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CENTRIFUGE MACHINE

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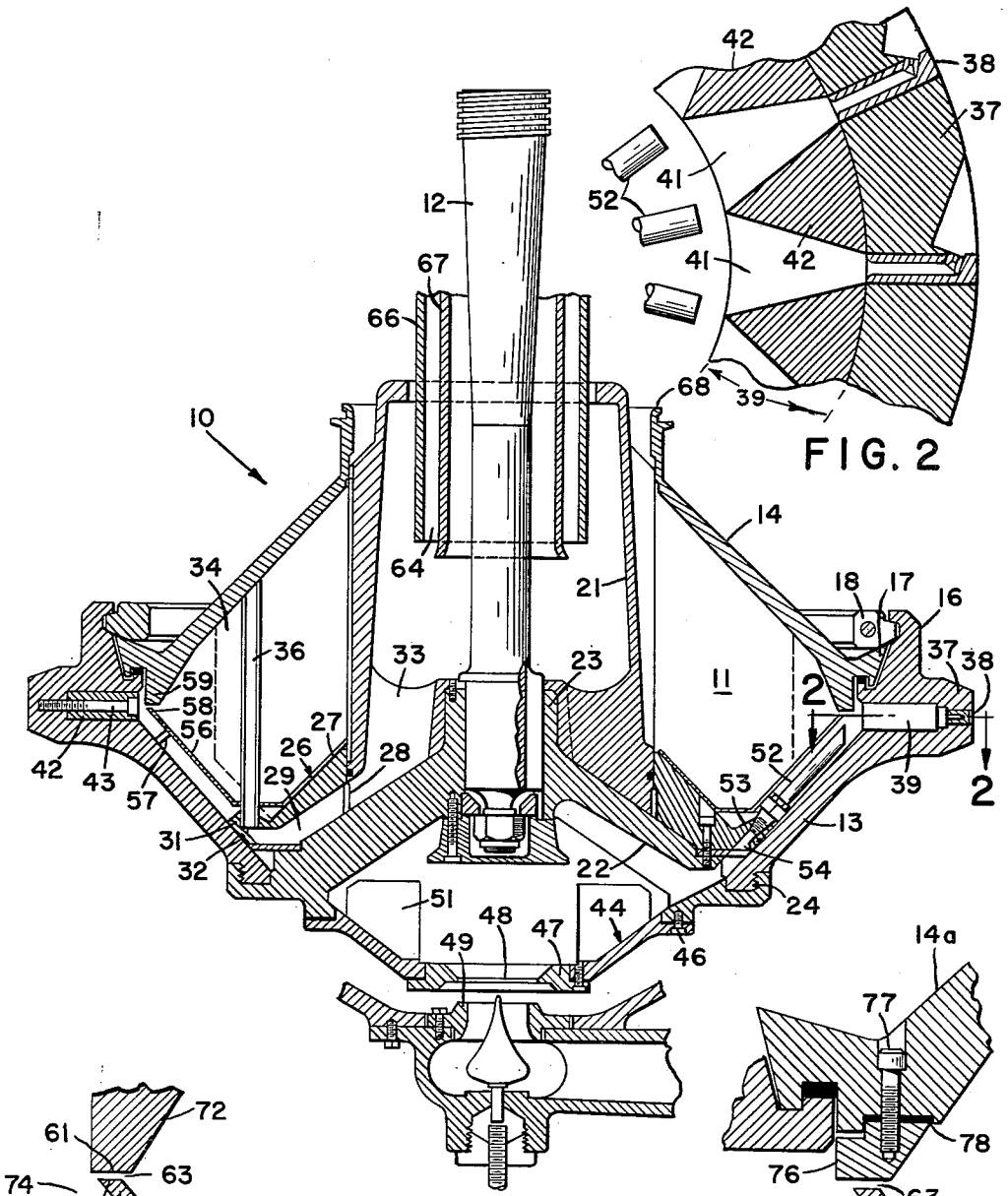


FIG. 2

FIG. 1

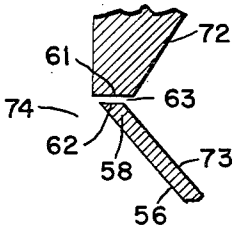


FIG. 3

FIG. 4

INVENTOR.
RALPH H. HALBACH
BY
Flehr & Swain
ATTORNEYS

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CENTRIFUGE MACHINE

Ralph H. Halbach, San Leandro, Calif., assignor to Dorr-Oliver Incorporated, Stamford, Conn., a corporation of Delaware

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This invention relates generally to centrifuge apparatus for carrying out separating operations on a fluid feed material. The machine is particularly applicable for the removal of an underflow which contains centrifugally separated solid particles and is relatively free of solubles (i.e. material in solution) present in the feed.

Commercial machines are in use which are capable of continuously separating operations on feed materials containing solid particles in suspension or as a slurry (see Patents 1,923,454 and 2,525,629). Assuming that solubles (i.e., substances in solution) are present in the feed, solubles normally are present in the underflow containing the heavier separated solids. Because the application of centrifugal separating forces does not of itself separate or concentrate solubles into one of the separated fractions, solubles tend to be present in both the underflow and underflow drawoffs in proportion to the amount of fluid medium (i.e. water) from the feed that is present. The amount of solubles in the underflow can be reduced in part by controlled introduction of wash liquor (e.g. fresh water) into the rotor. Thus assuming use of a machine having a return circuit for continuously returning underflow material back into the rotor, wash can be added to the return material in such a manner as to displace liquor from the feed, thereby reducing the amount of solubles in the underflow drawoff. Actual experience with such machines, when used on feeds such as starch slurries, shows that there is a limit to the effectiveness with which solubles can be displaced, and that substantial amounts of such contaminants remain in the underflow drawoff. This tends to limit application of such centrifuges in many processing operations. With respect to starch manufacturing processes, the use of one or more centrifuge stages for the separation of starch from gluten and solubles, provides a starch liquor containing sufficient residual solubles as to require extensive further treatment (e.g., filtration, washing, etc.) for obtaining the desired degree of purity.

In general it is an object of the present invention to provide a centrifuge apparatus of the above character capable of effective elimination of solubles in the underflow drawoff.

Another object of the invention is to provide an apparatus of the above character which will effectively wash solid particles separated from the feed, thus greatly reducing the amount of soluble contaminants in the underflow drawoff.

Another object of the invention is to provide an apparatus of the above character which will accomplish the desired objectives, without materially reducing the capacity of the machine.

Further objects and features of the invention will appear from the following description in which the preferred embodiments have been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

FIGURE 1 is a view in section and elevation showing a centrifuge apparatus in accordance with the invention.

FIGURE 2 is an enlarged detail view along the line 2—2 of FIGURE 1.

FIGURE 3 is an enlarged fragmentary view, similar to FIGURE 1, showing a detail of the invention.

FIGURE 4 is a view like FIGURE 3, showing an embodiment on which the orifice is adjustable.

The centrifuge illustrated in FIGURE 1 consists generally of a rotor 10 having an inner separating chamber 11, and carried by the vertical rotatable shaft 12. The rotor in this instance is formed of a plurality of sections, including the bowl 13, and the rotor cover 14. Both of these sections are formed generally as truncated cones. The bowl and cover sections have mating annular portions 16 and 17, and are releasably held together by the clamp ring 18 (see Patent 2,760,889).

A tapered shell 21 surrounds shaft 12 and forms a feed well that seats upon a conical shaped structure 22. The latter is disposed within the bowl and has a hub 23 for rigid attachment with the shaft 12. The outer peripheral portion of structure 22 is attached to the lower end of the bowl 13, as by threaded connection 24.

Extending outwardly from the lower end of the feed well, there is a feed impeller 26. This impeller can consist of a conical shaped wall structure 27, together with radially extending vanes 28, which serve to define outwardly extending passages 29. The outer peripheral portion 31 of the feed impeller is suitably sealed with respect to the bowl, as by means of the resilient seal ring 32 of the O-ring type. The lower portion of the feed well is provided with vanes 33, which serve to impart rotary movement to feed material, whereby this material is delivered from the feed well downwardly and outwardly into the passages 29.

The interior of the rotor is provided with nested separating disks 34, which occupy the space overlying the feed impeller 26. Suitable means is provided for distributing the feed material to the separating disks, as, for example, the vertical feed tubes 36, which are provided with vertically extending slots or like suitable openings for discharge of the feed material, and which tubes extend upwardly through the separating disks.

The annular peripheral portion 37 of the bowl serves to mount a plurality of circumferentially spaced underflow discharge nozzles 38, which can be of the type disclosed in Patent 2,695,748. The annular space 39 formed within the bowl portion 37, preferably is divided into a plurality of hopper-like spaces 41, there being one such hopper-like space for each discharge nozzle. These hopper-like spaces are formed by filler or hopper blocks 42, which can be held in place by suitable means such as screws 43.

Means are provided for continuously returning underflow material back into the centrifuge bowl. Thus a return impeller 44 is attached to the structure 22, as by means of screws 46, and serves to mount the impeller ring 47. The opening 48 in this ring overlies a nozzle 49 or like means for introducing material upwardly into the impeller. The impeller also includes the radially extending vanes 51, which impart rotary motion to the returned material.

A plurality of circumferentially spaced tubes 52 are arranged about the lower portion of the separating chamber, immediately overlying the upper inner surface of bowl 13. The inner and lower ends of these tubes are engaged with the annular portion 53 that is formed on the outer periphery of the impeller wall 26. Passages 54 in the annular portion 53, establish communication between the tubes 52 and the interior of the impeller 44. It will be understood that passages 54 are circumferentially spaced, and are interleaved between the passages 29, which communicate with the feed tubes 36.

As shown in FIGURE 2, the outer ends of the tubes 52 are located to discharge material against the apexes of the filler blocks 42.

Overlying the area occupied by the tubes 52, there is a conical shaped shroud 56. This shroud is supported by lugs or fins 57, and its outer and upper edge portion 58 preferably terminates in a plane substantially coinci-

dent with the plane of the underflow discharge nozzle 38 with the ends of the tubes 52 terminating substantially at the outer end of the shroud 56.

The peripheral portion 59 of the bowl cover 14 forms in effect an inner annular extension which terminates in a downwardly faced flat annular surface 61. As shown in enlarged FIGURE 3, the edge portion 58 of the shroud 56 provides an end surface 62 of substantial radial width that is parallel to the surface 61, and spaced therefrom to form the restricted annular orifice 63. The ends of the tubes 52 terminate adjacent to the orifice 63. Preferably this orifice and the nozzles 38 are in a common plane.

As shown in FIGURE 1, feed material can be introduced into the feed well through the passage 64 between the outer and inner concentric tubes 66 and 67. Centrifugally separated overflow discharges over the annular lip 68, formed on an upper extension of the bowl cover 14. The entire rotor is enclosed within an outer housing (not shown) which has volutes or like means for receiving the centrifugally separated overflow, and the underflow discharging from the nozzles 38. Although not essential, a closed return circuit is preferably employed whereby a desired amount of the material discharging from the underflow nozzles is continuously returned back into the machine, by way of the return impeller 44, and the remainder of the underflow removed from the machine. The formation of the housing and the return circuit can be substantially as disclosed in Patent 2,616,620. The return circuit has means for introducing wash liquor, such as fresh water, whereby such wash liquor is returned to the machine together with the returned underflow.

The operation of the machine described above can best be described by referring to a particular type of feed material consisting of a fluid carrier medium like water, together with solid particles in suspension or as a slurry, and solubles such as dissolved organic or inorganic chemicals. Starch liquors such as are encountered at various points in starch manufacturing processes, are feed materials corresponding to this description. As disclosed in Patent 2,323,077, centrifuges of the continuous type can be advantageously used in the wet starch process for the manufacture of starch from corn. Particularly one or more stages of such machines can be used to carry out the primary separating operation between starch and gluten. Instead of utilizing separation by centrifuging, the older tabling operations may be employed. After removing substantially all of the gluten and fibrous material from the starch magma, a starch liquor is obtained which normally is deemed to be of sufficient purity for final treatment to form finished starch. Such final treatment may involve chemical bleaching, together with several stages of filtration, each filtration stage being followed by washing of the filtered cake and repulping of the filter cake for further filtration. These filtering and purification operations are made more complicated and expensive by virtue of solubles present in the starch liquor, which prior centrifuging or tabling methods do not remove. In a typical instance, such starch liquor may consist of water, together with 33–38% starch solids, and 1.3% solubles in the form of dissolved organic and inorganic chemical.

In accordance with the present apparatus, such starch liquor, either before or after chemical treatment for bleaching, is fed to the machine described above, and a substantial amount of underflow is continuously returned, with a controlled amount of fresh water being added to the returned material. Within the centrifuge chamber separated starch particles progress outwardly, and in the vicinity of the orifice 63, the starch particles are concentrated along the inner surfaces 72 and 73 of the rotor cover and shroud 56 respectively. As the starch particles progress over the surfaces 72 and 73, they find their way to the annular orifice 63, and then progress through this restricted orifice into the space 74 immediately surrounding the orifice. From thence the starch progresses through the hoppers 41 and discharges through the underflow nozzles 38. The amount of wash added to the return is controlled whereby a substantial part of such wash passes through the orifice 63 countercurrent to the progression of starch particles. This results in a displacement and washing action whereby solubles remain within the main separating chamber for discharge with the overflow, and whereby the material passing through the orifice 63 is in water relatively free of solubles.

The orifice 63 requires proper proportioning to obtain effective starch washing in accordance with my apparatus. For example, in the construction of a centrifuge for the washing of starch, the bowl in one instance had an effective diameter of 30 inches, and was constructed substantially as described above. The restricted orifice 63 had a vertical dimension of 1/16 of an inch, and a mean diameter of about 30 inches. The end surface 62 had a radial width of about 3/16 inch. A total of 20 underflow discharge nozzles 38 were provided, each with an effective discharge orifice 1/16 inch in diameter. When such a machine was supplied with a starch feed comprising 16.5% starch particles, 0.962% solubles (as soluble protein), and water, an underflow drawoff was obtained consisting of 32.4% starch particles, and 0.15% solubles. This performance was obtained with a feed rate of 135 g.p.m. (gallons per minute) with wash water containing 0% solubles (as soluble protein) being introduced into the returned underflow to provide an overflow (i.e., water in excess of that withdrawn in the underflow) of 10 g.p.m. In contrast, prior continuous centrifuges of the type used in the starch industry, operating under comparable conditions, have been unable to reduce the solubles content below about 0.54%.

Assuming that this orifice should be greatly increased in the foregoing example from 1/16 to 1/4 inch, considerable turbulence would occur within the orifice with resulting induced turbulence adjacent the inner side of the orifice. Also a substantial part of the solubles of the feed would enter the orifice with the starch granules, by virture of the greatly reduced concentration of starch granules. Such turbulence interferes with sharp separation and effective counterflow washing of the starch granules, and this, together with the reduced concentration, causes substantial contamination of the starch underflow drawoff. With my invention a new apparatus is obtained whereby turbulence within the annular orifice is eliminated or reduced to a minimum, because of the adjacent parallel surfaces, and at the same time the concentration of starch granules within the orifice is made relatively high, whereby a minimum amount of fluid from the feed is present as the granules enter the orifice. As the granules enter the orifice, such fluid from the feed is effectively displaced by the countercurrent wash, and the granules are effectively washed whereby contamination of the underflow is reduced to a minimum.

In practice there are certain factors that limit the smallest permissible width of the orifice. Because a reduction in width increases the concentration of granules (i.e., the ratio between solid granules and carrier liquid), the width must be sufficient to insure a flowable slurry. For different feed materials, this limitation may vary somewhat depending upon the physical properties of the granules. For hydrous starch feeds, concentrations beyond about 43% starch are difficult to deliver through a small orifice without clogging, and for given operating conditions, the dimensioning of orifice 63 is such as to maintain somewhat lesser concentrations (e.g., 32 to 37.5% starch) which can be progressed without clogging or channeling. Note in this connection that substantially all of the fluid medium with the starch granules in orifice 63 is counterflow wash water, and not water from the feed. Another factor is the size of the granules relative to the width of the orifice 63. The orifice must have a width such that it passes the granules without clogging. With starch feeds it has been found that an orifice width of the order of

1/16 inch will pass the starch granules without clogging, and will provide the desired result.

In the foregoing example, the machine was operated with continuous return of substantially 70% of the underflow material back into the rotor. In some instances it may be desirable to use the machine without return of discharged underflow. In such event, wash liquor alone can be introduced into the impeller 44, for discharge with the underflow material.

As shown in FIGURE 4, the orifice may be adjustable. Thus a separate ring member 76 is attached to the cover section 14*a* by the screws 77. The gasket shims 78 can be adjusted to locate member 76 with respect to shroud 56, thus in effect providing an adjustment for the orifice 63. With this arrangement the machine can be adjusted for a given operating condition to afford maximum removal of solubles from the underflow solids.

I claim:

1. In a centrifugal machine for the continuous centrifugal treatment of a fluid feed mixture containing a fluid medium together with solid granules and solubles for effecting separation of the mixture into a relatively concentrated underflow product substantially free from solubles and an overflow product substantially free from solids and containing said solubles at a relatively high concentration, a rotor structure having a bowl of generally double trunco-conical configuration constituting an annular centrifugal separating chamber with overflow means provided at one constricted end of said bowl, a hub portion closing the opposite constricted end of said bowl and having provided therein a set of influent passages spaced around the rotor axis, underflow discharge nozzles equally spaced from one another in the intermediate peripheral portion of the bowl, a trunco-conical shroud member contained in said bowl concentric with the rotor axis and located opposite to said overflow so as to constitute with said hub portion and with the adjacent trunco-conical wall of the bowl a conical space closed at its narrow end whereat said influent passages are located, a complementary wall portion forming the upper part of the bowl and presenting a trunco-conical inner face opposed to said trunco-conical shroud member, the mutually adjacent ends of said wall portion and said shroud member constituting with each other an annular orifice located radially inwardly from said nozzles, said annular orifice being defined by substantially plane and parallel uninterrupted end faces with the radial dimension of said orifice substantially greater than the distance between said end faces, and said distance itself small enough to cause substantial concentration of solids in the inner annular zone adjacent to said orifice and also to cause non-turbulent progression of said concentration of granules moving outwardly through said orifice counter-current to a flow of a wash liquid, a set of divergently directed inflow tubular members located in said conical space and connected to said influent passages and extending therefrom so as to have their discharge ends located in an outer annular delivery zone surrounding the outer end portion of said shroud member adjacent the outer end of the annular orifice, said tubular members terminating adjacent to said orifice and substantially at the outer end of the shroud member, means for supplying feed mixture to said separating chamber, a stack of separating discs located in said separating chamber through which separated liquid and solubles pass radially inwardly to said overflow means, while solid particles are rejected, an annular wall means connected to the rotor having a central influent opening substantially aligned with the rotor axis and arranged and shaped so as to constitute with the outwardly facing side of said hub portion an influent chamber communicating through said plurality of influent passages with said divergent tube members, and means for supplying an auxiliary mixture of underflow solids and wash liquid through said aligned influent opening into said influent chamber for delivery from said divergent tubular members into said delivery zone, thereby minimizing the circumferential velocity differential between the solids concentrate in the orifice and the auxiliary feed mixture in said delivery zone, while inducing counter-current flow of wash liquid from said auxiliary mixture substantially evenly along the annular extent of the orifice from the delivery zone thus maintaining optimum solubles blocking conditions in said orifice, and discharging a mixture of washed solids derived from said auxiliary mixture and solids from said orifice as underflow.

2. Apparatus according to claim 1, wherein said bowl comprises a truncated body portion associated with said hub portion and having an enlarged rim portion containing said underflow discharge nozzles, a truncated cover portion providing said overflow means and held in said rim portion, and comprising a detachable ring member constituting said complementary wall portion, and means for adjustably connecting said ring member to said cover portion for adjusting said distance between the planar faces of the orifice.

3. Apparatus according to claim 1, wherein said bowl comprises a truncated body portion associated with said hub portion and having an enlarged rim portion containing said underflow discharge nozzles and providing an annular relatively shallow inwardly open recess located outwardly from and opposite to said orifice and concentric therewith and communicating with said nozzles and defined by parallel annular side faces, and filler blocks fitted between said annular side faces within the recess and dividing the same into hopper shaped spaces converging towards the nozzles, said filler blocks having a body portion substantially aligned with respective tubular members.

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