H. DE RAASLOFF & T. E. BROWN.

ART OF CENTRIFUGAL SEPARATION.

APPLICATION FILED JULY 31, 1911.

1,050,622.

Patented Jan. 14, 1913.

4 SHEETS—SHEET 1.

Fig. 1.

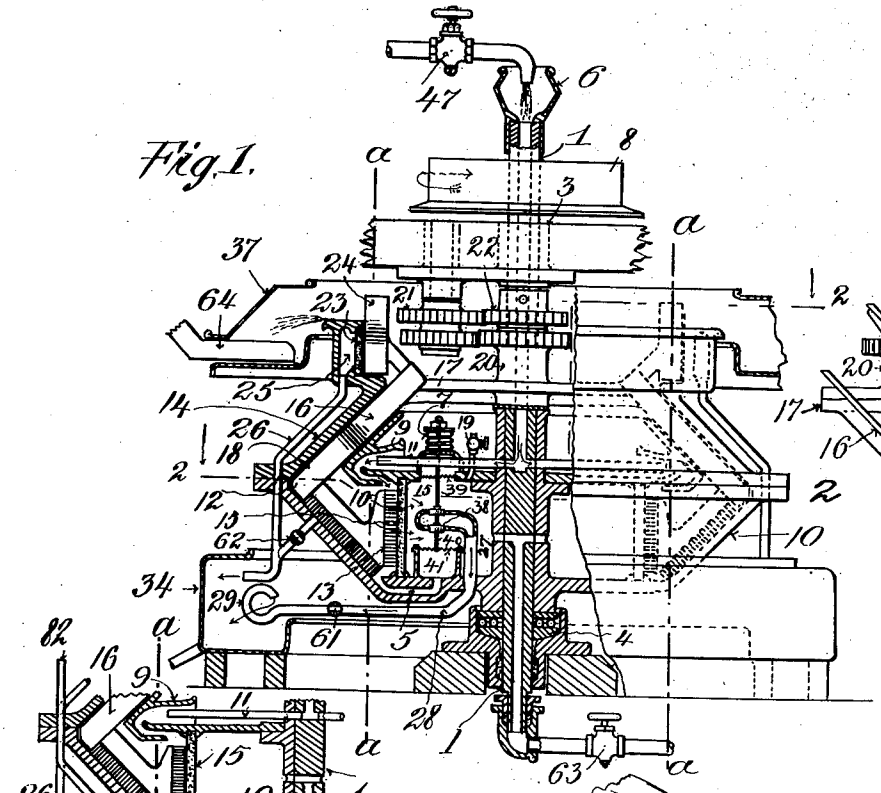

Fig. 3.

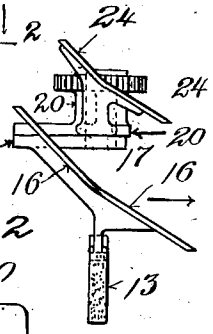

Fig. 7.

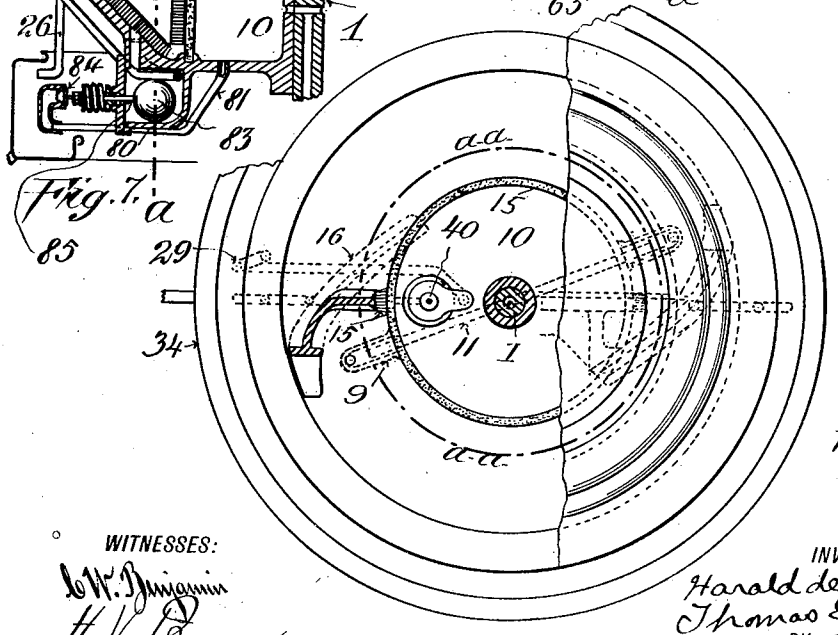

Fig. 2.

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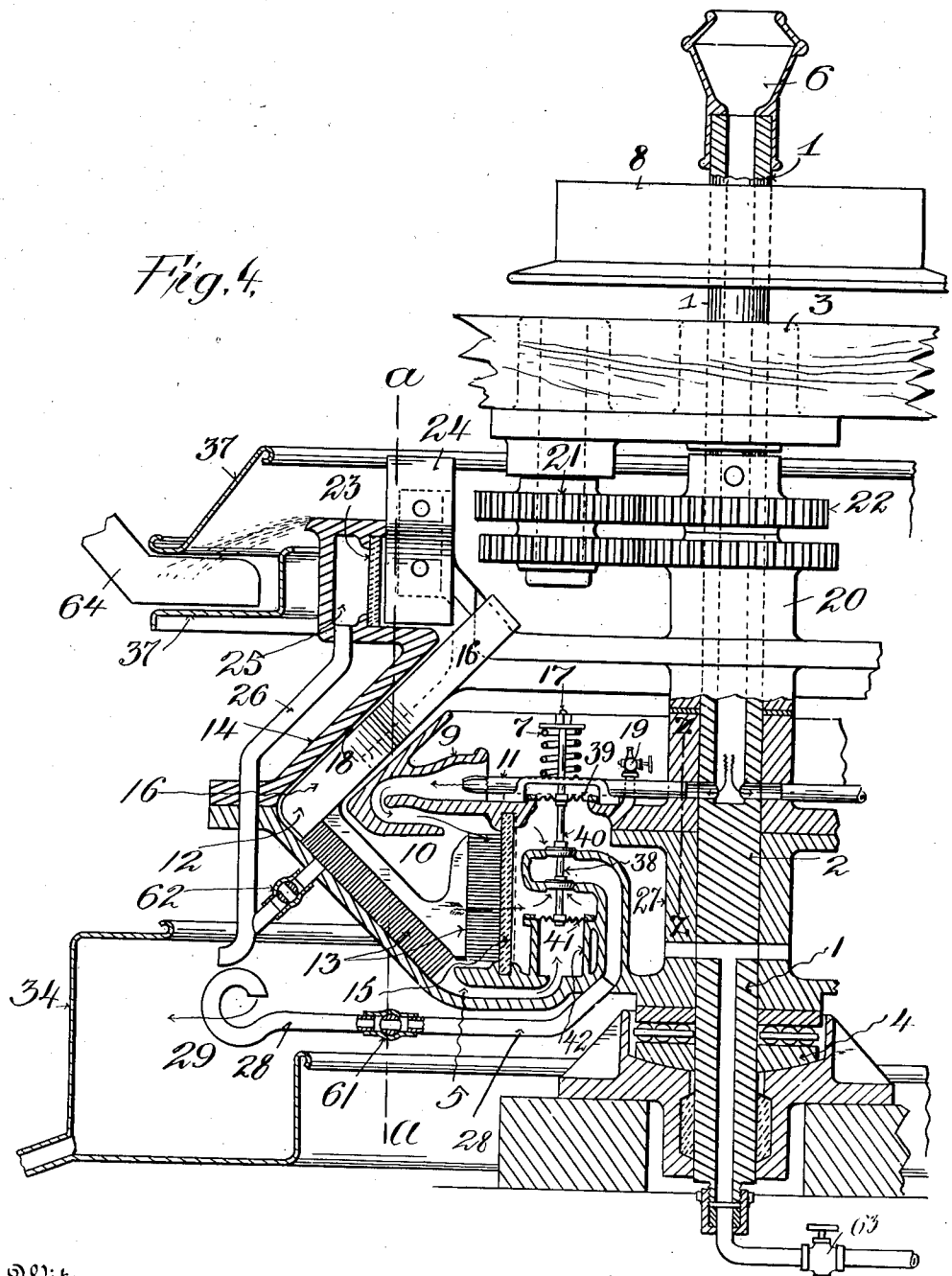
4 SHEETS—SHEET 2.

Fig. 4.



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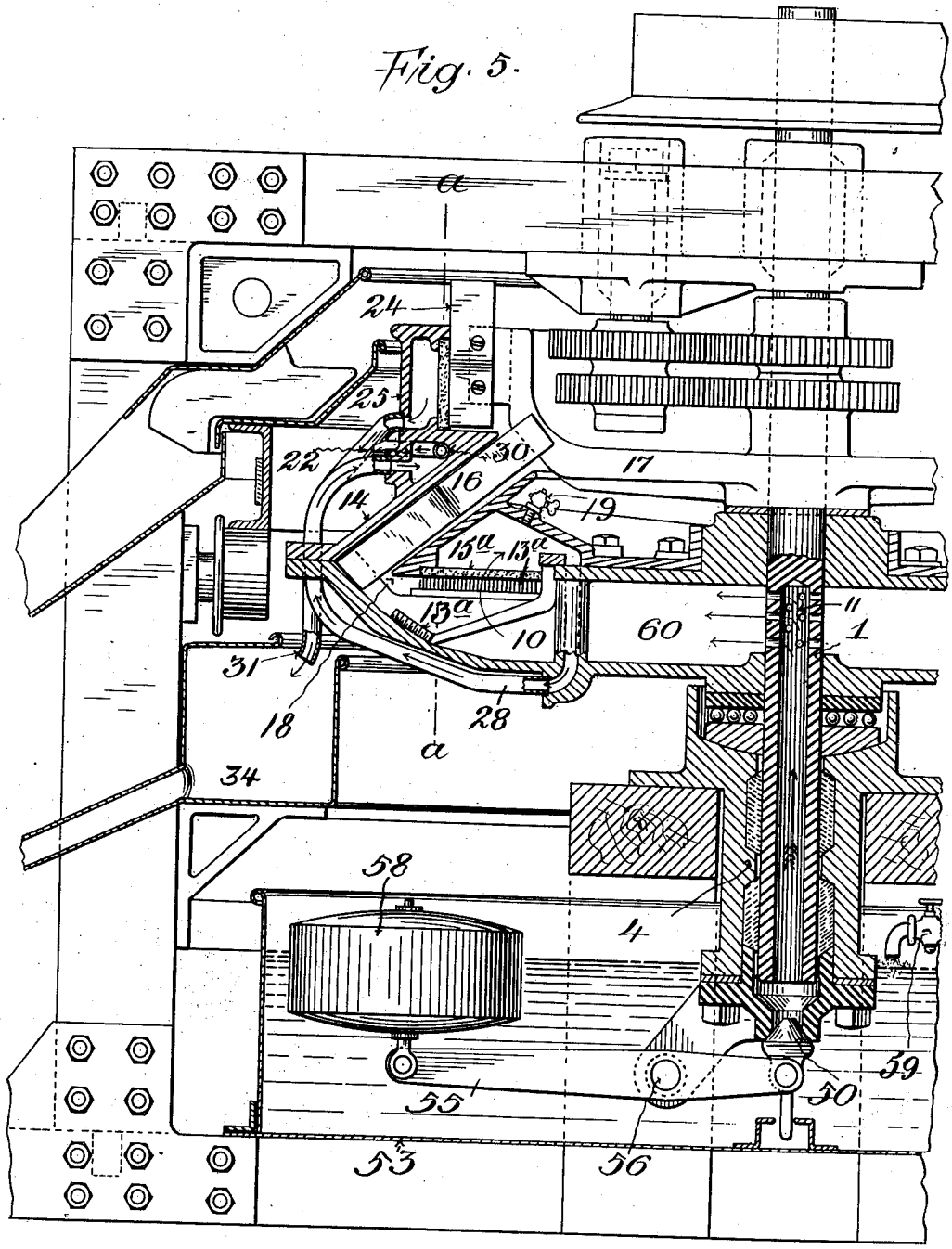
4 SHEETS—SHEET 3.

Fig. 5.



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4 SHEETS—SHEET 4.

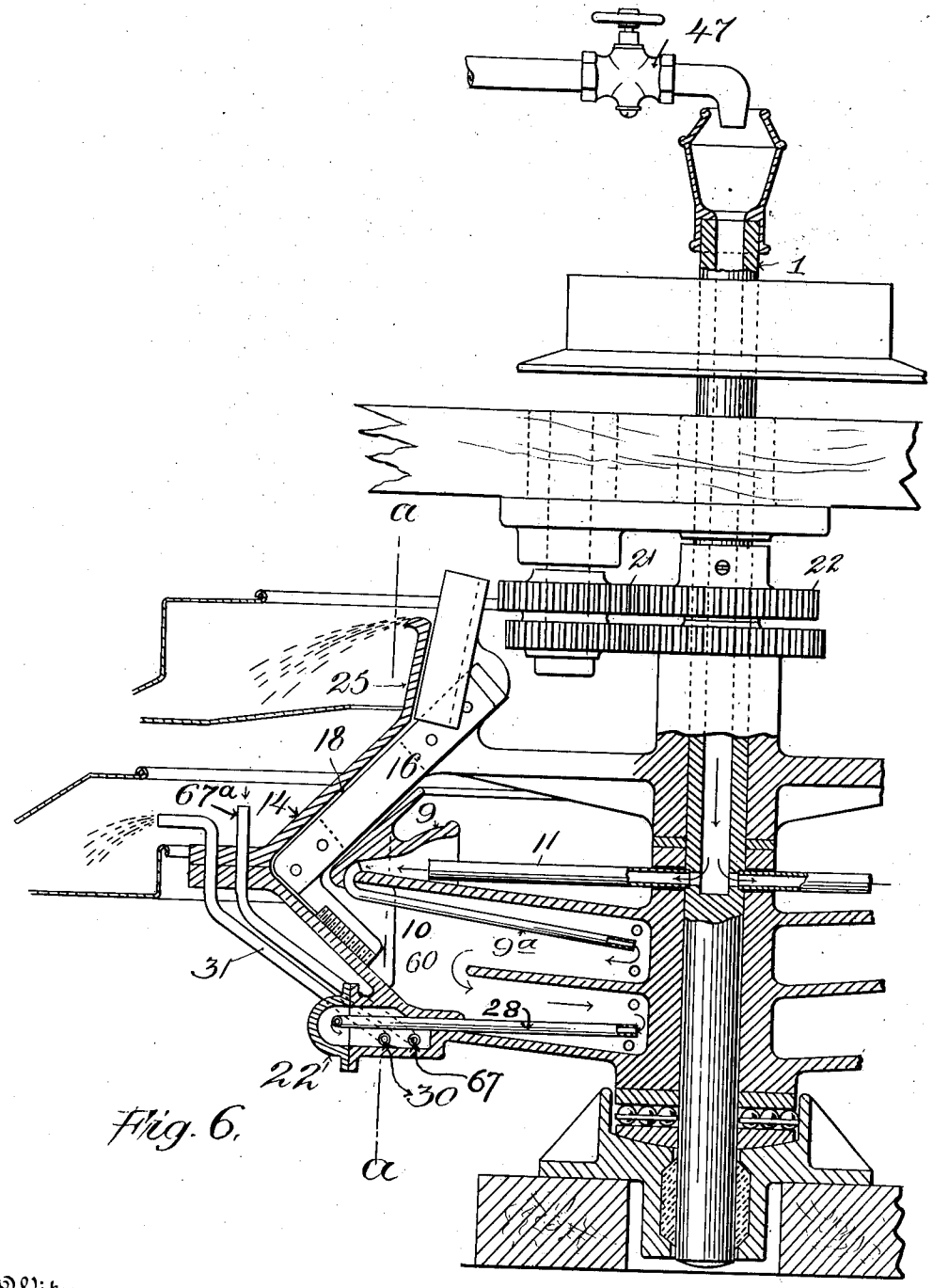

Fig. 6.

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UNITED STATES PATENT OFFICE.

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ART OF CENTRIFUGAL SEPARATION.

1,050,622. Specification of Letters Patent. Patented Jan. 14, 1913.

Application filed July 31, 1911. Serial No. 641,419.

To all whom it may concern:

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

This invention relates to improvements in centrifugal separators.

The invention particularly relates to machines for the separation of liquids from solids, and the separation of liquids of different specific gravities from each other.

The present application relates particularly to improvements in centrifugal machines for operating our improved process of filtration by the aid of centrifugal force; an important element in the said process being the utilization of an overbalancing atmospheric pressure, in opposition to the centrifugal force, for the purpose of preventing the egress of the lighter liquid from the separating chamber along with the heavier concentrated materials.

The present application relates to centrifugal machines for effecting the continuous separation of liquid and solid matters, and it especially relates to centrifugal machines in which the centrifugal force is supplemented by filtering means to enable the liquid to be freed from solid matters too fine to be separated by centrifugal force alone, and said filtering means are so constructed and arranged that the flow of the liquid therethrough is opposed to the centrifugal force, so that the centrifugal force tends to remove the solid particles from the surfaces of said filtering means and to keep them clean and in good operative condition.

Other important features of the present application are the means for causing overbalancing atmospheric pressure, the means for drying the concentrates, and the means for clarifying the separated liquid.

Still other important features and parts of the invention will be apparent from the description and the claims hereinafter following.

The invention to which this application relates is applicable to various modifications of centrifugal machines, and the accompanying drawings illustrate four forms of such machines embodying said invention. But said invention is not restricted to such modifications, but can be applied to all centrifugal machines in which the separation is effected in separating vessels provided with external outlets for the concentrates led to a point nearer the axis of rotation than is the extremity of said vessels, the term "extremity" indicating the part of the vessel radially farthest from the axis of rotation. The invention is also applicable to all centrifugal machines in which an overbalancing atmospheric pressure is utilized to prevent the egress of the lighter liquid along with the concentrates.

As hereinbefore stated, the present invention relates particularly to improvements in machines for applying the process set forth in our application for United States Letters Patent, filed June 30th, 1910, Serial Number 569,631, wherein the principle of the "vacuum" and its utility in preventing the discharge of the lighter liquid along with the concentrates, so that continuous separation of the liquid from the concentrates can be commercially effected, is fully set forth and disclosed. In the present application therefore, the specification is chiefly concerned with the improvements in the machine and the process is only briefly referred to.

Referring to the said drawings which accompany the specification, to aid the description, Figure 1 is a broken vertical section and elevation of one form of machine embodying our invention, and Fig. 2 is a plan and horizontal section of the same machine, the plane of the sectional parts of Fig. 2, being on the line 2—2 of Fig. 1. Fig. 3 is an edge elevation of the plows or scrapers for acting on the concentrates, the brush for cleaning a filter, and certain connected parts. Fig. 4 is a broken vertical section and elevation on large scale, of certain parts shown in Fig. 1. Fig. 5 is a broken vertical section and elevation on large scale of a modification of the machine, wherein the material is drawn in from below. Fig. 6 is a broken vertical section and elevation, on large scale, of another modification combining certain features of the machines illustrated in Fig. 1 and in Fig. 5. Fig. 7 is a broken sectional detail of certain parts of another modification of the machine, wherein the valve which determines the atmospheric line is controlled by a float.

Referring to Figs. 1, 2, 3 and 4, 1 is the

axis of revolution preferably in the form of a pipe, closed near the bottom 2, and revolved in suitable bearings 3—4 at high velocity by any suitable means, as pulley 8. The materials to be separated, as liquids and solids, are delivered into a funnel 6, fixed on the upper end of pipe 1. Said pipe 1 communicates with separating chamber 10, which is shown as of annular shape concentric to pipe 1, (Fig. 2), by branch pipes 11 and open traps 9. Said chamber 10 is preferably divided into an inner and an outer portion by a filter 15, situated between the inlet and the liquid outlet of chamber 10, the flow through the filter being in a direction opposed to the centrifugal force. The outer part of said chamber 10 is contracted to form an annulus 12 of small cross sectional area. The filter 15 may be made in any suitable manner, and of suitable filtering material for the particular substances to be treated. The concentration of the heavier materials takes place in the outer end of said separating chamber 10. Said chamber 10 is of such dimension radially to the machine that the extremity of said chamber is outside of, or farther from the axis of rotation than, the line of atmospheric pressure *a*—*a*. Said line of atmospheric pressure indicates the line on which, when the machine is revolving at its predetermined velocity, the pressure is equal to atmospheric pressure. The position of the said "line of atmospheric pressure" may be thus explained: Suppose said chamber 10 to be tightly closed, except at the annular outlet 18, and to be full of liquid. Now, if the said chamber 10 be rapidly revolved the liquid in said chamber will move outwardly and the liquid in said annular outlet will move upwardly and inwardly under the influence of the centrifugal force generated by the revolution of said chamber 10. The surface of the liquid in said outlet 18 will now form a parabolic wall, at the line *a*—*a*, which, when the apparatus is revolving at such designed high speed that the force of gravity may be neglected, will be practically the wall of a cylinder concentric with the axis of revolution of said chamber 10. We call the position of this wall the line of atmospheric pressure, because, at the position of said wall, the pressure of the liquid is equal to atmospheric pressure. The liquid in said chamber 10 will, at the same time, have moved outwardly from the axis of the said vessel, so that there will be a vacuum near the center of said vessel, and the surface of the liquid therein will form a wall at the position of the line *z*—*z*, which will also be practically the wall of a cylinder concentric with the axis of revolution of said chamber 10. We call the position of said last named wall the "line of zero pressure", because at the said wall the pressure is *nil*, and a vacuum exists at all points within said wall. It is manifest that the atmospheric pressure is opposed to the centrifugal force and prevents the escape of liquid from said annular outlet under the influence of the centrifugal force, and we therefore term the atmospheric pressure an "over-balancing pressure". The annulus 12 connects with casing 14, which forms an annular passage external to said chamber 10, and is carried at an inclination upwardly and inwardly, (forming an annular trap to prevent the admission of air), and toward the axis of rotation; and the annular passage formed by said casing 14 may be considered as an extension of said chamber 10, continued externally to said chamber 10 and inwardly toward the axis of rotation. Of course said chamber 10 might be without the contracted annular opening, or might have a long annulus of tubular like section, or might be formed of various shapes, but in all cases we consider the extremity of said chamber to be the part thereof, farthest from the axis of rotation, and practically where the connection with casing 14 is made. Said casing 14 contains plows or scrapers 16, carried on the arms 17, which are driven at proper speed in any suitable manner, as by differential gearing 21—22, or any suitable means. The arms 17 are attached to sleeve 20, running loose on pipe 1. The plows 16 are inclined, shaped, and arranged to discharge the concentrates upon an annular drier 25, equipped with filter 23, from which they may be removed by another plow or scraper 24, or in any suitable manner. The preferred shape and construction of said plows or scrapers 16 is shown in Fig. 3. It is to be understood that any other suitable form of conveyer or scraper and casing may be employed instead of the plow and casing shown in the accompanying drawings and described in the specification. Said separating chamber 10 is closed at its inner part 27, as clearly shown in Fig. 1, and the inner wall is located preferably a little outside of the line of zero pressure *z*—*z*, which line has been heretofore explained, that is, a little farther from the axis of rotation than is said line; so that said chamber 10 shall remain full of liquid when revolving at the designed velocity; and the designed velocity of the machine may be made such that the line of zero pressure *z*—*z* will coincide with the axis of rotation of the machine, or may even be such that said zero line will not exist, and there will be a slight pressure at the said axis. To facilitate freeing the apparatus from air, a pet cock 19 is attached to the top of chamber 10. 13 is a brush carried by, and rotating with, the plow 16. 26 is a pipe to convey any liquid which may pass into the drier 25 into a stationary circular trough

34. The plow or scraper 24 is preferably carried in advance of plow 16 to allow solid materials to remain for a proper time on the drier filter 23, before being discharged over the edge of the drier 25 and into the revolving drum 37 for the reception of the solid materials. Valve 63 and cocks 61 and 62 are for use when washing the filter 15, as will be described hereinafter. The position of the line of atmospheric pressure is determined by the valve 38, which is preferably a balanced valve, controlled by the diaphragm 41, which covers the cup or chamber 42, and is connected with the outer end of chamber 10 by the pipe 5. The valve stem 40 passes through a second diaphragm 39, covering a suitable hole in the top plate of chamber 10, and is connected by adjusting nuts with the adjusting spring 7. The spring 7 serves to counteract the atmospheric pressure on diaphragm 39 when the machine is in motion, and control the motion of the diaphragm 41 and valve 38. A piston and stuffing box could be used in place of diaphragms 39 and 41, but we prefer the diaphragms, to avoid friction and leakage. The supply of mixture is controlled by supply valve 47, by which the amount of material delivered to funnel 6 may be regulated.

The operation is as follows: Suppose the apparatus empty and at rest; and that the mixed liquid and heavier particles are run into said pipe 1 from valve 47, valve 38 being held closed by pressing on the top of stem 40, and pet cock 19 being open. The materials will pass down stem 1 out through pipes 11 into traps 9, and will fill chamber 10 and connected parts with said materials. the lighter liquid filtering through the filter 15 into the part of chamber 10 nearer the axis of the machine. Air will be expelled from the apparatus through the pet cock 19. When the machine is full, and all air expelled, the pet cock 19 is closed, the valve 38 is allowed to open, liquid flows down into and fills the discharge pipe 28 and trap 29, and flows into trough 34, and the machine is then started revolving and gradually attains the desired constant speed. As the speed increases to its limit, the liquid surface tends to take a vertical position in the annulus outlet 18; the suction induced by the centrifugal force of the liquid in pipe 28 causes less than atmospheric pressure in chamber 10; the atmospheric pressure on diaphragm 39 overcomes the tension of spring 7 and closes valve 38 until a balance is produced with the spring pressure on said diaphragm 41. The liquid pressure on the under side of said diaphragm 41 is dependent on the position of the line of liquid, or line of atmospheric pressure, since the liquid space beneath said diaphragm 41 is in communication by pipe 5 with the liquid in the outer part of said separating chamber 10 and said annulus 12. Therefore as the atmospheric line tends to move radially outward, the pressure in 41 falls and valve 38 closes, and should it tend to move radially inward, the valve opens; thus valve 38 controls the position of the line of atmospheric pressure irrespective of the amount of the supply of materials from valve 47. It will also be evident that should the filter 15 clog, and its resistance to the flow of fluid increase, the atmospheric line will move radially inward in the effort to overcome the increased resistance of the filter; this will cause the valve 38 to open until the suction induced by the centrifugal force of the liquid in pipe 28 compensates for the increased resistance of the filter. The heavier materials separate from the liquid in the outer end of the chamber 10, and concentrate on the walls near and in the annulus 12. The fine particles are caught and coagulate on the filter 15, and are brushed off by the brush 13, and pass by the centrifugal force to said annulus 12. The materials concentrated at the annulus 12 are plowed upwardly and inwardly along the casing 14, and are deposited on the filtering surface 23 of the drier 25. Any liquid drained off through filter 23 passes by the pipe 26 to the trough 34. The dried material remaining on 25 is lifted over the edge by the plow 24, and is discharged into the revolving drum 37, from which it may be removed in any suitable manner, as by employing a stationary scraper 64. The plow 24 is placed in advance of plow 16, so that material deposited on filter 23 by plow 16 remains drying thereon until removed by the next succeeding plow 24. One or more sets of plows 16 and 24 may be used. We prefer to use two sets diametrically opposite each other. The brush 13 is extended along the arm connecting it with the plow 16, as we find that gummy materials will adhere and build up on the inclined surface of chamber 10, and the centrifugal force alone may be insufficient to dislodge them.

We do not confine ourselves to the particular valve and operating devices for the same shown in Fig. 1, but consider any form of valve and operating devices which govern the position of the atmospheric line by controlling the flow through the liquid discharge pipe as within the scope of our invention.

Fig. 5 shows another form of our invention arranged to lift the material to be separated from below by the atmospheric pressure and vacuum induced by the centrifugal force. The separating chamber 10, casing 14, plows 16 and 24, driers 25, pipe 26, arms 17, filters 15^a, brushes 13^a, and numerous other parts are substantially the same in construction and operation with correspond-

ing parts of Fig. 1, and no further description of such parts is necessary, except to note that said filters 15[a], and brushes 13[a] are preferably arranged horizontally, and the hollow axis or pipe 1 is now closed at the top and open at the bottom, and works through a stuffing box in the bearing 4. The orifice for the inlet of the mixed material is now controlled by the valve 50, which preferably opens downwardly, and said orifice receives the mixed materials from a vessel 53, into which vessel said materials are delivered by a pipe and controlled by a valve 59. Said valve 50 is connected with a lever 55 fulcrumed at 56, and connected at its outer end to a float 58. In the form of our apparatus shown on Fig. 5, we do not use the diaphragm controlled valve 38 shown on Fig. 1, but regulate the line of atmospheric pressure by the outlet conduit 28 and trap 22 opened to atmosphere at 30 on the line of atmospheric pressure, and the discharge pipe 31, which delivers the discharged liquid into the trough 34. The operation of this machine is as follows: The machine being empty, and at rest, liquid is allowed to run into vessel 53 until the inlet and valve 50 are covered; the float 58 is then pushed down in any convenient manner, closing valve 50, and the machine is filled with water through the annular opening 18, by a hose or in any other convenient manner, air being allowed to escape through the pet cock 19. When the machine is full, pet cock is closed, and the machine started revolving. When the proper speed is attained the float 58 is released, and a proper supply of the material to be separated is admited through valve 59. The liquid rises in the stem 1, passes through openings 11 into chamber 10, and the operation is then as described for Fig. 1, except that the position of the atmospheric line is now determined by the position of the trap 22, opened to atmosphere at 30. In this form of apparatus the surface of the liquid in the annulus 18 will be nearer the axis than the atmospheric line, to give sufficient centrifugal force to overcome the resistance of the filter.

Both forms of the apparatus shown on Figs. 1 and 5 may be used without the filter screens, when the complete clarification of the liquid is not important. In such cases perforated partitions may be substituted for the screens to prevent direct flow between the inlet and outlet orifices; also radial partitions 60, Fig. 5, may be used to impart angular velocity to the entering liquid. The form shown in Fig. 1 may also be used with inlet below, the pipes 11 acting as centrifugal pumps, and the valve 50 being added for priming, or the liquid may be introduced from below under pressure. The form of machine shown in Fig. 1 may be used with inlet either above or below, and with the trapped conduit 28, trap 22, and discharge pipe 31, as shown on Fig. 5, instead of the diaphragm-regulated valve 38, and this arrangement we prefer in cases where the filters 15 are not used.

An arrangement without filters and taking supply from above, is shown in Fig. 6. In Fig. 6, for convenience of construction, we show the trap 22 placed below the separating vessel. The air inlet 67 to trap 22 is continued by pipe 67[a] to a point above trap 9 and pipe 11, and also above the outlet end of the liquid discharge pipe 31. The normal atmospheric line in this form of the machine is at *a*—*a*. The machine having been primed through pipe 1, and started up the atmospheric line is maintained in position, by the outlet 30 of pipe 31 from trap 22 as described for Fig. 5. In this form of the machine the only valve required is that on pipe 47, and in this form of the machine, as in all others embodying our invention, the reduced pressure in chamber 10 prevents the lighter liquid from discharging with the heavier concentrates. In Fig. 6, we also show the drier 25 without filter. The materials are delivered on the smooth surface of the drier 25, which is placed at such an angle that the centrifugal force and gravity will not cause the concentrated material to slide on the surface of 25. Any liquid draining from the drying materials runs back by gravity and centrifugal force into the annulus 18. The shape of the chamber 10 in Fig. 6 is such as will enable the machine to free itself of air without the said pet cock 19.

The filter may in time become clogged and require washing. This may be accomplished with apparatus arranged as in Figs. 1 and 4, by closing cock 61 on pipe 28, and opening cock 62 on the drip pipe from chamber 10. Wash water is then let in through cock 63, and the machine is rapidly revolved. The wash water fills the inner part of chamber 10, is forced outwardly through filter 15, or in the direction the reverse of that of the usual flow, cleaning the filter, and discharging through cock 62 and pipe 25 into trough 34.

Referring to Fig. 7, the lighter liquids discharge from chamber 10 by pipe 81, the end of which is provided with a valve seat and controlled by valve 84; said valve 84 being in turn controlled by a float 83 on valve stem 85. Said float 83 is located in a trap 80 which is connected with atmosphere by pipe 82. Therefore, when the machine is running at its proper speed the surface of the liquid in said trap 80 stands on a substantially vertical wall at the atmospheric line *a*—*a*. Should the atmospheric line move outward, the surface of the liquid in said trap 80 will also move outward and said float 83 will close said valve 84, and

should the atmospheric line move inward the surface of the liquid in said trap 80 will move inwardly and said float will open said valve 84. Thus the float will control the position of the atmospheric line under all circumstances and variations of supply; this modification being in all essential respects the equivalent of the machine shown in Fig. 1.

Now having described our improvements, we claim as our invention:

1. In a centrifugal machine, a rotating vessel having a circumferential trapped outlet concentric with the axis of revolution.

2. In a centrifugal separator, a rotating separating vessel having an annular trapped outlet passage extending nearer the axis of rotation than the extremity of said vessel.

3. The combination in a centrifugal separator of a separating vessel having an annular trapped outlet concentric with the axis of rotation for the heavy concentrated materials extending from said vessel to nearer the axis of rotation than the extremity of said vessel, and means for removing the concentrated materials from said outlet.

4. The combination in a centrifugal separator of a separating vessel having an annular trapped outlet extended from said vessel to a point of discharge nearer the axis of rotation than is the extremity of said vessel and means for removing the concentrates from said outlet.

5. The combination in a centrifugal separator of a separating vessel, an annular trapped outlet for the discharge of heavy cencentrated materials extending from said vessel to a point nearer the axis of rotation than is the extremity of said vessel, and a discharge conduit for the liquid separate from said outlet for the heavier materials.

6. In a centrifugal machine an annular outlet therefrom, cencentric with the axis of rotation 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.

7. In a centrifugal machine a revolving separating vessel provided with an annular outlet concentric with the axis of rotation 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 annular outlet.

8. In a centrifugal machine, the combination of a separating vessel provided with an outlet for the heavier concentrated materials and with a separate conduit for the discharge of the lighter liquid, and a valve controlling said conduit and adapted to maintain lower than atmospheric pressure in a part of said vessel.

9. In a centrifugal machine, the combination of a separating vessel provided with an outlet for the heavier concentrates and a separate outlet for the lighter liquids, and a valve in said last named outlet adapted to control the position of the liquid in said vessel.

10. In a centrifugal machine the combination of a separating vessel, a filter therein, and means to control the difference of pressure on the two sides of the filter according to the variation of resistance to flow through the filter.

11. In a centrifugal machine a separating vessel, a filter therein, an outlet conduit for the filtered liquid and a valve in said conduit to control the difference of pressure on the two sides of the filter according to the variation of resistance to flow through the filter.

12. The combination in a centrifugal machine of a separating vessel containing less than atmospheric pressure in a part thereof, and means for removing concentrates rotating with said vessel, but at a different angular velocity from that of said vessel, and adapted to move the heavy materials to a point nearer the axis of rotation than is the line of atmospheric pressure.

13. The combination in a centrifugal machine of a separating vessel containing less than atmospheric pressure in a part thereof, a discharge conduit for liquid from said vessel, an external annular outlet separate from said liquid conduit, and a scraper adapted to move the heavy materials in said annular outlet to a point nearer the axis of rotation than is the line of atmospheric pressure.

14. The combination in a centrifugal machine of a separating vessel adapted to contain less than atmospheric pressure in a part thereof, and a valve operated by the pressure in said vessel for controlling the discharge of liquid from said vessel.

15. The combination in a centrifugal machine of a rotary separating vessel and a valve controlling the discharge from said vessel.

16. The combination in a centrifugal machine of a separating vessel and a diaphragm-operated valve controlling the discharge of liquid from said vessel.

17. In a centrifugal separator, the combination of a separting vessel provided with an outlet for the heavier concentrates and a separate outlet for the lighter liquid, a valve in said last named outlet adapted to control the position of the liquid in said vessel, and means for operating said valve according to the position of the liquid.

18. The combination in a centrifugal separator of a separating vessel containing less than atmospheric pressure in a part thereof, an outlet for the heavy concentrated materials, and a trapped inlet for the mixed materials opened to atmospheric pressure at substantially the line of atmospheric pressure.

19. The combination in a centrifugal separator of a separating vessel containing less than atmospheric pressure in a part thereof, an outlet for the heavy concentrated materials, and a trapped inlet for the mixed materials opened to atmospheric pressure at substantially the line of atmospheric pressure, and a trapped outlet for the lighter liquid also opened to atmosphere at substantially the line of atmospheric pressure.

20. In a centrifugal machine, a separating vessel containing less than atmospheric pressure in a part thereof, a trapped inlet for the mixed materials, a trapped outlet for the heavier concentrated materials, and a separate trapped outlet for the lighter liquid.

21. In a centrifugal separator, a separating vessel containing less than atmospheric pressure in a part thereof, and a filter therein so placed that the flow of liquid through said filter is opposed in direction to the centrifugal force.

22. In a centrifugal separator, a separating vessel and a filter so placed that there will be less than atmospheric pressure on both sides of said filter.

23. In a centrifugal machine, a filter so placed that the direction of the flow through said filter is opposed to the direction of the centrifugal force, and a brush acting on said filter.

24. In a centrifugal machine a filter so placed that the direction of the flow through said filter is opposed to the direction of the centrifugal force, and a brush acting on said filter and means to revolve said brush.

25. In a centrifugal separator, a filter so placed that the direction of flow through said filter is opposed to the direction of the centrifugal force, and a plurality of brushes acting on said filter.

26. In a centrifugal separator, a filter so placed that the direction of flow through said filter is opposed to the direction of the centrifugal force, brushes acting to clean said filter and means to control the difference of pressure on both sides of said filter according to the variation of resistance to flow through said filter.

27. The combination in a centrifugal separator of a separating vessel, having an annular outlet for the heavy concentrated materials extending to nearer the axis of rotation than the extremity of said vessel, and a filter in said vessel so placed that the flow of liquid through said filter is opposed in direction to the centrifugal force.

28. The combination in a centrifugal separator of a separating vessel, having an annular outlet for the heavy concentrated materials extending to nearer the axis of rotation than the extremity of said vessel, a filter in said vessel so placed that the flow of liquid through said filter is opposed in direction to the centrifugal force, and brushes to clean said filter.

29. The combination in a centrifugal separator of a separating vessel, having an annular outlet for the heavy concentrated materials extending to nearer the axis of rotation than is the extremity of said vessel, means in said outlet for the extraction of the heavy concentrated materials, and a filter in said vessel so placed that the flow of liquid through said filter is opposed in direction to the centrifugal force.

30. The combination in a centrifugal separator of a separating vessel, having an annular outlet for the heavy concentrated materials extending to nearer the axis of rotation than the extremity of said vessel, means in said outlet for the extraction of the heavy concentrated materials, and a filter in said vessel so placed that the flow of liquid through said filter is opposed in direction to the centrifugal force, and brushes to clean said filter.

31. The combination in a centrifugal separator, of an annular rotary separating vessel provided with separate outlets for the discharge of heavier concentrates and lighter liquid, means to produce lower than atmospheric pressure in a part of said vessel, and means for removing the concentrates from said vessel.

32. The combination in a centrifugal separator, of an annular rotary separating vessel provided with separate outlets for the discharge of heavier concentrates and lighter liquid, means to produce lower than atmospheric pressure in a part of said vessel, a filter in the area of said lower pressure, and means for removing the concentrates from said vessel.

33. The combination in a centrifugal separator, of a rotary separating vessel provided with separate outlets for discharge of heavier concentrates and lighter liquid, means to produce lower than atmospheric pressure in a part of said vessel, a filter in the area of said lower pressure, and means for removing said concentrates from said vessel.

Signed at New York city in the county of New York and State of New York, this 29th day of July A. D. 1911.

HARALD DE RAASLOFF.
THOMAS E. BROWN.

Witnesses:
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