W. L. D'OLIER & H. H. STEPHENS.

CENTRIFUGAL APPARATUS.

APPLICATION FILED NOV. 9, 1911.

1,124,715.

Patented Jan. 12, 1915.

3 SHEETS—SHEET 1.

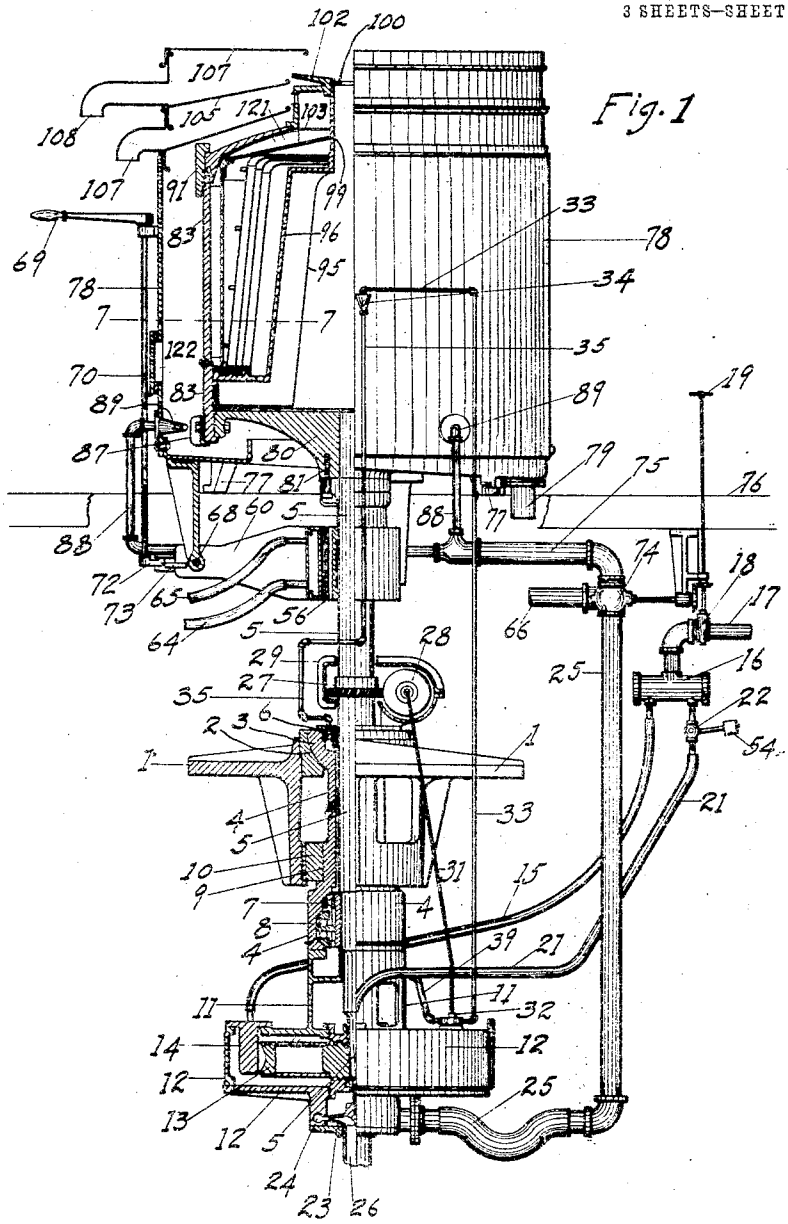


Fig. 1

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3 SHEETS—SHEET 2.

Fig. 3

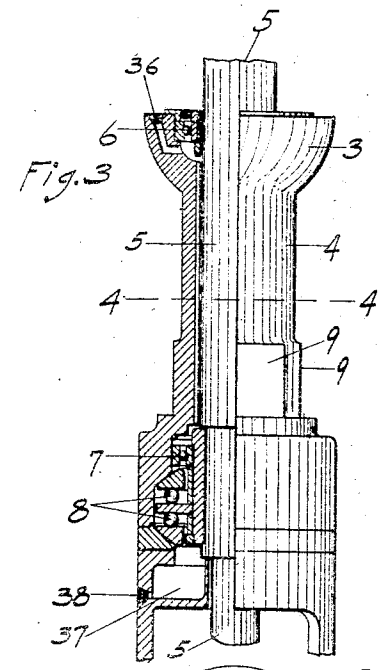


Fig. 4

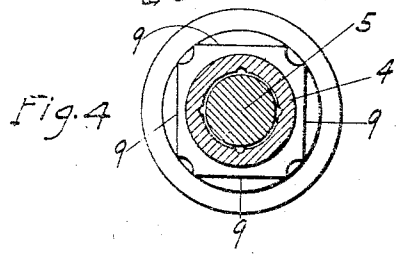


Fig. 2

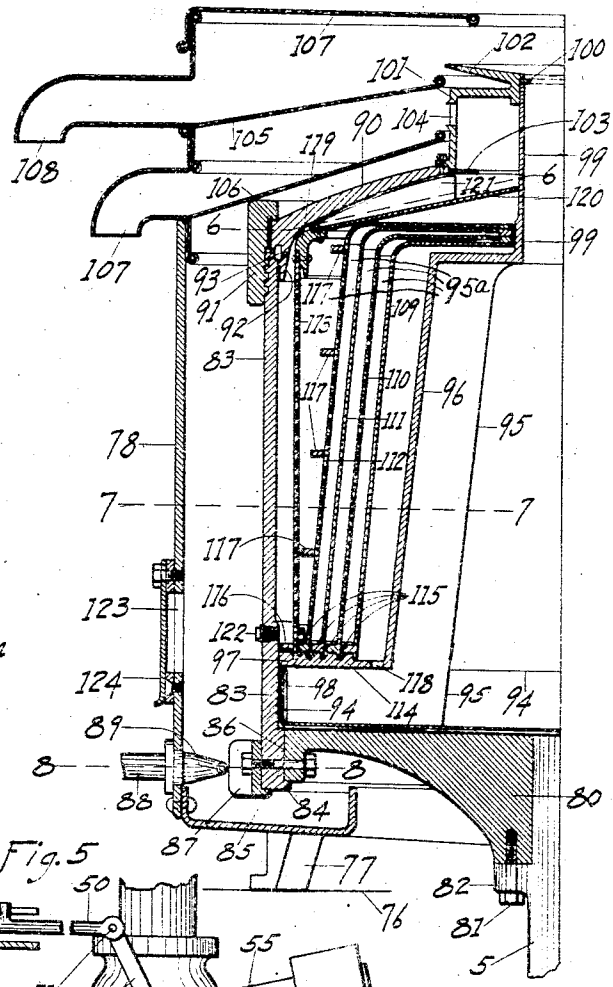
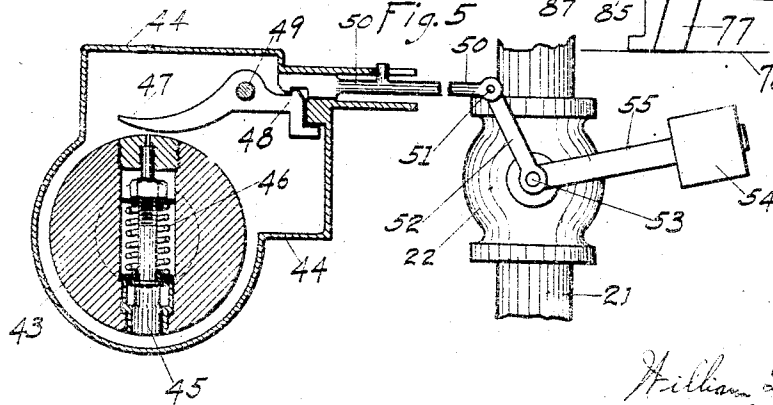


Fig. 5



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3 SHEETS-SHEET 3.

Fig. 6

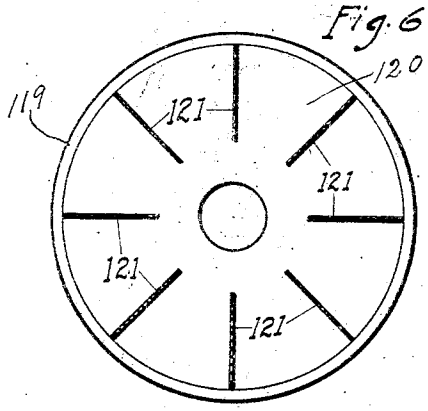


Fig. 9

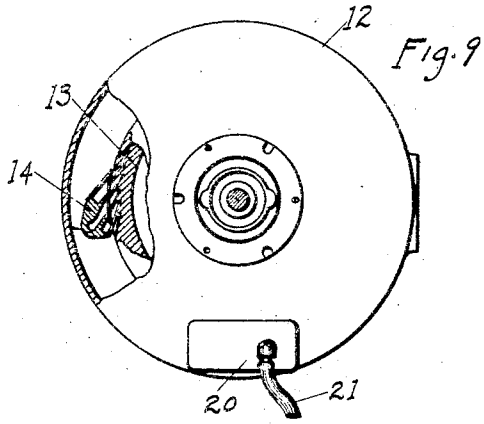


Fig. 7

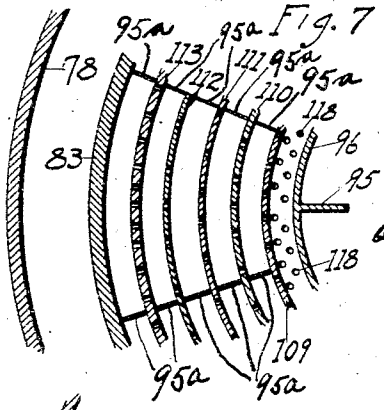


Fig. 10

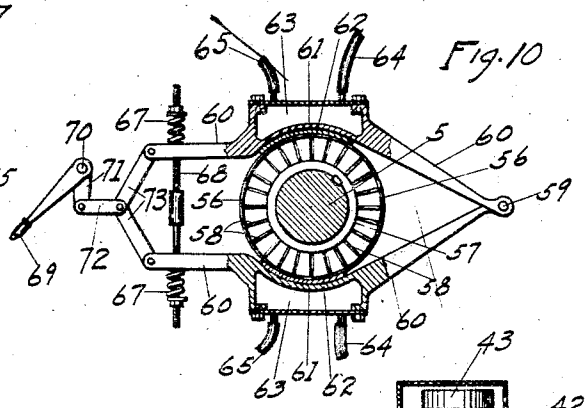


Fig. 8

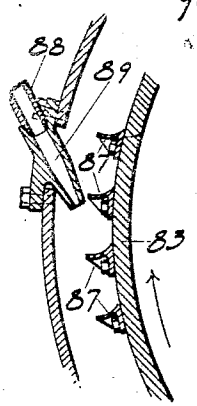
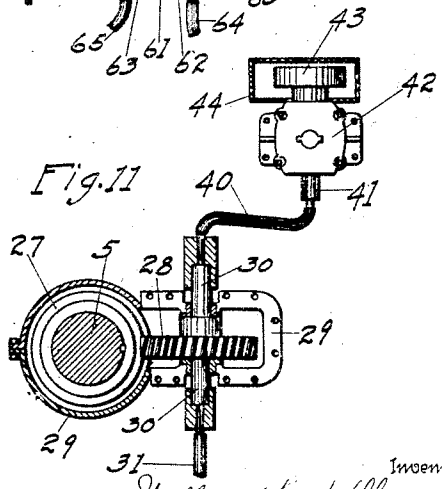


Fig. 11



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CENTRIFUGAL APPARATUS.

1,124,715. Specification of Letters Patent. Patented Jan. 12, 1915.

Application filed November 9, 1911. Serial No. 659,302.

To all whom it may concern:

Be it known that we, WILLIAM L. D'OLIER and HARRY H. STEPHENS, citizens of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented new and useful Improvements in Centrifugal Apparatus, of which the following is a specification.

Our invention relates to centrifugal apparatus, particularly centrifugal machines for the centrifugal separation of solids from liquids, liquids from liquids, etc., in fact, for centrifugal separation of any kind to which a machine of this type is adapted.

Our invention resides in a centrifugal machine which is adapted to run at particularly high speeds, considering the size of the machine, for the separation of solids or semi-solids and the like from sugar solutions, syrups, varnish, or other viscous fluids, or for any centrifugal separation where excessively high speeds are necessary, as where the material to be separated from the body of the solution is of only relatively slightly different specific gravity, or is finely divided and in suspension in the liquor.

Our invention resides in the features hereinafter described and claimed.

For an illustration of one of the forms our invention may take, reference is to be had to the accompanying drawings, in which:

Figure 1 is a vertical half sectional view, and half elevational view, of one form our machine may take. Fig. 2 is an enlarged sectional view, similar to that shown in Fig. 1, of the rotating bowl and accessories, the stationary curb, etc. Fig. 3 is a vertical sectional view and side elevational view of the main bearing and support. Fig. 4 is a section taken upon the line 4—4 of Fig. 3, some parts being shown in plan. Fig. 5 is a view partly in section and partly in elevation of a speed limit device. Fig. 6 is a partially sectional and part plan view taken on the line 6—6, Fig. 2. Fig. 7 is a fragmentary horizontal sectional view taken on the line 7—7, Fig. 2. Fig. 8 is a fragmentary horizontal sectional view taken on the line 8—8, Fig. 2. Fig. 9 is a top plan view, partly in horizontal section, of the steam turbine. Fig. 10 is a horizontal sectional view, some parts in plan, of a hand brake. Fig. 11 is a view partially in horizontal section and partly in plan, of means for driving the speed limit device and oil pump.

Referring to the drawings, a main hanger or support 1 sustains the weight of the rotating parts of the centrifugal apparatus, and is itself supported by any suitable means such as beams or the like. The member 1 carries at its upper end a hemispherical bearing member 2 in which engages the hemispherical part 3 of a gyratory sleeve 4 through which a centrifugal spindle or shaft 5 extends. Within the part 3 is a ball bearing 6 being a lateral ball bearing for the spindle 5 upon the part 3. On the inside of the lower end of the sleeve 4 are the lateral and vertical ball bearings 7 and 8 respectively; the spindle 5 having lateral bearings on the ball bearings 6 and 7 and having a vertical thrust bearing upon the ball bearings 8 such bearings transmitting the load of the spindle 5 and the parts carried thereby to the gyratory sleeve 4, the rotating spindle and the parts attached thereto gyrating with said sleeve 4 upon the hemispherical bearing 2, 3, it being well understood in this art that the centrifugal basket or bowl or drum should be free to gyrate while in operation. The sleeve 4 has a squared portion 9 which prevents its rotation with the shaft 5, the member 1 being provided in its lower end with a suitable opening in which the squared portion 9 is disposed to prevent such rotation, and resilient buffers 10 intervening to cushion any gyration or any rotative effort of the sleeve 4. Supported by the same sleeve 4 is the vertically extending portion 11 of the non-rotating casing 12 of the driving motor, which may be of any suitable type, as an electric motor, but here shown as a steam turbine. The rotor 13 of the steam turbine is secured upon the shaft 5 and, in consequence, the casing 12 and the rotor 13 gyrate with the shaft 5 maintaining, however, their proper relation with respect to each other. The member 14 carries the steam nozzle to which steam is led through the flexible pipe or hose 15 from the chamber 16 which communicates with the source of steam through pipe 17 controlled by the valve 18 having the hand wheel 19. An auxiliary nozzle or nozzles is or are provided for the steam turbine located, for example, as shown at 20, Fig. 9, a second

flexible pipe or hose 21 communicating with such auxiliary nozzle or nozzles and with the steam receptacle 16 through the valve 22, the latter controlled as hereinafter described. At the extreme lower end of the shaft 5 is secured the runner or impeller 23 of a centrifugal pump, the impeller discharging into the casing 24 which delivers to the flexible pipe 25, the suction pipe 26 for the pump communicating with a suitable source of water.

From the foregoing description, it is apparent that the spindle 5 in gyrating carries with it the motor or turbine as well as the centrifugal pump. Above the member 1 there is secured upon the spindle 5 a worm 27 meshing with the gear 28, the worm 27 and gear 28 being inclosed within the stationary casing 29. The shaft 30 of the gear 28 extends to the outside of the casing 29 and there is secured to one end of said shaft 30 a flexible shaft 31 connecting to the rotating element of the oil pump 32 disposed upon the turbine casing 12. The oil delivered by this pump passes upwardly through the pipe 33 and discharges into the funnel 34 from which descends the pipe 35 delivering oil into the opening 36 in the sleeve member 4, see Fig. 3. The oil thus delivered floods the upper ball bearing 6 and passes down through the space between the sleeve 4 and the shaft 5 flooding the lower ball bearings 7 and 8, and ultimately passing into the oil receiving chamber 37 having the outlet 38 communicating by hose or pipe 39 with the intake of the oil pump 32. Thus a circulation of oil through the bearings is maintained while the spindle 5 is running.

The other end of the shaft 30 of gear wheel 28 is connected by the flexible shaft 40 with the shaft 41, having a bearing at 42, of the rotating element 43, within the casing 44, of a centrifugal speed limit device. The member 43, see Fig. 5, is rotated by the flexible shaft 40 at a speed directly proportionate to the speed of the main shaft or spindle 5. Within the member 43 is a plunger 45 adapted to move radially outward with respect to the member 43, due to centrifugal action, and this outward movement is opposed by the spring 46. If the speed of the spindle 5 reaches a certain value, due to the centrifugal force, the plunger 45 has been moved outwardly and in rotating engages the tail 47 of the latch 48 pivoted to the casing 44 at 49, rotating the latch 48 in a clockwise direction upon the pivot 49, as viewed in Fig. 5, thereby releasing the rod 50, which extends outwardly from the casing 44 and is pivoted at 51 to the arm 52 secured upon the spindle 53 of the valve 22, a counterweight 54 adjustable on the arm 55, tending always to move the spindle 53 in such direction as to close the valve 22. Consequently, when the speed of the shaft 5 reaches a predetermined value, the rod 50 is released as described before, and the weight 54 closes the valve 22. This speed limit device is used particularly in connection with the starting of the apparatus. In starting the valve 18 is opened by operation of the hand wheel 19 allowing the steam to pass through both pipes or hose 15 and 21, thereby supplying steam to all the nozzles of the turbine, whereby great starting torque or effort is available to accelerate the shaft 5 and its attached parts in a suitably short time. When the speed of the shaft 5 is that desired for normal running, the latch 48 is actuated, as above described, and the valve 22 closed, thus shutting off the steam from the auxiliary nozzle or nozzles of the turbine, and the turbine then receives the steam only through the pipe or hose 15, which steam is sufficient to maintain the parts running at the necessary high speed.

Above the speed limit device there is secured upon the shaft 5 a brake wheel 56, see Figs. 1 and 10, having the hub 57 keyed to the shaft 5. The brake wheel 56 proper is secured upon the hub 57 by the spokes 58 which serve also as fan blades or the like for causing a draft of air through the interior of the wheel 56 between the blades 58, the blades 58 being suitably shaped and inclined for the purpose. This draft of air assists in cooling the brake surface 56. At 59 are pivoted the arms 60 carrying the brake shoes 61 between which and the brake wheel 56 may intervene suitable material 62 to be the actual wearing material. To the rear surfaces of the shoes 61 is applied cooling water delivered to the chambers 63 by the flexible hose or pipes 64, the cooling fluid or water being discharged through the hose or pipes 65. The hose or pipes 64 receive their water from the pipe 25 at 66, Fig. 1. The outer ends of the arms 60 are acted upon by the springs 67, associated with the rod 68, the pressure of the springs being normally exerted to press the brake shoes against the brake wheel. To lift the brake shoes the handle 69 is provided, the same being upon the vertically extending rod 70 to whose lower end is connected the crank 71, Fig. 10, to which is pivoted the link 72, in turn pivoted to the link 73, pivoted to the outer ends of the arms 60. By moving the handle 69 in a counter-clockwise direction about the center 70, as viewed in Fig. 10, the brake shoes will be lifted, and rotating the handle 69 in opposite direction will assist the springs 67 to apply the brake shoes to the brake wheel to retard and stop the shaft 5 and all attached parts.

The water for cooling the brake shoes is derived from the centrifugal pump 23, 24 through the pipe 25 in which is provided a valve 74, Fig. 1, operated simultaneously with the valve 18 by the hand wheel 19.

When the valve 18 is closed by the hand wheel 19, the valve 74 is opened allowing the water to pass through pipe 66 and also through pipe 75 to the hydraulic brake later to be described.

The line or surface of the floor, upon which an attendant or operator may stand, is shown at 76, Figs. 1 and 2. Upon this floor upon feet 77 is supported the curb 78 surrounding the centrifugal apparatus proper. The bottom of the curb slopes toward the right, as seen in Fig. 1, and the water or other material finding its way into the curb is discharged through the pipe 79.

The upper end of the shaft 5 extends into the bottom or driving member 80 of the bowl, basket, or centrifugal drum proper. This member 80 is preferably of cast steel, but may be of other suitable material. The member 80 is bolted to and driven by the shaft 5 by a plurality of bolts 81 passing through a flange or the like 82 upon the shaft 5.

Around the periphery of the bottom member 80 is disposed the drum, bowl, or centrifugal basket 83 preferably of nickel steel, or other material, which is of such high tensile strength as to withstand the extreme stresses exerted thereon when driven at very high number of revolutions per minute, as, for example, in the case of a basket or bowl 83 of 36 inches diameter running at 2,000 revolutions per minute, approximately. At its lower end the bowl or basket 83 is provided with a ledge 84 engaging against the lower edge of the member 80 and a plurality of bolts 85 passes through the outer flange of the member 80 and the bowl or basket 83. These bolts, however, do not in themselves generally suffice for keeping the joint 86 between the bowl 83 and the member 80 tight, for at the speeds employed the liquids within the bowl or basket exert extremely high pressures and leak through what would be tight joints in ordinary centrifugal apparatus. This difficulty is overcome, however, by the construction here shown, where the joint is in such position, and where the modulus of elasticity of the member 80 differs from the modulus of elasticity of the bowl 83 in such degree that, at the high speeds attained, the member 80 stretches radially, under the centrifugal force of acting, at a greater rate than the stretching or expanding, under centrifugal forces, of the bowl member 83. It follows from this construction and choice of materials that the joint 86 is made tighter and tighter as the speed of rotation is increased, due to the fact that the member 80 expands or increases in diameter at a greater rate than the member 86. This last mentioned feature is one of the important ones of our invention and was evolved by us only after having tried various other forms of unsuccessful joints and constructions in a machine of the size and speed aforementioned. During operation a pressure is exerted vertically against the cover 90 thus tending to lift the bowl 83 vertically with respect to the member 80 which would thereby cause a shear upon the bolts 85, but the bolts 85 are relieved from this shearing action by the ledge 84 which is made deep enough, vertically, to withstand any shearing action, the upward thrust being exerted upon the ledge 84 and upon the flange of the member 80.

For bringing the parts to rest a hydraulic brake in addition to the hand brake above referred to is provided. This comprises buckets 87, similar to water wheel buckets, secured upon the outside of the bowl 83 at its lower edge, see Figs. 2 and 8. In Fig. 8 the arrow indicates the direction of rotation of the bowl 83. The water derived from the pump 23, 24 through pipe 25, valve 74, pipe 75 and pipes 88, is delivered to the nozzles 89 which deliver the water against the buckets 87 in such direction as to oppose the rotative movement of the member 83.

A cover 90 for the bowl 83, also preferably of nickel steel, rests upon the top edge of the bowl 83 and is clamped to the latter by the ring nut 91, screw-threaded upon the bowl 83, and preferably also of nickel steel. The cover 90 has a flange 92 extending downwardly beyond the upper edge of the bowl 83, a recess being provided for the rubber or other gasket 93 which extends across the horizontal joint between the cover 90 and the top edge of the bowl 83. With the recess containing the gasket 93 communicate several holes extending through the flange 92, whereby the high pressure liquid, when the bowl is running, exerts pressure upon the gasket 93, holding it all the more firmly across the joint and rendering the device liquid-tight at these high pressures.

Within the bowl 83 and resting upon the bottom 80 thereof is a mud-tray 94 adapted to receive the solid and semi-solid and other material separated from the liquor under treatment. Resting upon the bottom of the mud-tray or drum 94 are the vanes 95, preferably radial, integral with or secured upon the member 96, see Figs. 2 and 7. The member 96 is shown conical in form, but may be of any other suitable form, as cylindrical. The member 96 at its bottom has the horizontal portion 97 from which extend downwardly to rest upon the bottom of the tray 94 the vertical portions 98 of the vanes 95. The member 96 extends upwardly to form the throat 99 at whose mouth or receiving opening is provided a ring 100 of suitable diameter, with relation to the speeds employed, to prevent a rising wall of liquid from passing over and out at the top of the throat. Supported upon the cover 90 is the

circular member 101 carrying at its upper edge the flange 102 inclined downwardly and inwardly to the intake of the throat 99. Between the outer wall of the throat 99 and the outer wall of the member 101 is formed an annular chamber to which the treated or clarified liquid is delivered past the diaphragm or ring 103, of suitable opening considering the speeds employed. And for varying the rate of discharge and for treatment of materials varying in character and varying in amount and nature of solids or semi-solids or other matter to be separated, rings 103 of different sized openings may be employed. The liquid passes from the annular chamber through the opening 104 into the chamber between the stationary members 105 and 106, discharging at the spout 107. Any overflow of the raw liquor supplied to the machine must pass the diaphragm or ring 100, thence over the member 102 into the chamber between the stationary members 105 and 107, and is discharged at the spout 108, where it may be caught and re-introduced into the machine.

Outside of the member 96 are disposed the members 109, 110, 111, 112, (shown as conical but which may be of any other suitable form, as cylindrical) and 113, all having perforations as shown in Fig. 7. A filter paper or medium may cover the inside wall of member 113. The members 109 to 112 inclusive are horizontal at their upper portions and extend in to the throat member 99. At their lower edges they extend into the circular grooves in the horizontal part 114 of the member 96. This insures a long and tortuous path for liquor leaking from one space to another, and minimizes such leakage. The members 109 to 112 inclusive have at their lower parts the separator rings 115. And a separator ring 116 is provided outside of the member 113. Through these separator rings and the vanes 95^a the outward thrusts of all the cones are transmitted to the drum 83. Upon the cone or cylinder 112 are provided the strengthening bands 117. In the member 114 are the perforations 118 to allow the liquor to rise into the space between the members 96 and 109. The member 113 at its upper edge is joined to the ring 119 to which, in turn, is connected the flat cone 120 carrying on its upper surface the radial or curved vanes 121, see Figs. 1, 2 and 6.

Through the bowl or drum 83 extends a plug 122 accessible through the hand hole 123 in the curb 78, the hand hole 123 having a pivoted cover 124. By removal of the plug 122 the liquor within the drum or bowl 83 may be drained off.

The operation of our apparatus is as follows: Assuming the apparatus at rest, to start the same, the hand wheel 19 is operated to open the steam valve 18 and simultaneously close the water valve 74. Steam now passes through pipes 15 and 21 to both sets of nozzles of the steam turbine causing the same to rotate and to accelerate the shaft 5 and the bowl 83 and attached parts. When the parts have attained the desired speed of revolution, the speed limit device, as hereinbefore described, actuates the latch 48 and releases the rod 50, whereupon the weight 54 closes the valve 22 shutting off steam from one set of nozzles of the steam turbine, the steam supplied to the other set of nozzles being sufficient to maintain the apparatus at its necessary high speed. And while the shaft 5 is in motion the oil pump 32 produces a circulation of oil, as hereinbefore described.

The liquor to be treated is introduced into the throat 99 through the diaphragm 100 and passes into the space within the member 96 where it is caused to rotate with the parts by the vanes 95, and the centrifugal action is sufficient for immediate separation of heavy solids. The liquor rises through the perforations 118 to the space between the members 96 and 109 and is subjected to centrifugal action, and passes through the perforations in the member 109 to the space between the members 109 and 110 and thence through the successive cones 111 and 112, and finally out through the perforations in the member 113 into the space between the same and the bowl or drum 83, then passes upwardly through the space between the ring 119 and the cover 90 and above the cone 120 in which place it is also kept in rotation by the vanes 121. It then discharges through the diaphragm 103 and finally through the orifice 104 and spout 107. Liquor is continuously fed through the diaphragm 100 and is delivered continuously through the orifice 104 and spout 107 until so much solid or semi-solid material has been extracted that the drum and the parts within must be cleaned. In this centrifugal operation extremely high pressures are developed within the drum 83, but nevertheless the joints 86 and 93 are maintained tight, by the actions hereinbefore described. By the employment of the vanes 121 the success and efficiency of the machine is greatly increased for, in fact, without these vanes very little, if any, practical quantity of fluid is discharged. And by properly adjusting the diameters of the openings in the diaphragms 100 and 103 the rate of treatment of liquid may be greatly increased or diminished. And notwithstanding the great liquid pressures developed within the centrifugal apparatus the amount of flow through the apparatus will depend upon the difference in head between the inlet through diaphragm 100 and the outlet through diaphragm 103 and orifice 104.

When it is desired to stop the machine,

the valve 18 is closed and the valve 74 opened and the hand brake set by the lever 69. The steam being entirely shut off from the turbine the parts now run under their own momentum and the kinetic energy of the rotating parts is consumed in actuating the centrifugal pump 23, 24, delivering water through pipe 25 to cool the brake shoes of the hand brake and also to supply water under pressure to the nozzles 89 of the water brake. Thus, the kinetic energy is used to operate the water brake, the load of the water pump serving to diminish the speed and, furthermore, the same water operating against the direction of rotation of the parts at the water brake, still further decreases the speed, and finally the parts come to rest, the last part of the braking being due principally to the hand brake.

For the different liquors operated upon, containing different amounts of sediments or semi-solids, different numbers of cones or cylinders as 109, etc., may be employed. With liquors containing much sediment one or more of the inner members 109, 110, etc., may be omitted to provide greater storage capacity for the solids or semi-solids.

We believe we are the first to successfully construct and operate a large size centrifugal machine at such high speeds; and in doing so have overcome many defects in prior machines of like size which, when driven at the high speeds, failed in one or more respects. And our invention resides in part in features lending themselves to the successful construction and high speed running of so large a centrifugal machine.

What we claim is:

1. In centrifugal apparatus, a rotating shaft, a centrifugal drum, a member secured upon said shaft and to said drum for rotating said drum, and a joint formed between said drum and said member, said member having a modulus of elasticity differing from the modulus of elasticity of said drum, whereby at high speeds said joint is maintained tight.

2. In centrifugal apparatus, a shaft, a drum, a member forming the bottom of said drum and secured to said shaft, said drum secured to said member, and a joint between said member and drum, said member being of a material yielding to a greater degree than said drum under centrifugal forces, whereby said joint is maintained tight.

3. In centrifugal apparatus, a drum, a shaft, a bottom member for said drum secured thereto and to said shaft, a ledge on said drum against which said bottom member engages, and a joint between said drum and said bottom member, said drum and said bottom member expanding at different rates under centrifugal forces, whereby said joint is maintained tight.

4. In centrifugal apparatus, a drum of nickel steel, a shaft, a bottom for said drum of material of lower tensile strength secured to said shaft and to said drum.

5. In centrifugal apparatus, a drum of nickel steel, a shaft, a bottom for said drum of material of lower tensile strength secured to said shaft and to said drum, and a joint between said bottom and said drum, said bottom expanding in a greater degree than said drum under centrifugal forces, whereby said joint is maintained tight.

In testimony whereof we have hereunto affixed our signatures in the presence of the two subscribing witnesses at Philadelphia, Pennsylvania.

WILLIAM L. D'OLIER.
HARRY H. STEPHENS.

Witnesses:
ANNA E. STEINSOCK,
ELEANOR T. McCALL.