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ART OF CENTRIFUGAL SEPARATION.

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1,050,720. Patented Jan. 14, 1913.

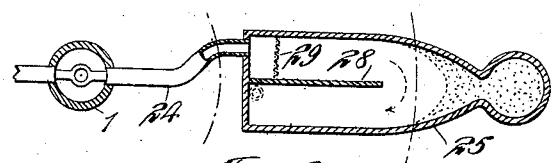

Fig. 2.

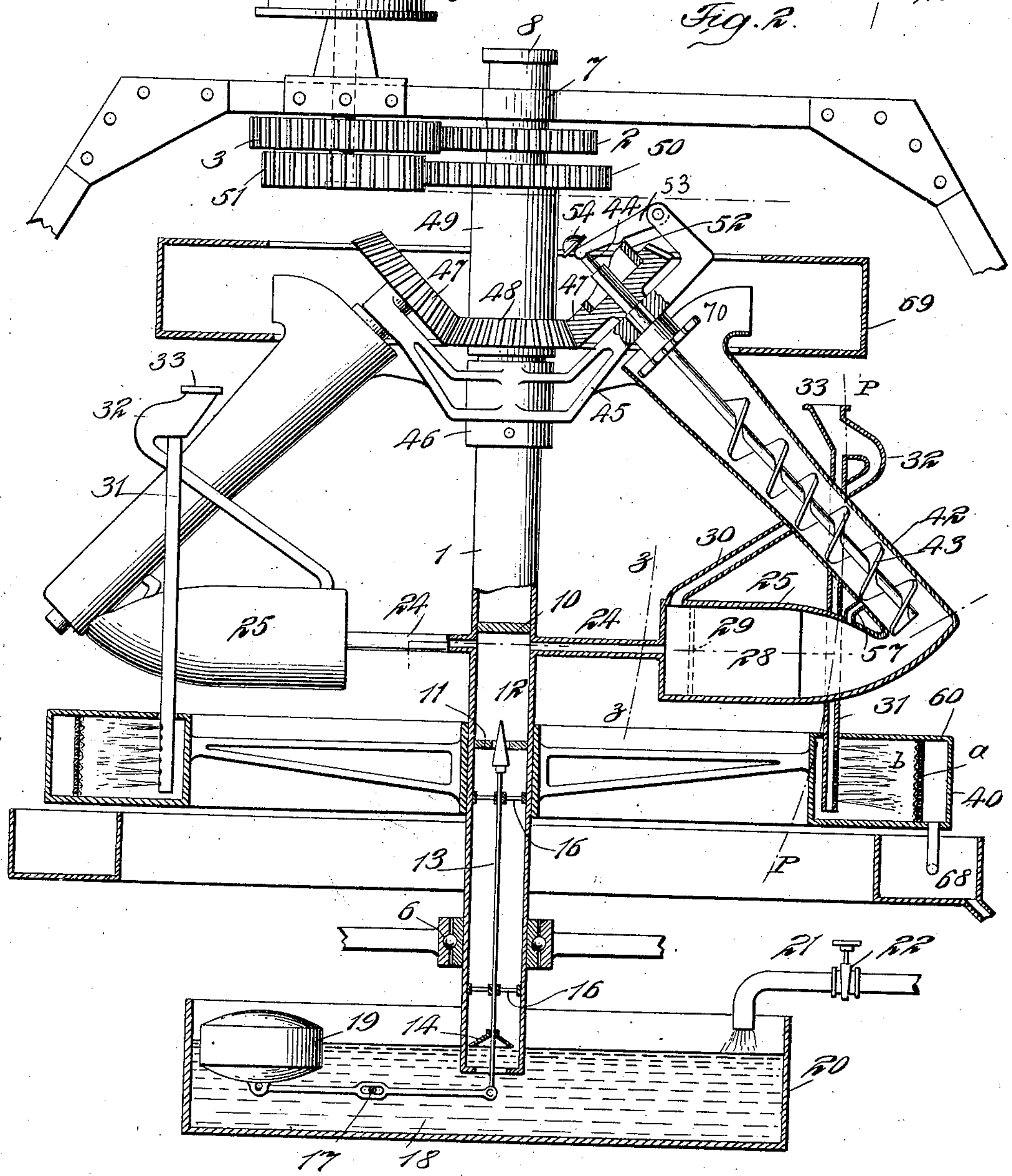

Fig. 1.

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ART OF CENTRIFUGAL SEPARATION.

1,050,720. Specification of Letters Patent. Patented Jan. 14, 1913.

Application filed June 30, 1910, Serial No. 569,631. Renewed November 5, 1912. Serial No. 729,659.

To all whom it may concern:

Be it known that we, HARALD DE RAASLOFF and THOMAS E. BROWN, citizens of the United States, and residents of the borough of Manhattan, 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 the art of centrifugal separation of materials of different specific gravities.

The invention is applicable to the separation of materials of different specific gravities in all cases wherein at least one of the materials is a liquid, and it is equally applicable to cases in which the other material is also a liquid.

The essential step of the process is the generating, either through the centrifugal force or through other agencies, of a pressure in the mixture less than normal atmospheric pressure. This low pressure is generated at a part of the vessel containing the mixture, which is nearer the axis of rotation of the mixture than is the point at which the heavier concentrates are discharged from said vessel; and said part is also nearer the said axis of rotation than is the part of said vessel in which the heavier materials concentrate as they separate from the lighter materials. Therefore, when, in the description or the claims, we use the term "point of concentration" or "place of concentration," we include either the discharge outlet for heavier material from the separating chamber or the part of said chamber in which the heavier material concentrates. Moreover, for brevity of description, we frequently hereinafter designate the said reduced pressure in the mixture by the term "vacuum," meaning thereby not necessarily an absolute vacuum, but any pressure less than the contemporary normal atmospheric pressure outside of the apparatus in which the process is then being operated.

The process therefore, broadly speaking, consists in revolving the mixture of the materials which are to be separated, and at least one of which must be a liquid, around an axis of rotation, whereby a centrifugal force is developed which impels the heavier material outwardly from the said axis, and separates, or at least tends to separate, it from the lighter material. Simultaneously with the generating of the centrifugal force, a pressure less than the normal atmospheric pressure is developed in a part of the mixture which is nearer the axis of rotation than is the point of concentration of the heavier material. The consequence of developing this reduced pressure at this part is that the normal atmospheric pressure acts upon the lighter material in a direction opposed to the direction of the centrifugal force, and, thereby, to the degree due to the excess of the normal atmospheric pressure over said reduced pressure, prevents the lighter material from moving outward with the heavier material. To produce the most perfect separation the velocity of revolution of the mixture is limited so that the centrifugal force generated thereby in the lighter material is less than, or at least can never exceed the force due to, normal atmospheric pressure; and thereby the lighter materials are perpetually restrained from flowing out by the discharge outlet for the heavy materials and reuniting with them after the separation has once occurred. Finally the process includes the application of separate forces, independent of the centrifugal force, to remove the lighter and the heavier materials by different outlets.

The process can be carried out by many different apparatus, among which are, for example, the apparatus hereinafter described, and the apparatus which is the subject of our application for United States Letters Patent filed March 16, 1909, Serial Number 483,670, and now pending; and the process can also be carried out by various other apparatus. The process is therefore not limited to any particular apparatus or elements, and we consider one aspect of our invention to broadly consist in the process as hereinbefore defined, however the apparatus which applies it may be constructed or arranged.

For the purpose of rendering the application of said process clear, we hereinafter describe it in connection with that form of apparatus which we prefer to use in connection with it, and we claim various parts and

combinations of parts of said apparatus in a divisional application.

Referring to the drawings which accompany the specification, and, as hereinbefore stated, illustrated the preferred form of apparatus for applying the process, Figure 1 shows a vertical section and elevation, partly broken away, of an apparatus in which the mixture is drawn in by suction from below. Fig. 2 is a broken horizontal section of one of the separating chambers.

Referring to said drawings, a rotary pipe or vessel 1 is revolved at high speed by any suitable means, as gears 2, 3 and pulley 5, from any source of power. Said pipe 1 is preferably supported vertically in suitable bearings 6, 7, which may be anti-friction ball bearings. Said pipe 1 is closed at the top 8, and its lower open end dips into the materials to be separated in the vessel 20, to which vessel they are delivered in any suitable manner as by pipe 21, controlled by valve 22. Said pipe 1 is connected by branches 24 with any desired number of separating chambers 25, preferably arranged symmetrically around said pipe 1; and a short distance above its junction with said branches, said pipe 1 is closed as seen at 10. Below said branches is a control valve 12, preferably of long conical shape, seating on a seat in diaphragm 11. A valve stem 13, suitably guided through the guides 16, 16, is pivotally connected by lever 18, fulcrumed at 17, to a float 19, which rises and falls according to the level of the contents of said receptacle 20; and the arrangement of the parts is such that when the level of said contents rises said valve 12 opens, and when the level of said contents falls said valve 12 closes; and by reason of the gradually tapering shape of said valve 12 the opening and closing of said valve is also gradual, and perfect control of the delivery of the material to the separating chambers 25, and of the vacuum, is attained. A check valve 14, guided on stem 13 and opening upwardly may also be employed if desired. The inner closed end of each of said separating chambers 25 is arranged at a short distance outside of the line of zero pressure z—z, and each of said chambers is preferably relatively long in a radial direction and provided with a contracted outer end forming a nozzle. Each of said chambers 25 is also preferably provided with a partition 28 extending part of the length of said chamber 25. The said branch pipe 24 connects with the chamber on one side of said partition 28, and the discharge for the lighter separated materials 30 connects with said chamber 28 on the other side of said partition, and with the top of said chamber 25, 29 being a diffusing screen. Thus said partition 28 prevents the mixture from flowing directly from the inlet to the discharge pipe 30, causes it to circulate properly in said chamber 25, and for a time sufficient to effect the separation of the heavier materials. Said pipe 30 is preferably carried at an upward inclination to or slightly outwardly beyond the line of atmospheric pressure, P—P, where said pipe 30 is trapped, as shown at 32, and is opened to atmospheric pressure just within said atmospheric line as at 33. From said trap 32 a discharge pipe 31 leads down and discharges into the annular revolving receptacle 40 provided with a suitable discharge.

In order to produce a final clarification of the separated liquid, we prefer to place annular filtering screens 60 in said receptacle 40, and to arrange said receptacle 40 to discharge into a lower stationary annular receptacle 68. Said filtering screens 60 are preferably composed of perforated metal rings a backed by any suitable filtering material b. The outer end of each said separating chamber is connected with suitable means for removing the concentrated heavier material as rapidly as the same is formed; and the preferred device is illustrated in Fig. 1, and consists of a revoluble and reciprocating worm 43 in a worm casing 42. Said worm 43 may be all of uniform pitch; or it may be of a plurality of different pitches. Fig. 1 showing said worm in two parts, whereof the upper part may have the greater pitch. Said worm casing 42 may be throughout of uniform diameter or it may be of gradually increasing diameter toward its discharge end; and said worm and casing are preferably arranged at an inclination upwardly and inwardly, so that the discharge from the worm takes place within the said atmospheric line P—P, and so that the effect of said worm 43 is to propel the concentrates in a direction opposed to that of the centrifugal force. Said worm discharges into a annular receptacle 69. Rotary and reciprocating motion are imparted to said worm 43 in any suitable manner. As shown in the drawings, the worm shaft 44, is suitably guided through the revolving bracket 45, which is carried on the sleeve 46, and revolves with said pipe 1. Said worm is driven by beveled gear 47 meshing with beveled gear 48 carried on loose sleeve 49, which sleeve is in turn driven with differential velocity, by the gears 50, 51. A square part of said worm shaft 44 works longitudinally through a square hole in said gear 47, but turns with said gear. Said worm 43 can thus reciprocate while being revolved by said gear 47. A cam 52 carried by said gear 57, and properly formed, lifts a rocker 53 pivoted at one end on said bracket 45, and having a fork at the other end which engages under the head 54 of said worm shaft 44. Thus, at proper in-

tervals, said worm 43 is moved endwise in the direction for discharging the concentrates, and as the said cam 52 continues its revolving, the centrifugal force forces said worm in the opposite direction, thrusting the end of the worm into the concentrates, which then travel more or less up the said worm 43, as the same revolves and are finally lifted up to the discharge outlet by the end-wise motion of said worm. Of course springs or other devices in addition to centrifugal force could also be employed to force said worm into the concentrates. The reciprocating of the worm, with or without the increasing pitch, and with or without the gradually increasing diameter of the worm or the worm casing toward the discharge end, enables the worm to properly discharge materials of any quality or consistency, and whether the concentrates are slimy, greasy, or granular and gritty. Said worm shaft may be provided with a rotary cutter 70, to cut or scrape off the ends of the mass of concentrates, as the same are forced upward by the worm. We prefer to connect the outer ends of said separating chambers 25 with the worm casings 42 by short pipes 57, as indicated, in order to equalize the mixture in said chambers 25 and said worm casings 42, particularly when the plugs of concentrates are of impervious clayey materials.

The production of the vacuum.—It being understood that the machine is revolved at such velocity that the centrifugal force at the point of discharge of the lighter ingredients will just balance atmospheric pressure, then we prefer to generate the vacuum in a part of each separating chamber which is nearer to the axis of rotation of the machine than is the point of discharge from the said chamber of the heavier ingredients, in the following manner: Suppose the separating chambers and other parts of the machine to be full of the mixture, the machine being originally at rest and the valve 12 closed, said chambers having outlets permitting the discharge of concentrates at the rate they are formed. Now suppose the machine to be revolved at the determined velocity, valve 12 being still closed. Then the concentrates would form under the influence of centrifugal force, and the plug of concentrates would discharge, and there would be developed in part of said chamber 28 and said branch 24 and pipe 1, a vacuum. Now suppose the valve 12 is opened a certain amount, mixture then enters through said valve 12 into said chambers 25, and the several materials discharge therefrom only at the rate at which mixture enters through said valve 12, and manifestly there will be a pressure lower than normal atmospheric pressure in the part of said chamber which is within the line where the heavier materials concentrate, and particularly there will be a pressure lower than atmospheric in the part of said chamber 25 which is nearer the axis of rotation than is the point of discharge of the heavier concentrates. Consequently the normal atmospheric pressure will develop a force in the light liquid opposed to the centrifugal force, and which prevents the lighter liquid from flowing out with the heavier concentrate through the same opening. Thus the development of a vacuum in a part of the separating chamber nearer to the axis of rotation thereof than is the point of discharge of the heavier concentrates is an indispensable step in our process of separation, and while we prefer to generate the vacuum through the centrifugal force due to the revolution of the machine, yet we can develop said vacuum by means independent of the centrifugal force, as by suitable suction pumps properly connected with the inner ends of the separating chambers; and as hereinbefore stated our invention is not limited to any particular means of producing said vacuum.

The process as a whole.—The process as an entirety is operated in the following manner: The apparatus having been suitably primed preferably when at rest, and the valve (or said valve 12 and check valve 14, if both are used) being closed, the machine is started up. The centrifugal force causes the excess liquid to overflow at trap 32, and a vacuum is formed in pipes 1 and 24, and part of chamber 25. The supply valve 22 is opened the proper amount, the materials rise in receptacle 20, the float 19 opens the valve 12, and adjusts the area of the orifice to suit the supply admitted by said valve 22, the atmosphere presses on the surface of the materials in said receptacle 20, causes them to rise in pipe 1, and the centrifugal force projects the mixed materials into the chambers 25, where the centrifugal force causes the heavier matters to move outwardly and concentrate in the outer part and the nozzles of said chambers. At this point the traps formed by the inward inclination of the worm casings 42 prevent the discharge of the said heavier concentrates by centrifugal force. Therefore said concentrates continue collecting at the outlets of said chambers and inlets of said worm casings, until the proper motion of said worm 43 pushes the end of said worm into the mass of concentrates, and the rotation and the upward lengthwise motion of the worm then discharge a mass of concentrates out of the upper end of said worm casing into said receptacle 69. Thus another step in our complete process is the removal of the heavier concentrates by a force or forces, other than centrifugal force. In the

mean time the lighter liquid materials flow gently, and without injurious eddies, around said partition 28 from the branch 24 to the pipe 30, to the traps 32, and thence down by pipe 31 to the filtering receptacle 40, being filtered through the filtering screen 60, and finally discharge into receptacle 68. Thus, by reason of the vacuum in part of said chamber 25, there is no tendency for violent gushing-out of the lighter liquid from the separating chambers, but there is a regular even discharge of said liquid from said chambers at the same rate as that at which the liquid is supplied to said chambers by said valve 12. In case an increased quantity of mixture enters said receptacle 20, through some variation in the supply head, float 19 will rise and will open valve 12 until the discharge through said valve 12 into the separating chambers equals the amount delivered by valve 22 to receptacle 20; and in case the quantity of mixture supplied to said receptacle 20 by valve 22 decreases, float 19 will fall and valve 12 will more or less close until the supply admitted to the separating chambers equals the quantity delivered to said receptacle 20. Thus all irregularities in the supply are compensated for, and the process continues without interruption, the concentrates being removed at the rate at which they are formed and by their own proper outlet, and the lighter liquid being, as it were, held in check by the excess of normal atmospheric pressure over that existing in the said part of the separating chambers, and being discharged regularly and under control by its proper outlet, separate from the outlet which the heavier concentrates are discharged, and at the rate at which said liquid is delivered to said separating chambers.

The operation of the reciprocating worm.—In connection with our said process the reciprocating worm hereinbefore described is very useful, although not indispensable. With various materials of a gritty nature the reciprocation of the worm may be dispensed with, since a rotary worm, without reciprocating, will properly convey and discharge such materials. But when the concentrates are slimy and slippery, with but little friction against the walls of the worm casing, it is necessary to employ a reciprocating worm to effect the proper discharge of the concentrates. For such concentrates are liable to merely revolve with the worm in the casing and not to advance, unless the worm reciprocates. But with our reciprocating worm, then, at proper intervals, the worm first pushes into the concentrates, which fill, more or less, a number of threads of the worm, and then the upward motion of the worm lifts the charge of concentrates, and very soon after the machine is started up there takes place a regular discharge of the concentrates into the said receptacle 69; the several motions of the worm being so timed that the concentrates are removed at the rate at which they are formed.

Now having described our improvements we claim as our invention.

1. The process of separating from each other materials of different specific gravities, and one at least of which is a liquid, which consists in revolving the mixed materials and thereby generating centrifugal force in the mixture which throws the heavier material outward from the axis of rotation and tends to separate it from the lighter material, and simultaneously developing a pressure less than atmospheric pressure in the mixture, whereby the greater normal atmospheric pressure opposes the effect of the centrifugal force on the lighter material and prevents said lighter material from moving outward along with said heavier material.

2. The process of separating from each other materials of different specific gravities, and one at least of which is a liquid, which consists in revolving the mixed materials and thereby generating centrifugal force in the mixture which throws the heavier material outward from the axis of rotation and tends to separate it from the lighter material, and simultaneously developing a pressure less than atmospheric pressure in the mixture, whereby the greater normal atmospheric pressure opposes the effect of the centrifugal force on the lighter material and prevents said lighter material from moving outward along with said heavier material, and extracting the concentrated heavy material as the same is concentrated.

3. The process of separating from each other materials of different specific gravities, one at least of said materials being a liquid, which consists in revolving the mixed material and thereby generating centrifugal force which throws the heavier material outward from the axis of rotation and tends to separate it from the lighter material, simultaneously generating a pressure less than atmospheric pressure in the said mixture, whereby the normal atmospheric pressure opposes the outward motion of the lighter material along with said heavier material, and applying force independent of the centrifugal force to separately extract the concentrated heavier material and the lighter material.

4. The process of separating from each other materials of different specific gravities, one at least of said materials being a liquid, which consist in revolving the mixed material and thereby generating centrifugal

force which throws the heavier material outward from the axis of rotation and tends to separate it from the lighter material, simultaneously generating a pressure less than atmospheric pressure in the said mixture, whereby the normal atmospheric pressure opposes the outward motion of the lighter material along with said heavier material, applying force independent of the centrifugal force to separately extract the concentrated heavier material and the lighter material, and clarifying the lighter material.

Signed at New York city in the county of New York and State of New York this 29th day of June A. D. 1910.

HARALD DE RAASLOFF.
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