H. DE RAASLOFF & T. E. BROWN.

CENTRIFUGAL SEPARATOR.

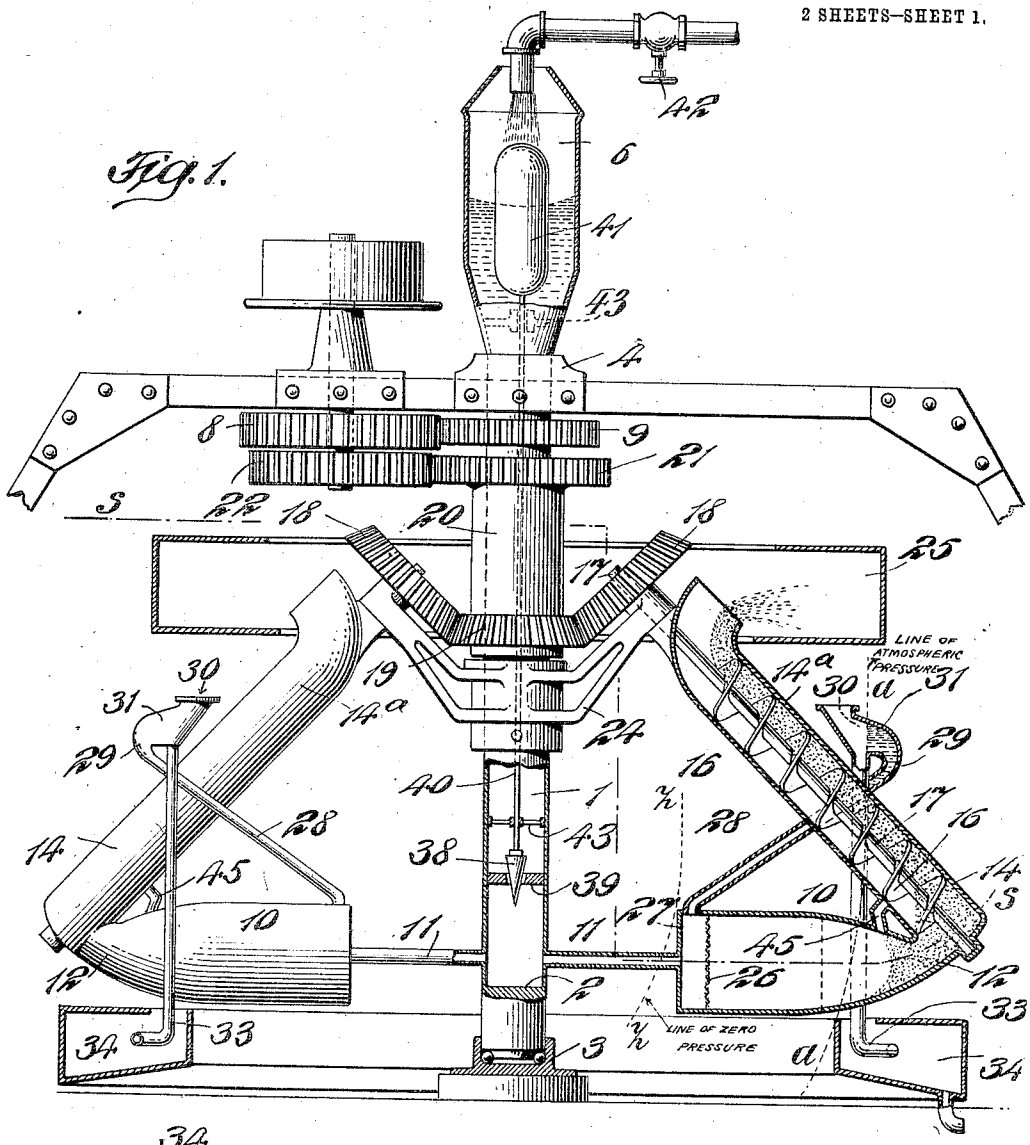
APPLICATION FILED MAR. 16, 1909.

1,044,570.

Patented Nov. 19, 1912.

2 SHEETS—SHEET 1.

Fig. 1.



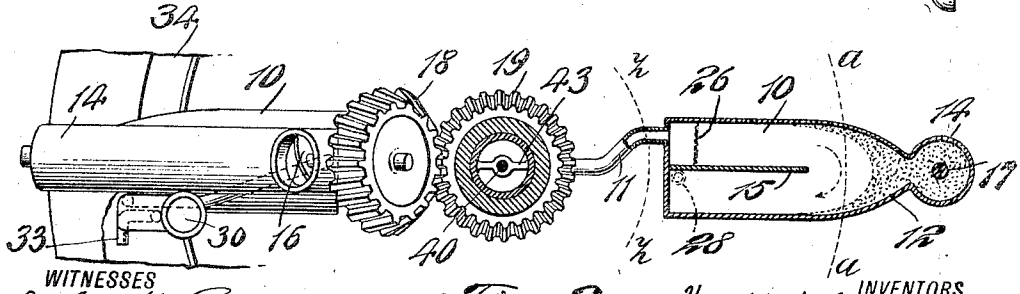


Fig. 2.

WITNESSES

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2 SHEETS—SHEET 2.

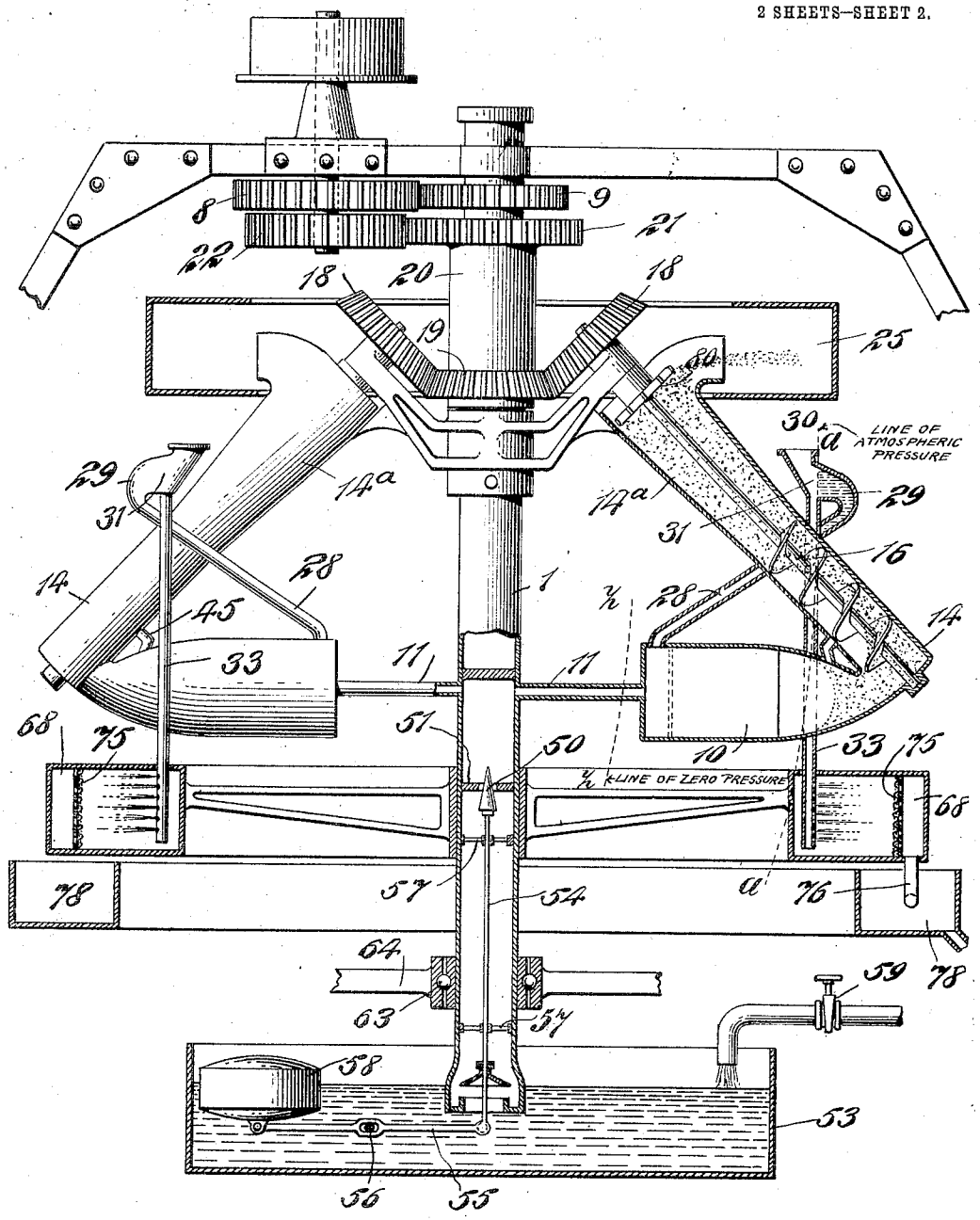

Fig. 3.

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CENTRIFUGAL SEPARATOR.

1,044,570. Specification of Letters Patent. Patented Nov. 19, 1912.

Application filed March 16, 1909. Serial No. 483,670.

To all whom it may concern:

Be it known that we, HARALD DE RAASLOFF and THOMAS E. BROWN, both being citizens of the United States of America, and residents of the borough of Manhattan, in the city of New York and State of New York, have invented certain new and useful Improvements in Centrifugal Separators, of which the following is a specification.

This invention relates to improvements in centrifugal separators, and particularly to improvements in that class of centrifugal machines which are intended to effect the separation from liquids of comparatively finely divided heavier solid particles.

An example of the class of machines to which the invention is particularly adapted, although it is not limited to such machines, is machines for effecting the separation of the mud, pulp or slimes from the liquid in the various processes of ore dressing and treatment.

It is the purpose of this invention to provide a machine which will effect the continuous separation of the liquid and the solid matters; will prevent the escape of the liquid with the solid matters; will enable the liquid and the solid matters to be thoroughly separated from each other, and collected in different receptacles; and will enable the solid matters to be extracted from the machine in the driest possible condition.

As is well known to those experienced in this art, the continuous separation of liquid from solid matters originally mixed with the liquid, without loss or waste of one or the other ingredient, is a matter of great difficulty. On the one hand, the liquid tends to escape with the heavier particles and from the same orifice, which destroys the effect of the separation; upon the other hand the "plug", or mass of concentrated heavier particles, acquires such a condition, sometimes too soft, sometimes too hard, that its continuous extraction from the separating chamber becomes impossible; and if the continuous extraction of the solid matters is interrupted at any time, the machine clogs and the operation must stop. The concentration of the heavier particles on the extended surfaces of the peripheral walls of the separating vessels, in the form of rings or layers of concentrated material, which rings or layers are of relatively great superficies and relatively small thickness, and the removal of these concentrates by scrapers or conveyers are not successful. For the ring of lighter liquid is unavoidably in such state of agitation adjacent to the layer of concentrates, that the latter are more or less disintegrated and remixed with the liquid from which it has just been separated; and in all such machines the disturbance of the liquid due to the incoming flow and circumferential motion of the liquid is further aggravated by the stirring up and agitation of the liquid by the motion of the scrapers or conveyers. Nor can any attempt at centrifugal separation of such materials as are now in question be effectual, in which the concentrates are conveyed through any part of the body of the liquid out of which separation is taking place, for in any such case, the liquid through which the concentrates are conveyed will by its motion more or less disintegrate the concentrates and impair the extraction and the motion of the conveyer will impair the centrifugal separation.

We have invented a machine by which the foregoing and other difficulties are overcome in the manner hereinafter more fully explained.

Certain of the important features of the invention are here summarized, to aid in understanding the fuller explanation hereinafter given.

First: The chambers in which the separation takes place, termed "separating chamber," are of relatively great radial dimension, so as to obtain a considerable depth of gently flowing liquid and sufficient time for the separation and deposit of the particles of heavier material. But portions of separating chambers are preferably of small cross area, and particularly is this so where the concentration takes place, so that the separated heavy material deposits and concentrates in relatively contracted passages or necks, and forms what we term "plugs," which are of such dimensions and consistencies as to be readily operated upon by conveyers, and removed from the separating chambers at the same rate as that at which the plugs are formed. The plugs fill, or partially fill, said passages or necks and separate the liquid undergoing separa-

tion from the nozzles in which extraction takes place. As the plugs are of relatively great radial length, and are removed by the conveyers at the same rate as that at which the plugs are formed, some plug remains continuously in the neck of each chamber, and always divides the liquid undergoing separation from said nozzles.

Second: The outlet orifices of said separating chambers are connected with nozzles, or chambers, wholly external to the separating chambers and extending to a point nearer the axis of rotation of the machine than the extremity of said chamber, and in fact, said nozzles extend inwardly at least to the line of atmospheric pressure or line of liquid, but are, as herein above stated, wholly external to the separating chambers. According to well understood principles of centrifugal force and frictional resistances, the plugs, were there no conveyers, would be forced into these nozzles by the centrifugal force, until the slope of the surface of the plug was at the angle of friction of that particular material, and thereafter the plug would move no farther and would resist any further movement of plug from the separating chamber. That part of the plug which is in the said nozzle is entirely separated from and out of the way of the liquid in the separating chamber, and the conveyer may therefore remove it without interference with or from the liquid in the separation chamber. As the conveyer removes the outer end of the plug, the centrifugal force moves the plug out, and the formation of the plug in the separating chamber and its removal by the conveyer go on continuously and simultaneously.

Third. The liquid outlet, or overflow, determines the "line of atmospheric pressure," and the machine is so constructed and is operated at such speed, that at this overflow the centrifugal force of the liquid just overbalances atmospheric pressure. The machine is also so constructed, and the flow of the materials into the separating chamber is so controlled, that approximately zero pressure exists at some point between the "line of atmospheric pressure" and the axis of rotation of the machine, and the line of zero pressure defines, by preference, the location of the inner ends of the separating chambers, said ends being preferably located just outside the line of zero pressure, so that said separating chambers will remain full of liquid; and said chambers are preferably connected with said point of liquid discharge or overflow by pipes or conduits which connect with said separating chambers just outside of said line of zero pressure. By the aforesaid relations of atmospheric pressure and zero pressure in the machine, we are able to obtain, within comparatively small radial dimensions, a machine, the separating chambers of which have relatively great radial depth of liquid in such a state of gentle flow as affords ample time for the separation and deposit of the heavy materials, and effectually obviates injurious eddies and whirls in the liquid in said separating chambers.

Fourth. To insure removal of the plug in the driest possible condition, and in a thoroughly practicable manner, the nozzles on said separating chambers have extensions, or conveyer casings, extended on a proper inclination toward the axis of rotation, and to a point within the line of atmospheric pressure or "line of liquid," so that the part of the conveyer casing within said "line of liquid" constitutes a drying chamber for the plug, centrifugal force and gravity both coöperating to free the plug from the liquid which may have been in its pores: the discharge of the plug taking place at a point well within the said line of liquid, and it being understood that said conveyer casing, as well as said nozzles, are wholly external to said separating chambers, so that the plug, during all its movement from the point of concentration to the place of discharge, is separated from the mixture which is undergoing separation.

The principle of the machine may now be more clearly explained as follows: Suppose a vessel closed at one end and of relatively great length and relatively small cross area, and having a still more contracted neck, said neck connecting with a nozzle turned upward and backward, to be revolved around an axis perpendicular to its length: the neck being filled with a plug of finely divided heavy solid particles, and the rest of the vessel containing a liquid. Now the centrifugal force will squeeze the plug outwardly through the neck. The liquid will also move out and rise in the nozzle the inner end of the liquid forming a wall having a position and slope determined by the relation of the centrifugal force to the atmospheric pressure and gravity, and there will be a vacuum behind the inner wall of the liquid, and the position of that wall will be the line of "zero pressure," and the line of liquid in the nozzle will be at the line of atmospheric pressure. Now the neck of the vessel being connected with an external nozzle or chamber, as for example the necks of separating chambers 10 in Figure 1 of the accompanying drawings are connected with the external nozzles 14, then the plug would enter the nozzle until the surface of the plug acquired the angle of friction for that plug, when the plug would advance no farther into the nozzle. Now suppose the said vessel to be provided with an escape pipe for

the liquid led outwardly but to a convenient point preferably nearer the axis of rotation than is the point of concentration, and at that point opened to atmosphere, but being properly curved or trapped, and the inner end of said liquid escape pipe being connected with said vessel just outside the line of zero pressure. An illustration of a possible position for such pipe is given in Figs. 1 and 3 of the accompanying drawings, where the pipe is indicated by the number 28. Now suppose that the apparatus is revolved at such velocity that the centrifugal force at the open end of said liquid discharge pipe is just equal to atmospheric pressure. Plainly there would be no discharge of liquid by centrifugal force, the atmospheric pressure and the centrifugal force just balancing each other. Now suppose the inner end of this said vessel connected with a source of supply of the mixed liquid and solid materials, so controlled that the mixture can enter the vessel only at such a rate as will give ample time for the separation and deposit of the heavier solid particles, and without producing injurious currents or eddies. The mixed materials would manifestly enter the vessel under a head equal to the hydraulic head of the mixture plus atmospheric pressure. And if the supply of the mixture to the tank or reservoir from which it flowed to the separating vessel were constant, manifestly an orifice or pipe of proper constant size connecting the reservoir with the separating vessel would be sufficient, without a controlling valve. But because of variations in the amount to be separated, it is desirable to use a control valve, whereby the area of the inlet orifice to the separating vessel will be varied to suit the supply admitted to the machine and thus maintain the vacuum or "zero pressure." Under the conditions assumed, it will be manifest that the discharge of the liquid from the apparatus, after separation of the solid matters, will be exactly equal to the inflow, and is therefore governed by the aforesaid hydraulic and atmospheric head, not by the centrifugal force, and can be controlled with great nicety, and without tending to disintegrate the plug, which is formed and expelled from the separating vessel by centrifugal force and through an outlet independent from the liquid outlet. Finally assume, that as the plug enters the said external nozzle it is caught by a conveyer, which conveys it through a chamber or casing in such a direction that the plug moves toward the axis of rotation against the centrifugal force, and to a point nearer the axis of rotation than the line of liquid. Manifestly the liquid could not flow through said conveyer casing, or said nozzle, against the centrifugal force and atmospheric pressure, and could never reach a point materially nearer the axis of rotation than the line of liquid; and therefore a portion of the conveyer casing would constitute a drying chamber, and the plug would be dried to the greatest possible degree by its passage through the dry part of the conveyer casing. Now as the mixture is continually flowing into the separating vessel at a uniform rate, and as the plug is continually forming and continually being removed by the conveyer at the rate at which it is formed, the operation goes on continuously, without ever clogging the separating vessel with unremoved deposits of concentration, or ever permitting the escape and waste of the liquid through the plug nozzles.

The apparatus illustrated in the accompanying drawings, and hereinafter described, illustrates two modifications of machines constructed according to the foregoing principles, but it will be understood that the invention is not restricted to such particular apparatus, but includes all centrifugal separators which embody the principle of producing the separation in separating chambers provided with external nozzles for the concentrates led to a point nearer the axis of rotation than is the extremity of said chamber and also all centrifugal separators which embody the principle of the atmospheric and zero pressures to attain the desired length and time of flow of the liquid through the machine.

Referring to the drawings which accompany the specification to aid the description, Fig. 1 is a vertical section and elevation of one form of apparatus embodying the invention. Fig. 2 is a broken plan and horizontal section, on the line *s*—*s* of Fig. 1. Fig. 3 is a vertical section and elevation of another form of apparatus embodying the invention, in which the material is drawn in from below.

Referring to Figs. 1 and 2, 1 is the vessel or reservoir, preferably in the form of a pipe positioned at the axis of rotation and closed at the bottom 2, and revolved in suitable bearings 3, 4 at high velocity by any suitable means, as gearing 8, 9. The materials to be separated, as liquids and solids, are delivered into a funnel 6 fixed on the upper end of pipe 1, said funnel also preferably constituting a float chamber for controlling the inlet valve, as will be hereinafter explained. Said pipe 1 communicates near its lower end with separating chambers 10, preferably disposed symmetrically around the axis of rotation and connected with said pipe 1 by branch pipes 11. Each said chamber 10 is preferably relatively of great dimension in a direction perpendicular to the axis of rotation of the apparatus, and is preferably divided by a longitudinal parti-

tion 15 for a portion of its length, to prevent direct communication between the inlet and the outlet of chamber 10, and the outer end of each said chamber is also preferably contracted to form a neck of small cross sectional area, 26 being a perforated diaphragm or partition preferably used and positioned as seen in Figs. 1 and 2. The concentration of the heavier materials takes place in the outer end of the separating chamber. Said chambers 10 are also of such length, radially to the machine, that the extremities of said chambers are outside of,—or farther from the axis of rotation than—the line of atmospheric pressure *a*—*a*. Said necks 12 connect with nozzles or casings 14, which are wholly external to said chambers 10, and carried at an inclination upwardly and inwardly, forming a trap to prevent the admission of air, and toward the axis of rotation, and said nozzles or casings 14 may be considered as extensions of said chambers 10 or necks 12 continued externally to said chambers 10 and toward the axis of rotation. Of course said chambers 10 might be without contracted necks, or might have long tubular-like necks, or might be formed of various shapes, but in all cases we consider the extremity of said chamber to be the part of the chamber or neck farthest from the axis of rotation, and practically where the connection with the nozzle or conveyer casing is made. Connected with and extending upwardly and inwardly from said casings 14 are the worm casings 14ª, which may either be connected with the ends of said casings 14 by flange joints or in any other suitable manner, or may be integral with said casings 14, as shown in the drawings. Said worm casings 14ª contain worm conveyers 16, the shafts 17 of which are driven at proper speed in any suitable manner, as by bevel gears 18—18 of the worm shaft and bevel gear 19 on a sleeve 20 turning on pipe 1, and driven at suitable differential velocity by gears 21—22 or any suitable means; 24 being brackets fixed on said pipe 1, and carrying the bearings for the upper ends of the said worm shaft 17, and the lower ends of said shafts 17 being conveniently stepped in the lower heads of said casings 14. We prefer to somewhat enlarge the upper ends of said worm casings 14ª, as seen in Fig. 3, to facilitate their use as drying chambers, and the worms 16 should then preferably not extend to the upper ends of said casings 14ª. Said casings are arranged to discharge the concentrates into an annular trough 25, from which they may be removed in any suitable manner. And it is to be understood that any other suitable form of conveyer, casing, or nozzle may be employed instead of the worm conveyer, and the conveyer, casing and nozzle shown in the accompanying drawings and described in this specification. The inner closed ends 27 of said separating chambers 10, are located a little outside of the line of zero pressure *z*—*z*—that is a little farther from the axis of rotation than is said line,—so that said chambers 10 shall remain full of liquid, when revolving at the designed velocity, and each of said chambers 10 will be connected with a liquid discharge pipe 28 conducted outwardly and trapped or curved at the outer end as at 29, and opened to atmosphere at the "line of atmospheric pressure," as indicated at 30. To facilitate freeing the apparatus from air, said pipes 28 are preferably connected with the tops of said chambers 10, and are inclined upwardly toward their outlets. Said trapped ends 29 of pipes 28 are preferably inclosed in trap vessels 31, having openings to atmosphere and provided with pipes 33 discharging into a stationary annular trough 34, from which the separated liquid will be drawn or discharged by any suitable means. Said trap vessels 31 may be supported by said worm casings 14ª, but have no communication with the interior of said casings.

To adapt the apparatus to a variable supply of mixture, and to a variable output controlled by supply valve 42, said pipe 1 is provided at a point above pipes 11, and preferably below the traps 29, with a conical valve 38 seating on a conical seat through a diaphragm 39, and said valve is suspended by a stem 40 from a float 41 operated by the rise and fall of liquid in said funnel 6, 43 being a guide for said stem 40.

The operation is as follows: Suppose the apparatus to be empty and at rest; and that the mixed liquid and heavier particles, in more or less finely divided condition, are run into said pipe 1 from valve 42, valve 38 being closed. As the mixed materials rise in funnel 6 they will at last lift said float 41, open said valve 38, and fill the chambers 10 and connected parts with said mixed materials to such a level that the said materials will overflow at the trapped end of pipe 28 and discharge at the lower end of pipe 33. The entry of the mixture will also expel the air from the machine. As soon as this discharge at pipe 33 is observed the machine is started revolving; if then no more liquid is admitted from valve 42—the overflow will continue at 29, and the float will fall, closing valve 38. The centrifugal force will continue the overflow at 29 and the liquid under valve 38 will move out, causing a vacuum under valve 38, until the inner end of the liquid in pipe 11 is nearly to the inner end 27 of chamber 10. At this time the machine has reached its proper velocity, further overflow at 29 ceases, and the liquid stands at the "line of liquid" in the nozzle 14. The head or pressure on the liquid at the level of the

diaphragm 39 is now the height of the column of liquid in pipe 1, plus atmospheric pressure. The valve 42 is now opened and set to the desired amount, the materials flow into the funnel 6, again raise float 41, open valve 38, and thereby adjust the orifice until the inflow, due to the head and atmospheric pressure, just equals the supply from 42, and an equal overflow of liquid occurs and continues at trap 29. The mixed solids and liquids flow gently through chambers 10, the solids separate from the liquid, collect on the sides of chambers 10, are moved outward by the centrifugal force, and concentrate in the necks 12. The materials first entering pass to nozzles 14 and are churned by the worms 16 until sufficient plug has formed in 12 to press them to a proper consistency to resist turning. The worms 16 will thereafter convey the plugs through said nozzles 14 and casings 14ª to the upper discharge ends of said casings 14ª, which, as hereinbefore stated, are nearer the axis of rotation of the machine than are the extremities of the separating chambers 10; and from said discharge ends of said casings 14ª the said concentrated materials discharge into the said troughs 25, and are conveyed away in any suitable manner.

The upper parts of the casings 14ª constitute a drying chamber, since they extend within the liquid line, whereby the pulp is more or less dried before it is discharged from the said casings 14ª; and since said worms 16 do not fit water tight in said nozzles 14 or casings 14ª, or are perforated or arranged to permit the liquid which separates from the concentrates, as the worm raises said concentrates, to trickle through the interstices of the material under the influence of centrifugal force and gravity, and past the worm blades back to the normal "line of liquid." In the case of impervious clayey plugs it will be difficult for the liquid in nozzles 14 to equalize with the liquid in chambers 10, and with such materials we prefer to use an equalizing pipe 45 connecting the nozzles 14 outside of the line of liquid with chambers 10. In order to obtain the best results with said worms, and to obviate the revolving of the concentrates by the worms, it is preferable to arrange the worms at about an angle of 45° with the direction of centrifugal force, *i. e.* the radius, but they need not be in the plane of the axis of rotation, but may be in any convenient plane. The lighter liquid elements of the mixture entering said chambers 10 flow gently back, without violent currents or eddies, to the connections with said pipes 28, through said pipes to their trapped ends, which are just outside of and determine the line of atmospheric pressure, out of said trapped ends to the trap vessels 31, and thence by the pipes 33, discharge into the trough 34. Thus the utilization of the atmospheric pressure and the zero pressure provides a body of liquid of such considerable radial length, as to afford proper time for the separation and concentration of the heavier materials, and avoids eddies and whirls which would injuriously affect the separation, and this without unduly increasing the radial dimensions of the machine, or interfering with the proper location of its various parts.

The machine may be started by simply setting it in rotation and turning on the valve 42 to the proper amount, but in this case a longer time will be required to expel the air and attain the operating conditions, hence we prefer to start in the manner described.

Referring to Fig. 3, the apparatus is shown arranged to lift the material to be separated from below by the atmospheric pressure and the vacuum induced by the centrifugal force. The separating chambers 10, nozzles 14, worm casings 14ª, worms 16, pipes 28, traps 29, trap vessels 31, discharge pipes 33, and numerous other parts are substantially the same in construction and operation with corresponding parts of Fig. 1, and no further description of such parts is necessary. But the valve 50, which controls the orifice for the inlet of the mixed materials, is now arranged below the pipes 11, and preferably to open downwardly, and in practice the said valve 50 may be arranged nearer the open lower end of pipe or vessel 1, and if desired a check valve opening upwardly may also be provided in said pipe 1, below said valve 50, the swiveled valve stem 54 being guided by a suitable guide or guides 57. Said lower open end of pipe 1 enters the mixed materials in a vessel 53, into which vessel said materials are delivered by a pipe and controlled by a valve 59. Said valve 50, preferably opening downwardly, is connected by the stem 54 with a lever 55 fulcrumed at 56, and connected at its outer end to a float 58. Said pipe 1 will be closed above pipes 11. Any suitable bearing, as 63, supported on arms 64 connected in any suitable manner with the frame work of the machine, may be provided to support and aline the lower end of said pipe 1.

The operation is as follows: The apparatus being preferably at rest, and valve 50, (or both said valve and the said check valve, if both are used) being closed, the apparatus is primed by pouring priming liquid, (which may be the same as the materials to be treated) in through trap vessels 31 until the machine is full. The machine is now started up, the centrifugal force causes the excess liquid to overflow at trap 29 and a vacuum is formed in pipes 1 and 11 as before. The supply valve 59 is opened the proper amount, the materials rise in vessel

53, the float 58 opens the valve 50 and adjusts the area of the orifice to suit the supply admitted by valve 59; the atmosphere presses on the surface of the materials in vessel 53, causes them to rise in pipe 1, and the centrifugal force projects the mixed materials outwardly from pipe 1 into chambers 10, where the separation takes place, and the plugs form and are removed by the worms 16 as before, while the lighter liquid flows by pipes 28 to trap vessels 31, and thence by pipes 33 to the troughs 68, which may be provided with filtering screens as will be hereinafter described.

A priming pipe and valve may be attached to the apparatus, but we prefer to prime as above described, and avoid possible leakage of air through unnecessary joints and valves.

The final clarification of the separated liquid, and the separation therefrom of very minute particles of solid matter such as cannot be directly separated by centrifugal force, may be facilitated by placing filtering screens 75 in the troughs 68, said screens being of any suitable material, and supported in any suitable manner. In Fig. 3 said screens are shown as a perforated ring covered with suitable filtering material arranged a short distance inside of the outer wall of the trough 68, and said trough is preferably fixed to said pipe 1, and revolved therewith. One or more outlets 76 from said trough 68 discharges the filtered liquid into another annular stationary trough 78 from which it is removed by any suitable means. In Fig. 3 we also show a scraper 80 fixed on the conveyer shaft above the upper end of the casing 14^a, and in such a position as to cut or scrape off the upper end of the plug, as the same is worked up by the conveyer, and deliver it into the said trough 25. Said scraper may be of any desired construction as a wheel with scraping or cutting blades, and it will be understood that scrapers and filtering screens may be used with all forms of the machine.

To prevent spilling the discharged plug and liquid over their respective troughs 25, 34 and 68, the tops of said troughs should preferably be partly covered, about as indicated in the drawings, and the discharge end of pipes 33 will preferably be directed so as to discharge the liquid in a tangential direction opposed to the direction of revolution of the machine and not radially.

In place of the worm conveyers and casings shown in the drawings and hereinbefore described, any other suitable form of conveyer and casing may be employed, it only being necessary that the conveyers and casings be so constructed and arranged as to convey the concentrates externally to the separation chambers and in such direction that the motion of the concentrates produced by the conveyers is opposed to the motion which would be induced by the centrifugal force.

Now having described our improvements we claim as our invention.

1. The combination in centrifugal separators of a separating chamber of relatively great radial dimension, and a nozzle for the discharge of the heavy concentrated materials extended externally from said chamber to a point nearer the axis of rotation than the extremity of said chambers.

2. The combination in centrifugal separators, of a separating chamber of relatively great radial dimension, a nozzle for the discharge of the heavy concentrated materials extended externally from said chamber to a point nearer the axis of rotation than is the extremity of said chamber, and a conveyer for removing said concentrated materials from said nozzle.

3. The combination in a centrifugal separator, of a separating chamber of relatively great radial dimension and having a concentrating space of relatively small cross section, a nozzle extended externally from said chamber to a point of discharge nearer the axis of rotation than is the extremity of said chamber, and a conveyer for moving the said concentrates through said nozzle.

4. The combination in centrifugal separators, of a separating vessel of relatively great radial dimension and having a concentrating space of relatively small cross section, a nozzle for the discharge of the heavy concentrated materials extended externally from said chamber to a point nearer the axis of rotation than is the extremity of said chamber, and a discharge conduit for the liquid separate from said nozzle.

5. The combination in a centrifugal separator, of a separating chamber of relatively great radial dimension and having a concentrating space of relatively small cross section, a nozzle extended externally therefrom to a point of discharge nearer the axis of rotation than is the extremity of said chamber, a conveyer for moving the said concentrates through said nozzle, and a discharge conduit for the liquid separate from said nozzle.

6. The combination in a centrifugal machine of a reservoir for the mixture to be separated, a revolving separating chamber connected therewith and having relatively great radial dimension and a concentrating space of relatively small cross area, a nozzle for the discharge of the heavy concentrated materials external to said chamber and extending nearer the axis of rotation than is the extremity of said chamber, and an outlet for liquid separate from said nozzle.

7. The combination in a centrifugal machine of a reservoir for the mixture to be separated, a revolving separating chamber

connected therewith and having relatively great radial dimension, a nozzle for the discharge of the heavy concentrated materials external to said chamber and extending nearer the axis of rotation than is the extremity of said chamber, an outlet for liquid separate from said nozzle, and a conveyer for moving said concentrated materials through said nozzle.

8. In a centrifugal machine, an outlet therefrom for the discharge of the heavier separated materials, and means adapted to produce an overbalancing atmospheric pressure opposed to the egress of the lighter liquid from said outlet.

9. In a centrifugal machine, a rotary separating chamber provided with an outlet for the discharge of the heavier concentrated materials, and means adapted to produce unbalanced atmospheric pressure to prevent the efflux of the lighter liquid from said outlet.

10. In a centrifugal machine, a rotary separating chamber provided with an outlet for the discharge of the heavier concentrated materials, and with an independent outlet for the discharge of the lighter liquid, and means adapted to produce unbalanced atmospheric pressure to prevent the efflux of liquid with said heavier concentrated materials.

11. In a centrifugal machine, the combination of a separating chamber, and a valve in operative communication therewith and adapted to maintain pressure lower than atmosphere in a part of said chamber.

12. In a centrifugal machine, the combination of a separating chamber provided with an outlet for heavier concentrated materials, and a valve adapted to maintain pressure lower than atmospheric pressure in a part of said separating chamber nearer to the axis of rotation than is said outlet.

13. In a centrifugal machine, the combination of a separating chamber provided with an outlet for the heavier concentrated materials, and with an inlet for mixed materials, and a valve controlling said inlet and adapted to maintain lower than atmospheric pressure in a part of said chamber nearer to the axis of rotation than is said outlet.

14. In a centrifugal machine, a rotary separating chamber having relatively great radial dimension and a concentrating space of relatively small cross area and containing less than atmospheric pressure in a part of said chamber nearer the axis of rotation than is said concentrating space.

15. In a centrifugal machine, a rotary separating chamber having relatively great radial dimension and a concentrating space of relatively small cross area and containing less than atmospheric pressure in a part of said chamber, said chamber being provided with an outlet for heavy concentrated material, and with a separate conduit for lighter liquid extended from said chamber to a point where the centrifugal force is substantially equal to atmospheric pressure.

16. The combination in a centrifugal machine, of a separating chamber containing less than atmospheric pressure in a part thereof and provided with an outlet for the heavy concentrated material and with a conduit for liquid extended from said chamber to a point where the centrifugal pressure substantially equals atmospheric pressure.

17. The combination in a centrifugal machine, of a separating chamber containing less than atmospheric pressure in a part thereof, and a conveyer adapted to convey the heavy materials to a point nearer the axis of rotation than is the line of atmospheric pressure.

18. The combination in a centrifugal machine, of a separating chamber containing less than atmospheric pressure in a part thereof, a conduit for liquid extended from said chamber to a point of substantially atmospheric pressure, an external nozzle separate from said liquid conduit, and a conveyer adapted to move the heavy materials in said nozzle to a point nearer the axis of rotation than is the line of atmospheric pressure.

19. The combination in a centrifugal machine of a separating chamber containing less than atmospheric pressure in a part thereof and provided remote from the axis of revolution with a trapped outlet, and a valve controlling the area of the orifice through which materials to be separated are supplied to said separating chamber.

20. The combination in a centrifugal machine, of a separating chamber containing less than atmospheric pressure in a part thereof and provided remote from the axis of revolution with a trapped outlet for separated materials and with an inlet, and a valve controlling the orifice through which the mixture is supplied to said separating chamber.

21. The combination in a centrifugal machine, of a separating chamber adapted to contain less than atmospheric pressure in a part thereof, a reservoir for the materials to be separated, and a valve operated by the height of liquid in the reservoir for controlling the orifice through which the mixture is supplied to said chamber.

22. The combination in a centrifugal machine, of a separating chamber containing less than atmospheric pressure in a part thereof, a reservoir for materials to be separated, and a float-controlled valve for controlling the orifice through which said materials are supplied to said chamber.

23. The combination in a centrifugal machine, of a reservoir, a revolving separating

chamber connected therewith and provided with an outlet for the discharge of the heavy concentrated materials and with an independent outlet for the discharge of the lighter liquid substantially at the line of atmospheric pressure, a valve controlling the inlet to said separating chamber and adapted to maintain less than atmospheric pressure in said separating chamber, and a float adapted to open and close said valve according to the level of the mixture in said reservoir.

24. The combination in a centrifugal machine, of a separating chamber provided with an outlet for the discharge of the heavy separated materials, and with a conduit for the discharge of the lighter liquid substantially at the line of atmospheric pressure trapped to prevent the entry of air, and a valve to maintain less than atmospheric pressure in said separating chamber.

25. The combination in a centrifugal machine, of a reservoir for the materials to be separated, a revolving separating vessel connected with said reservoir, and provided with an outlet for the discharge of the heavy concentrated materials and with an independent trapped outlet for the discharge of the lighter liquid at substantially the line of atmospheric pressure, a valve controlling the inlet to said separating chamber and adapted to maintain less than atmospheric pressure therein, and means operated by the level of the materials in said reservoir for opening and closing said valve.

26. In a centrifugal machine, a separating chamber provided with an outlet for the discharge of heavy solid materials, a separate outlet for the discharge of liquid distant therefrom and extended substantially to the line of atmospheric pressure, and with a partition extended into said chamber to a point intermediate of said outlets.

27. The combination in a centrifugal separator, of a separating chamber, a nozzle for the discharge of heavy materials, a conveyer for conveying said materials along said nozzle, and a scraper adapted to remove portions of said materials.

28. The combination in a centrifugal machine, of a separating chamber provided with an outlet for the discharge of heavy materials and with a conduit for the discharge of liquid opened to atmosphere substantially at the line of atmospheric pressure, a discharge pipe from said conduit, and a discharge receptacle adapted to receive the discharge from said pipe.

29. The combination in a centrifugal machine, of a separating chamber, a reservoir operatively connected therewith, a float chamber, a float therein, and a valve operatively connected with said float and adapted to control the inlet orifice to said chamber according to the level of the mixture in the float chamber and maintain less than atmospheric pressure in said chamber.

30. In a centrifugal machine, the combination with a rotary reservoir of a plurality of separating chambers each being of relatively great radial dimension and having a relatively contracted concentrating space, and each said chamber containing less than atmospheric pressure in a part thereof nearer the axis of rotation than is said concentrating space and having an outlet for the discharge of liquid extended substantially to the line of atmospheric pressure.

31. In a centrifugal separator, the combination with a rotary reservoir of a plurality of separating chambers each provided with an external nozzle for the discharge of heavy materials extended to a point nearer the axis of rotation than is the extremity of said chamber.

32. In a centrifugal machine, the combination with a rotary reservoir, of a plurality of separating chambers operatively connected therewith, and each said chamber containing less than atmospheric pressure in a part thereof.

33. In a centrifugal separator, the combination with a rotary reservoir, of a plurality of separating chambers each provided with a nozzle for the discharge of heavy materials extended externally to said chamber to a point nearer the axis of rotation than is the extremity of its said chamber, and with an outlet for liquid extended substantially to the line of atmospheric pressure.

34. The combination in a centrifugal machine, of a rotary reservoir, a plurality of separating chambers connected therewith, each being of relatively great radial dimension and having a relatively contracted concentrating space and having less than atmospheric pressure in a part of each said chamber, and each said chamber having an outlet for the discharge of heavy materials extended to a point nearer the axis of rotation than is the point of atmospheric pressure, and an outlet for the discharge of liquids extended substantially to the line of atmospheric pressure.

35. In a centrifugal machine, a separating chamber provided with an outlet for the discharge of the heavy materials from a part of the chamber where the centrifugal force is relatively great and with an outlet for the discharge of liquid opened to atmosphere at a point where the centrifugal force of said liquid substantially equals atmospheric pressure, and a valve controlling the inlet orifice for the supply to said chamber of materials to be separated.

36. In a centrifugal machine, the combination of a reservoir, a plurality of separating chambers connected therewith, and each said chamber being provided with an

outlet for the discharge of heavy materials from a part of the chamber where the centrifugal force is relatively great and with an outlet for the discharge of liquid, opened to atmosphere at a point where the centrifugal force of the liquid substantially equals atmospheric pressure.

37. In a centrifugal machine, the combination of a reservoir, a plurality of separating chambers connected therewith and each said chamber being provided with an outlet for the discharge of heavy materials from a point of the chamber where the centrifugal force is relatively great and with an outlet for the discharge of liquid opened to atmosphere at a point where the centrifugal force of the liquid substantially equals atmospheric pressure, and a valve controlling the supply inlet for the materials to be separated in said chamber.

Signed at New York city this 15th day of March, 1909.

HARALD DE RAASLOFF.
THOMAS E. BROWN.

Witnesses:
HERMAN J. RUBENSTEIN,
JNO. L. BERNSTEIN.