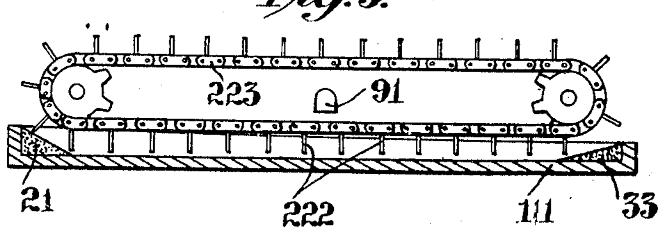


Fig. 5.



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UNITED STATES PATENT OFFICE.

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PROCESS OF SEPARATING LIQUIDS AND SOLIDS.

1,055,254. Specification of Letters Patent. **Patented Mar. 4, 1913.**

Original application filed February 17, 1908, Serial No. 416,298. Divided and this application filed May 11, 1908. Serial No. 432,223.

To all whom it may concern:

Be it known that I, JOHN J. BERRIGAN, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Process of Separating Liquids and Solids, of which the following is a specification.

My invention relates to an improved process of separating liquids and solids, preferably through the agency of "centrifugal force".

My said process comprises forming a long layer of settled solids in a body of liquid, working the solids toward one end of the layer while avoiding so far as possible disturbing the settling in said layer, and moving said solids up over the liquid level to a discharge point, while discharging liquid at another and opposite end of said layer and while continuously feeding fresh wet material to be separated to a mid-portion of the layer. When, as is preferable, the separation is conducted through the agency of "centrifugal force" the said layer of solids and liquid will constitute an annulus held against the inner surface of a rotating drum or bowl by "centrifugal force".

The object of my invention is to separate liquids and solids efficiently, particularly those mixtures of liquids and solids, which, because of the fine sub-division of the solid material, its slimy or slippery nature, its close approximation in specific gravity to that of the liquid, or other reason, are very difficult to separate, or even practically impossible to separate efficiently by means such as ordinarily used heretofore.

In the accompanying drawings I illustrate apparatus such as may be used for carrying out my invention; and I will first describe such apparatus and then my said process as carried out in such apparatus.

In said drawings: Figure 1 shows a vertical axial section of one form of centrifugal separator embodying my invention; Figs. 2 and 3 show transverse vertical sections of said apparatus on the lines X—X and Y—Y respectively; Figs. 4 and 5 are diagrammatic views showing the apparatus as it might be if "developed", Fig. 4 showing a plan view and partial section and Fig. 5 a longitudinal vertical section.

In the drawings, 1 designates a separating cylinder or drum having heads 2 and 3 and journals 4 and 5 mounted in bearings in standards 6 and 7 whereby the drum is mounted for rotation. Both of journals 4 and 5 are hollow, journal 4 having within it a supply-passage leading from a hopper 8 to a head 9 having a discharge opening 10; there being, in such supply passage, 11, and in the corresponding portion of the feed-hopper, 8, suitable conveying means, such as the screw conveyer 12, whereby material may be fed positively from said hopper to passage 11 and thence delivered through discharge-opening 10 into the interior of drum 1. Within the other journal, 5, of the drum, is a shaft 13 projecting into the interior of the drum and provided with the conveying-means or scrapers hereinafter referred to. Upon the extended end-portion of journal 5 is a belt-wheel 14 constituting means for rotating drum 1; and upon the outer end of shaft 13 is a belt-wheel 141 constituting means for rotating said shaft. The drum 1 and shaft 13 will normally rotate at different speeds; but, preferably, in the same direction. The difference in speed may not be great.

Near one end of drum 1 there is an annular rib or bridge, 15, constituting means for fixing an approximate normal thickness of the liquid-layer in the machine; and beyond this bridge there is a discharge outlet or outlets for the liquid. Such liquid discharge outlets may be in either the periphery or the head of the drum, and in the drawings I have shown two such openings, 16 and 17, one in the periphery of the drum and the other in head 2, either one of which may be used as preferred or as the quality of the material treated may make advisable; the opening not to be used being closed by suitable means, as for example the screw-plug 18. Near the other head of the machine there is a discharge-opening 19 for solids, and between this opening and the main portion of the interior of drum 1 there is an annular rib or bridge 20 having a height greater than the normal height of the liquid-layer in the drum as fixed by bridge 15 or discharge-opening 16. Bridge 20 will cause a conical ring 21 of the solid material being separated to form adjacent to it, and up this conical ring, and so above the level of the liquid, the solid material will be forced by the conveyer blades 22 and 221 on shaft 13 above mentioned.

In my Patent No. 834,043, dated Oct. 23, 1906, I have shown a centrifugal separator comprising a conical drum, in the larger end of which the liquid accumulates and overflows through a discharge opening, while the solid material is fed along the inclined periphery of the drum toward a discharge opening at its smaller end. In many mixtures of liquid and solid materials, for example, in mixtures containing precipitates and caustic soda solution, the solid material is so finely divided, or slimy, that it is difficult or impracticable to force it up along the surface of a drum having even very slight taper until the liquid has been so far removed from it that it is dry, or nearly so. For this reason the drum of the machine of the present case is substantially cylindrical; *i. e.*, has practically no taper whatever; and it is not until the solid material has been freed from the greater part of its liquid that it encounters the conical ring 21 and is forced up thereby toward the axis of the drum and so toward the discharge outlet 19.

At the liquid end of the machine there is an annular hood 23 to receive the discharged liquid; said hood having an outlet 24. At the solid end of the machine there is another annular hood, 25, to receive the discharged solid; said hood having an outlet 26.

For feeding the solid material along the periphery of the drum, as the latter rotates, the helical conveyer blades 22 and 221 on shaft 13 are provided. For carrying these blades, said shaft is provided with radial arms 27 carrying angle-iron strips 28, on which are mounted, (and secured by adjusting-nuts 29,) the screws 30 carrying the said blades 22 and 221. Since the strips project past the discharge head 9, these ends of the strips 28 may be supported by a spider 31 rotatively mounted on journal 4.

The conveyer blades 22 sweep as close to the periphery of the drum as practicable when, as is usually the case, the solid material is somewhat heavier than the liquid material and so forms the outer layer of the annulus of material treated, against the sides of the drum; but blades 221 (which are the blades rotating within the region of the cone 21 to be formed and maintained) are inclined inward progressively, so forming a screw conveyer of gradually decreasing diameter corresponding to the intended slope of cone 21. It is obvious that by adjusting the angle of incline of blades 221 and the point at which said blades begin to incline inward, the length and pitch of the inwardly-inclined surface of cone 21 may be varied as desired. Blades 32 upon the angle irons 28 serve to sweep the solid material around the drum into the discharge opening 19, and so prevent accumulation of the solid material at this end.

The conveyer blades 22 and 221 are not each complete spirals or helices, but each comprise a portion only of a turn, usually between 200 and 300 degrees, the ends of adjacent blades overlapping as clearly shown in Figs. 2 and 3. The result of this is that the blades form, with the sides of the drum 1, a zigzag passage for the flow of the liquid, whereby the liquid in passing from, say, the cone 21, to the liquid discharge opening, follows a course the length of which is many times that of the distance, in a direct line, from cone 21 to said discharge opening; and the length of this zigzag may be increased or decreased as desired by increasing or decreasing the number of conveyer blades 22 and their pitch and by increasing or decreasing the extent of lapping of adjacent blades. That such zigzag passage is formed will be seen by reference to the diagrammatic views, Figs. 4 and 5, which may be considered to be views of the machine of Figs. 1, 2 and 3, "developed." The drum 1 then becomes a trough 111, and the conveyer blades 22 become blades 222 movable lengthwise of this trough by means of sprocket chains 223, and overlapping respectively as do blades 22, so dividing the trough into a zigzag passage. The supply head 9 becomes a supply pipe 91 arranged to discharge into the trough. It will be obvious that in such an apparatus, which is in effect a settling apparatus, the length of the zigzag passage is determined by the number of the blades 222 and the extent of overlap of the blades. Centrifugal separating apparatus such as shown in Figs. 1, 2 and 3, is in principle the same as the trough apparatus shown in Figs. 4 and 5, except that for gravity, the only force tending to produce separation of solids and liquids in such trough apparatus, is substituted the vastly more powerful "centrifugal force"—the power of which is determined by the speed at which the drum is rotated, *i. e.*, the peripheral speed of the drum. When the drum is rotating, the material acted on is held out against its sides by centrifugal force, and the blades 22 and 221, being higher than the maximum depth of the annulus of material so formed, the liquid can reach the discharge opening, 16 or 15, only by flowing backward, zigzag fashion, between the blades. This is important, for it provides, within a drum of convenient length and weight, a settling passage of any length desired, so affording ample opportunity for the separation of the liquid from the solid matter; the solid matter being forced onward steadily toward the end having the discharge outlet 19, the liquid being displaced by the continually advancing layer of solid material and caused to flow back toward the liquid discharge outlet, 15 or 16. The action which takes place is, in principle, a settling action; but owing to the magnification, under the influence of centrifugal force, of the effect of the difference of specific gravity between the liquid and the solid material, the separation takes place relatively rapidly and perfectly, whereas in a trough apparatus such as shown in Figs. 4 and 5 it might take place very slowly if at all, with certain materials which are hard to settle.

The method of carrying out my process in the above apparatus is as follows: The drum 1 being in rotation at the proper speed, wet material to be separated is fed in through the hollow trunnion at one end of the machine and through the head 9 and discharge opening 10, and forms an annulus against the inner surface of the drum, the solid material, owing to greater specific gravity, going to the outside of this annulus, and the liquid to the inside. This separation of solid and liquid is not in most cases instantaneous, but is continuing throughout, or nearly throughout, the entire length of the annulus. The solid material is continually forced toward one end of the annulus by the revolving conveyer blades which blades, owing to the fact that they are not continuous helices, and yet overlap, form tortuous or zigzag passages through which the liquid flows backward to the liquid discharge. By the time the solid material has reached the conical ring 21 near the discharge opening for solids, it will be nearly free from liquid, and therefore will have lost those properties which made it substantially impossible to force the material up an incline when first introduced into the machine; and therefore the solid material will be forced up readily over the incline 21 to the discharge opening for solids; and in being forced up over this incline the greater portion, if not all, of what moisture may remain in the solid material will be driven out. Similarly, at the opposite end of the machine, the liquid flowing out through the liquid discharge will be nearly, if not entirely, free from solid, practically all of the solid material having separated out of the liquid by the time it reaches the liquid discharge opening, the annular rib or bridge 15 preventing the solid material from passing out at this end of the machine. Preferably the wet material to be separated is delivered to the annulus at a point where the composition of the material in the annulus is substantially the same as that of material being delivered to it. Separation then proceeds naturally, the proportion of solid material in the annulus growing progressively greater toward the discharge of the solids and the proportion of liquid material growing progressively greater toward the discharge for liquids.

Where, as in the present invention, the solids are continuously withdrawn from one end of a settled layer while the liquid is continuously withdrawn from the other end, the relative proportion of solids to liquid at any point in the length of such layer will depend upon the relative distances of such point from the solids-discharge end and the liquid-discharge end. Going toward one end, the settled mass becomes progressively richer in solids; going toward the other end, it becomes richer in liquid. Under the present invention therefore, the feed of mixed solids and liquid to be separated is preferably at a point where the ratio between solids and liquids in the mass undergoing settling is the same as the ratio of solids to liquids in the mixed material to be treated; it is at some mid point in the layer of material undergoing settling. This is particularly desirable where the materials to be treated are difficult to separate; a class of materials to which the present invention is particularly applicable.

With a slight differential in speed between the drum and the conveyer mechanism in the drum, such conveyer mechanism moves relatively to the layers of material to be treated at a correspondingly low speed and therefore produces little disturbance therein. And, from the arrangement of the conveyer blades, the backward path which the liquid travels is much longer than the length of the machine further minimizing the amount of disturbance at any one point in its path.

Most mixed materials where solids and liquids have any difference in specific gravity will tend to settle somewhat and the settled solids will stand some movement without again becoming suspended. In the present invention therefore, centrifugal settling having been produced the settled solids are slowly and gently pushed toward one end of the layer without disturbing the liquid more than can be avoided until finally they accumulate in a nearly dry condition at one end of such layer. At the point of feed where the raw material is thrown, more or less violently, into the liquid, more or less disturbance will be produced and this point is therefore chosen at what is, so to speak, the neutral point in the layer; the point where the ratio of solids to liquid in the layer is, at least approximately, the same as the ratio in the material fed thereto.

The apparatus herein illustrated and described, is covered by a separate application Sr. No. 416,298, filed February 17, 1908, (Patent No. 1,005,800, dated October 17, 1911), of which this is a division.

What I claim is:—

1. In the separation of liquids and solids, the process which comprises forming a long layer composed of settled solids beneath a body of liquid, continuously working said solids toward one end of said layer while avoiding so far as possible distributing the settling in said layer and moving said solids up over the liquid level to a discharge at said end while discharging liquid at the other end of said layer, and continuously feeding fresh wet material to be separated to a point in rear of the point where the elevation of said solids begins.

2. In the separation of liquids and solids, the process which comprises forming a long layer composed of settled solids in a body of liquid, continuously working said solids toward one end of said layer while avoiding so far as possible disturbing the settling in said layer and moving said solids up over the liquid level to a discharge at said end while discharging liquid at the other end of said layer, and continuously feeding fresh wet material to be separated to a mid portion of said layer at a point where the ratio of liquid to settled solids is approximately the same as the ratio of liquid to solid in such wet material.

3. In the separation of solids and liquids, the process which comprises forming a centrifugally supported annulus comprising an annular layer of settled solids beneath an annular layer of liquid, continuously working said solids toward one end of said annulus and there discharging them at a point nearer the axis of the annulus than the surface of the liquid layer while continuously discharging liquid at the other end of said annulus, and continuously feeding fresh wet material to a point in rear of the point where the raising of said solids toward the axis begins.

4. In the separation of solids and liquids, the process which comprises forming a centrifugally supported annulus comprising an annular layer of settled solids in an annular layer of liquid, continuously working said solids toward one end of said annulus and there discharging them at a point nearer the axis of the annulus than the surface of the liquid layer while continuously discharging liquid at the other end of said annulus, and continuously feeding fresh wet material to a mid portion of said annulus where the ratio of solids and liquids is approximately the same as the ratio of solid and liquid in such wet material.

5. In the separation of liquids and solids, the process which comprises forming a long layer composed of settled solids in a body of liquid, continuously working said solids toward one end of said layer in a path materially longer than said layer while avoiding so far as possible disturbing the settling in said layer and moving the solids up over the liquid level to a discharge at said end while discharging liquid at the other end of said layer, and continuously feeding fresh wet material to be separated to a mid portion of said layer.

6. In the separation of liquids and solids, the process which comprises forming a centrifugally supported annulus comprising an annular layer of settled solids in an annular layer of liquid, continuously working said solids toward one end of the annulus in a path materially longer than said layer and there discharging them at a point nearer the axis of the annulus than the surface of the liquid layer while continuously discharging liquid at the other end of said annulus, and continuously feeding fresh wet material to a mid portion of said annulus.

7. In the separation of liquids and solids, the process which comprises forming a centrifugally supported annulus comprising an annular layer of settled solids in an annular layer of liquid, moving said solids toward one end of the annulus, and causing the liquid to flow backward toward the other end of the annulus in a zigzag path, and feeding fresh wet material to the annulus.

8. In the separation of solids from liquids, the process which comprises forming a long layer composed of solids settled from liquid, the ratio of solids to liquid progressively increasing toward one end of such layer and the ratio of liquid to solids increasing toward the other, continuously removing solids from the former end and liquids from the latter end and continuously introducing fresh material to be separated at a point in said layer where the ratio of solids to liquids is substantially equal to the ratio of solids to liquids in such fresh material.

In testimony whereof I affix my signature, in the presence of two witnesses.

JOHN J. BERRIGAN.

Witnesses:
H. M. MARBLE,
FRANK E. RAFFMAN.