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APPARATUS FOR CENTRIFUGAL SEPARATION
WITH THE USE OF AN AUXILIARY LIQUID
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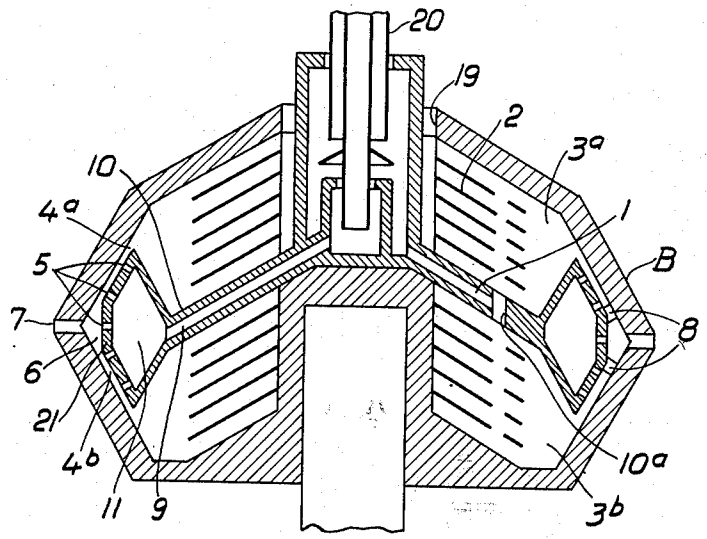


Fig. 1

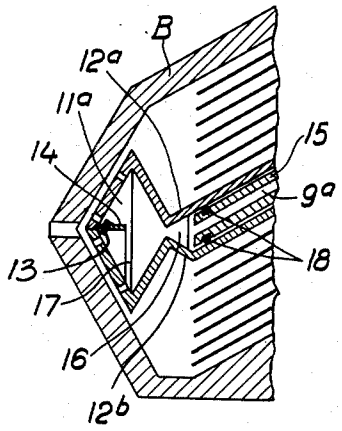


Fig. 2

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APPARATUS FOR CENTRIFUGAL SEPARATION WITH THE USE OF AN AUXILIARY LIQUID

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11 Claims. (Cl. 233—15)

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This invention relates to centrifugal separation with the use of an auxiliary liquid, to separate particles of different specific gravity or size from one another or to liberate solid particles from adhering liquid. More particularly, the invention has reference to an improved method and apparatus for this purpose.

In a copending application of Carl G. Eckers, Ser. No. 31,854, filed June 9, 1948, now Patent No. 2,599,619, there is disclosed a procedure utilizing a separator bowl provided with a system of channels, outside the separating zone or chamber. Through the channels, or part of them, an auxiliary liquid flows in an inward direction, it being possible to introduce it in or outside the channels. At the same time, a suspension containing solid particles, separated from the main liquid in the separating chamber, passes through the channels in an outward direction. In the channels, the main liquid of the suspension is partially replaced by auxiliary liquid. When the suspension contains particles of different specific gravity, or of the same specific gravity but substantially different size, it is also possible to obtain a sorting of the particles in the channels. The specifically heavier and the larger particles slide outward in spite of the inwardly directed current of liquid and can be discharged through openings in the bowl wall. The specifically lighter and the smaller particles follow the liquid current inwardly and may leave the bowl through outlets near to its rotation axis.

The present invention relates to improvements in the method and apparatus described above. According to the invention, the tangential velocity of the portion of auxiliary liquid flowing inwardly in the channel system referred to is changed by frictional forces only at the walls of the channels. There must, therefore, be no ribs or wings projecting into the inwardly passing layers of the liquid and preferably the channels should be entirely free from such parts.

In order to free the particles effectively from the main liquid and obtain a sorting of the particles, there should be a turbulency of suitable intensity in the flow of liquid through the channel system. It should be strong enough to keep the specifically lighter and the smaller particles suspended in the inwardly directed current but must not be powerful enough to prevent the heavier and the larger particles from moving outward towards the openings in the bowl wall. This turbulent flow can be obtained by properly determining the amount of auxiliary liquid passing inwardly in view of the dimensions of the

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channels. Considerable amounts of auxiliary liquid passing in the inward direction are generally required for this purpose, which increases the power consumption and encumbers the separating space, the latter effect being due to mixing of the main and the auxiliary liquids therein. An increase in the amount of auxiliary liquid increases the rate of flow through the separating space and thus impairs the result of the separation.

According to the present invention, the desired degree of turbulency is brought about by using small amounts of auxiliary liquid flowing inwardly.

Turbulent flow is obtained only when the velocity of the liquid current relative to the piping or confining walls of the current exceeds a certain critical value, one of the factors determining the latter being the viscosity of the liquid. In the procedure previously referred to, the velocity of the inward current of liquid was higher than the critical value. According to the invention, the liquid velocity required for turbulent flow is obtained by introducing the auxiliary liquid into the system of channels with, or therein giving it, a rotational velocity substantially different from that of the bowl. It is evident that a high liquid velocity relative to the rotating channels can be achieved by combining a low inward velocity with a high tangential velocity differential.

For a better understanding of the invention, reference may be had to the accompanying drawing, in which

Fig. 1 is a vertical sectional view of centrifugal bowl made according to the invention, and

Fig. 2 is a similar view of the outer part of a modified form of the bowl.

Referring to Fig. 1, the main liquid is fed through a system of channels 1 into the chamber of the centrifugal bowl B, this chamber having a separating zone divided into thin separating layers by the discs 2. When the main liquid passes between the discs, the particles contained in the main liquid are separated more or less completely. They slide along the lower surfaces of the discs into, and are accumulated in, spaces 3a and 3b outside the discs, whence they pass into the annular channels 4a and 4b inclined to the bowl axis and hence to the direction of the centrifugal force in the bowl. Into the latter, an auxiliary liquid is fed through holes 5 communicating with a channel 9 via an annular chamber 11 in a hollow ring 21.

When the auxiliary liquid leaves the holes 5, it

has the same rotational velocity as that of the bowl. In the channels 4a and 4b it is divided into one portion flowing outwardly and one flowing inwardly. It is now assumed as an embodiment of the invention that the channels 4a and 4b contain no wings in the path of the inwardly directed flow of liquid, which may act as conveyors. When a liquid element moves inwardly, it assumes a tangential velocity relative to the bowl, because it is influenced only by forces which themselves are created by a velocity differential between the liquid and the system of channels. The velocity of an element moving within the channel 4a in the vicinity of its lower boundary surface is changed by the frictional force between the element and the surface. This, in turn, is proportional to the velocity of the liquid element relative to the surface. This results in the inwardly flowing liquid, the distance of which from the rotation axis is successively reduced, obtaining, at each point of its path, a rotational velocity higher than the rotational velocity of its momentary point of contact with the boundary surface. When this velocity differential reaches a sufficient value, turbulence appears. The above description is a considerable simplification of the course of flow. It is complicated by (among other things) a concentrated suspension of solid particles moving outward along the outer boundary surface of the channel. As this suspension moves outwardly from within the bowl, it will, when conveyed only in the channel 4a by the friction at the boundary surface of the channel, rotate more slowly even when it is at a very small distance from the surface.

The invention also comprises modifications of the above-mentioned procedure and the apparatus for putting it into effect. In the following, the modifications will be described in conjunction with a starch manufacturing process by which the starch is separated from the gluten. The latter product has a flake-like consistency and lower specific gravity than the starch.

Starch and gluten separated from the main liquid between the discs 2 enter the channels 4a and 4b as a concentrated suspension. In these channels, as previously described, it meets a turbulent inwardly directed flow of auxiliary liquid. With the proper degree of turbulency, the starch is separated and enriched in a layer which slides outwardly along the outer boundary surface of each channel 4a and 4b and discharges through the ports 7 in the bowl periphery. The majority of the glutenous particles are kept suspended in the turbulent flow of liquid, by which they are carried off in an inward direction towards the center of the bowl. One part of the gluten passes through the disc interspaces and leaves the separator bowl at the outlet 19, while another part is separated out, enters the channels 4a and 4b again, and is returned towards the center.

When a highly turbulent flow is required, the auxiliary liquid should be fed into the annular chamber 6, to which the channels 4a and 4b converge at the bowl periphery. At the inner orifices of the channels 4a and 4b, the liquid will then have a higher tangential velocity in relation to the bowl than if it is introduced between the inner and outer orifices of the channels. The turbulency may also be increased by directing the openings 5 in the rotational direction of the bowl, because the liquid will then have, on entering the channels 4a and 4b, a higher rotational velocity than that of the bowl. It is impossible, however to make a general rule as to how the liquid is to be introduced into the channels in all circumstances. The method of introduction must be determined in view of the separating properties of the particles to be separated from one another. In some cases, it has proved advantageous to feed the auxiliary liquid into the channel through a plurality of holes arranged in several concentric systems. With this manner of introduction, the ring 21 may also be supported by the bowl wall by means of ribs or lugs 8, without thereby impairing the action of the channels 4a and 4b. It is to be noted that the ribs 8 are placed outside the outermost series of holes 5, since there is no inwardly directed flow of liquid in the channel outside this series of holes.

It is important that the suspension be evenly distributed circumferentially of the bowl even when it is only a small distance from the inlets to the channels 4a and 4b. When wings are provided in the chambers 3a and 3b outside the discs, an uneven distribution results. With such members, the starch and the gluten would be concentrated on the front side of the members, reckoned in the direction of rotation.

In Fig. 1, I have shown how the auxiliary liquid can be led through the chamber situated outside the discs 2 without wings or conveying members being formed which may cause uneven supply of suspension along the circumference of the channels 4a and 4b. The space 11 communicates with the system for supply of auxiliary liquid through channels 9 in the member 10. The latter is disc-shaped or circular and has no parts projecting into the space outside the discs 2. It divides the outer portion of the separator bowl into upper and lower parts, which communicate with one another only through the annular space 6. In the latter, the heavy particles which have passed through the channels 4a and 4b accumulate. Holes 10a, provided in the member 10 inside the outer edges of the discs 2, convey the liquid which has passed through the discs in the lower part of the separator bowl into its upper part, which is provided with an outlet 19 for the discharge of the liquid.

Channels 1 may also be provided within member 10 for the supply of the main liquid from inlet pipe 20.

Ribs may also be arranged on the outer boundary surfaces of the channels 4a and 4b in order to force the layers sliding along these surfaces to follow the rotational speed of the channels. It is important that such ribs are not so deep as to allow a layer to be formed nearest to the inner boundary surface of the channels 4a and 4b, where the auxiliary liquid should flow without being conveyed by the ribs.

As shown in Fig. 2, the disc-shaped member is made up of two parts 12a and 12b. A rubber ring 13, which establishes a tight joint between these parts, is supported by a disc 14 enclosed in the annular chamber 11a. The auxiliary liquid is fed into the latter from the channels 9a, situated in a central annular member 15, through an annular chamber 16, which preferably is provided with radial conveyor ribs 17 fixed to the parts 12a and 12b, and, if required, extending into the space 11a. The auxiliary liquid should be prevented from flowing inwardly from chamber 16, and for this purpose I provide rubber tightenings or packings 18 which make tight joints between the parts 12a and 12b and the central inlet member 15. The latter also in-

corporates channels for the main liquid, as in Fig. 1.

It will be noted that the channels 4a—4b have smooth inner walls (the walls nearer the rotation axis) providing an unobstructed rotation surface.

I claim:

1. In a centrifuge of the character described, a rotatable centrifugal bowl having a chamber including a separating zone, the bowl also having an inlet communicating with said zone for supplying the material to be separated thereto and an outlet in the peripheral wall of the bowl for discharging separated solids from the bowl, a generally annular member in the bowl rigidly connected thereto substantially concentric to said peripheral wall and defining with said wall a narrow annular channel disposed outwardly from said zone and inclined to the rotation axis of the bowl and to the direction of the centrifugal force therein, the channel affording communication between said zone and the peripheral part of the chamber at said outlet, means in the bowl forming an auxiliary liquid passage leading into said channel outward from its junction with said zone, and means for feeding an auxiliary liquid by way of said passage inwardly along the channel in countercurrent to separated material from said zone, the channel having a smooth inner wall forming an unobstructed rotation surface at least along a major part of its inner portion adjacent said zone.

2. A centrifugal bowl according to claim 1, comprising also a generally horizontal disc-shaped member in the bowl dividing the separating zone into upper and lower parts and having channels, said annular member having holes forming a plurality of said passages, said annular member also having a hollow interior to which said disc channels lead, whereby said feeding means are operable to feed the auxiliary liquid inwardly along said first channel by way of said disc channels, hollow interior and passages.

3. A centrifugal bowl according to claim 1, comprising also a generally horizontal disc-shaped member in the bowl dividing the separating zone into upper and lower parts and having channels, said annular member having holes forming a plurality of said passages, said annular member also having a hollow interior to which said disc channels lead, whereby said feeding means are operable to feed the auxiliary liquid inwardly along said first channel by way of said disc channels, hollow interior and passages, said disc-shaped member also having a passage communicating with the bowl inlet for feeding to the separating zone the material to be separated.

4. A centrifugal bowl according to claim 1, comprising also a generally horizontal disc-shaped member in the bowl dividing the separating zone into upper and lower parts and having channels, said annular member having holes forming a plurality of said passages, said annular member also having a hollow interior to which said disc channels lead, whereby said feeding means are operable to feed the auxiliary liquid inwardly along said first channel by way of said disc channels, hollow interior and passages, said annular member partly defining an annular chamber between the separating zone and said annular channel, said last chamber having smooth walls.

5. A centrifugal bowl according to claim 1, comprising also conveyor ribs in the channel extending along the outer wall thereof.

6. A centrifugal bowl according to claim 1, in which said passage and feeding means include a system of channels terminating in said annular channel.

7. A centrifugal bowl according to claim 1, in which said feeding means includes a chamber within the bowl chamber and located between said channel and said peripheral outlet.

8. In a centrifuge of the character described, a rotatable centrifugal bowl having a chamber including a separating zone, the bowl also having an inlet communicating with said zone for supplying the material to be separated thereto and a peripheral outlet for discharging separated solids from the bowl, a generally horizontal disc-shaped member in the bowl dividing the separating zone into upper and lower parts and having a feed passage communicating with said inlet to deliver to the separating zone the material to be separated, said member also having an auxiliary liquid channel, and a hollow ring at the periphery of the disc-shaped member and having a distributing chamber for receiving auxiliary liquid from said channel, the ring defining with the bowl a narrow annular channel disposed outwardly from said zone in inclined relation to the rotation axis of the bowl and affording communication between said zone and the peripheral part of the bowl, the ring having openings leading into said annular channel for feeding auxiliary liquid inwardly therealong.

9. A centrifugal bowl according to claim 8, in which the ring defines with the bowl a second narrow annular inclined channel affording additional communication between said zone and the peripheral part of the bowl, the ring also defining with the bowl periphery an outer annular chamber adjacent said peripheral outlet and to which said annular channels converge.

10. A centrifugal bowl according to claim 9, in which the ring has openings leading directly from the distributing chamber to said outer annular chamber.

11. A centrifugal bowl according to claim 8, in which said member has a hole located in the separating zone and through which said upper and lower parts communicate.

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