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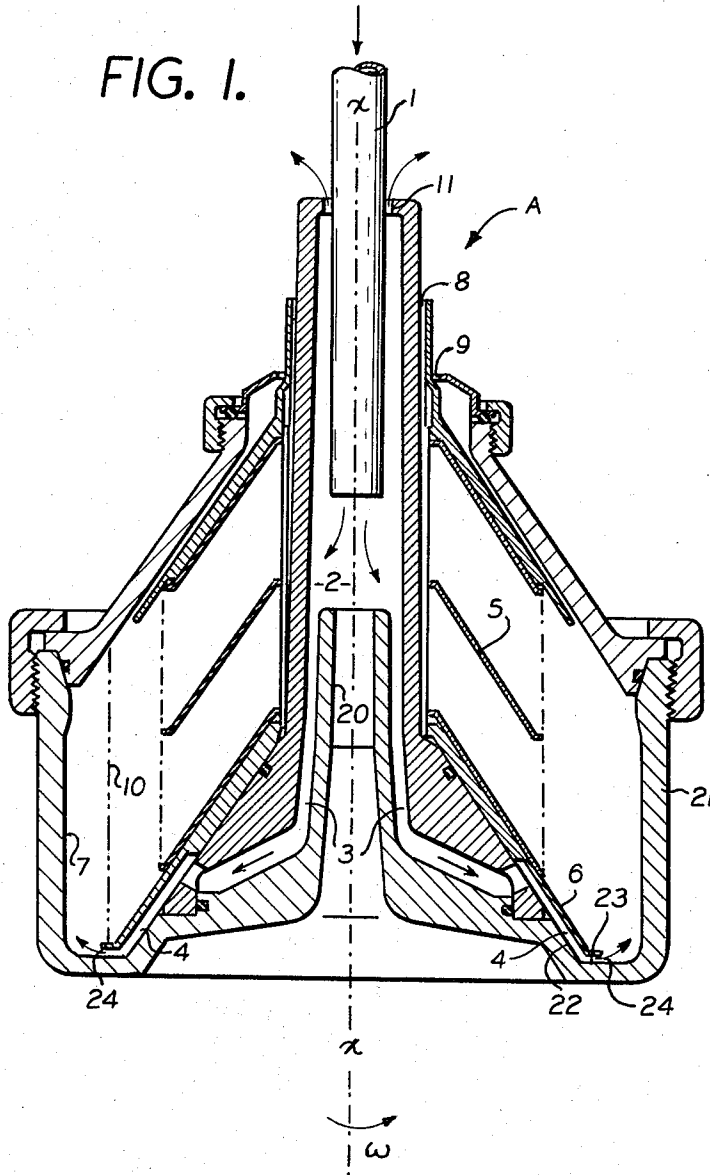
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PROTECTION IN CENTRIFUGE EQUIPMENT

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APPARATUS AND METHOD FOR AUTOMATIC OVERLOAD PROTECTION IN CENTRIFUGE EQUIPMENT

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ABSTRACT OF THE DISCLOSURE

This specification discloses a centrifuge particularly well adapted to the resolution of a multi-component liquid mixture wherein the components of the mixture have different specific gravities. The disclosed centrifuge provides for stoppage thereof upon the accumulation of a predetermined quantity of the heaviest component of the mixture being separated. This is accomplished by utilizing a liquid inlet arrangement comprising the conventional axially disposed inlet chamber and a conduit communicating between this inlet chamber and the interior of the centrifuge drum, which conduit has an exit aperture within the centrifuge drum interior which is disposed near the bottom of the drum interior and at a distance from the centrifuge axis greater than the distance the periphery of the plate stack of the centrifuge is from the centrifuge axis.

Further disclosed is a method of operating this novel centrifuge wherein the centrifuge is rotated, liquid is introduced thereinto through the inlet chamber and conduit means referred to above, and the heaviest component of the liquid is permitted to build up along the peripheral wall of the drum until such heaviest component blocks the inlet conduit means aperture, whereupon feed liquid backs up through the inlet chamber and into an overflow collector. There is further disclosed the use of control means in combination with the overflow collector so as to either warn an operator of the condition of the centrifuge, or automatically stop both the flow of liquid to be separated and the operation of the centrifuge.

This invention relates to centrifuge equipment in general, and more particularly to an apparatus and method for automatically limiting the build-up of radial layers of relatively high specific gravity components on the wall of a rotatable drum wherein the components of a liquid mixture are centrifugally separated.

In the centrifugal separation of such mixtures enclosed drums are generally used, such as for example, cylindrical drums having frusto-conical top closures. When a liquid mixture or a mixture of solid particles dispersed in a liquid is introduced into such a rotating drum, the individual mixture components are separated by centrifugal force into concentric radial layers, with the highest specific gravity component being collected and contained in the outermost layer which is adjacent to the inside wall of the drum, and the components of lesser specific gravity being each contained in layers arranged radially inward with respect to the axis of rotation and in the order of progressively decreasing specific gravity.

In a two-component mixture, the component of lesser specific gravity is usually continuously removed through an outlet disposed in the vicinity of the drum axis, and the heavier specific gravity component is collected on the drum wall.

As the thickness of the heavy component layer increases, the load on the drum periphery increases considerably, since the heavy component layer which oc-

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cupies the portion of the drum interior furthest away from the axis of rotation has a greater effect on peripheral pressure than the lighter component which fills the central portion of the drum. The greater the difference in specific gravity between the two components, the greater is the peripheral load increase during the course of drum rotation. Thus, for example, in the case of the centrifugal separation of mercury from an aqueous liquid, the drum may become dangerously overstressed.

To prevent such dangers in the operation of prior art centrifuges, it was necessary to analyze the mixture being centrifuged, and on the basis of the percentage of the specifically heaviest component and the throughput of the centrifuge, to calculate the time in which the maximum permissible thickness of the layer of the heavy component would accumulate in the drum, so that the rotation of the drum could be ceased at a safe time interval to permit periodic removal of the heavy component.

Aside from the fact that such analyses in many cases are very difficult and time-consuming, it must be assumed when making the calculation, that the composition of the liquid being centrifuged and the throughput of the drum do not vary. Even if these factors could be kept absolutely constant, the timely shutting off of the centrifuge still depends upon the alertness of the operators. It may also happen that, due to some disturbance in operation, the feed of material to the centrifuge temporarily stops. If the duration of the interruption cannot be determined precisely in such cases, the operators lose track of the actual running time of the centrifuge. This may then result in dangerous overloading of the drum, or in the centrifuge being stopped before the heavier substances have reached the layer thickness necessary for the stopping of the drum. In such cases the running time capacity of the drum is not fully utilized.

It is therefore an object of the invention to render the above-described analyses unnecessary and to provide an apparatus and a method to prevent drum overloading automatically.

In the apparatus and method according to the instant invention, after a predetermined depth of the heaviest component is reached, further separation of the components is automatically discontinued, and the mixture coming into the drum is forced out of the drum, untreated, through overflow collector. In this manner any further collection of heavier components in the drum is prevented.

A signalling system responding to flow can be installed in the overflow collector line, so as to signal the operating personnel that the drum is filled to the desired, safe extent with heavier components.

The apparatus for the performance of the process is thus characterized by a centrifugal drum in which means are provided which automatically shut off the entry of the liquid into the separating chamber when a certain depth of the heavier components is reached.

Accordingly another object of the invention is to provide a method of centrifuge operation and an improved centrifuge apparatus wherein the quantity of separated heavy components within the drum is automatically limited, and the occurrence of such limit quantity is indicated to the operating personnel.

Other objects and advantages of the method and apparatus of the instant invention will appear in, or become evident from, the following detailed description and accompanying drawings, in which:

FIG. 1 is an elevation view, partly in section, of a centrifuge apparatus constructed in accordance with the invention;

FIG. 2 is an elevation view, partly in section, of the basic centrifuge apparatus of FIG. 1 modified to include specific means for collecting the overflow mixture and an alarm system responsive to the presence of said overflow.

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Referring now to FIGS. 1 and 2, wherein 1 designates an inlet tube through which the liquid mixture to be centrifugally separated is introduced into an inlet chamber 2 of the centrifuge apparatus A, the centrifuge A is rotated about its vertical central axis $x-x$ with an angular velocity ω , on a drive platform (not shown) having a spindle (not shown), which is inserted with a locking taper-fit into the bore 20, so as to prevent liquid in the chamber 2 from spilling out therefrom.

The liquid mixture flows from the inlet chamber 2 through conduit passages 3 and 4 into the interior of the drum 21, where it is flung radially outward toward the inner wall 7 of said drum 21 by reason of the centrifugal force produced by the rotation of the drum 21.

The passage 4 is annular in shape and is bounded by a bottom frusto-conical plate 6 of the insert plate stack 5, and the adjacent frusto-conical surface 22 and bottom surface 23 of the drum 21.

While the centrifuging is being performed, the heavier component is deposited on the inner wall 7 of the drum 21 and gradually builds up in a radial layer, which increases in thickness in the direction of the drum axis $x-x$ as the quantity of the separated heavier component increases.

The lighter component or components pass out of the drum 21 through the outlets 8 and 9. In the case of one-phase vehicle liquids, outlet 9 is closed.

As soon as the heavier component layer builds up to a thickness, such as that indicated by the line 10, where the discharge aperture 24 of the passage 4 is covered thereby, further entry of the liquid mixture into the drum 21 is blocked, thereby causing the inlet chamber 2 to overflow and discharge said liquid mixture through the outlet 11.

With the flow of liquid mixture into the drum 21 thus cut off, by reason of the blocking of the aperture 24, the thickness of the heavy component layer is automatically limited, thereby protecting the drum 21 and centrifuge apparatus A from the dangerous and harmful effects of overloading, without the necessity of constant attention or pre-calculating on the part of the operating personnel.

Although the apparatus A as shown in FIG. 1 will suffice for descriptive purposes, and in applications wherein spillage of the overflowing liquid mixture can be tolerated, the embodiment of the invention as exemplified by FIG. 2, is generally preferable since it provides means for collecting the overflow, and monitoring means responsive to the presence of said overflow for indicating the occurrence of same to the operating personnel.

The apparatus A' of FIG. 2 is substantially the same as the apparatus A of FIG. 1, but with the addition of an overflow collector 25 having an outlet conduit 26, wherein a liquid mixture flow sensor 27 is disposed so as to be responsive to liquid mixture flowing through the conduit 26, as when the limit thickness of the heavy component layer has been attained. This sensor 27 can be any suitable conventional liquid flow-sensing device that will produce a signal (electrical, mechanical motion, dial indication, etc.) or an electrical circuit condition, such as the closing of a switch, when the liquid mixture flows through the conduit 26. If desired, the sensor 27 can be operatively connected to an alarm device 28, so that the occurrence of overflow and hence the accumulation of a heavy component layer of limit thickness, can be indicated to operating personnel.

If desired, additional sensors 27 operatively connected to indicating devices, such as an alarm 28, can be installed in the outlets 8 and 9, to indicate the occurrence of the aforesaid accumulation of the heavy component. However, in such case the alarm device 28 is made to respond to the cessation of liquid flow (i.e. lighter component) through said outlets 8 and 9.

In FIG. 2, the overflow collector 25 is provided with a rotary seal 29 which engages the exterior wall surface 30 of the inlet chamber 2, so that a stationary overflow col-

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lector 25 can be used with an inlet chamber 2, which rotates with the drum 21.

Although not specifically illustrated in the drawings herein, and as will be apparent to those skilled in the art, other types of conventional centrifuges which have rotatable drums and axially disposed inlet chambers for receiving a liquid mixture to be separated into its components, can be modified to incorporate the instant invention by providing in such a centrifuge, a radially disposed inlet conduit for introducing the liquid mixture into the interior of the drum, said outlet conduit being in communication with the inlet chamber and having a discharge aperture which is located at a predetermined radius from the drum axis of rotation, so that when the highest specific gravity component separated from the mixture has accumulated into a radial layer of thickness equal to the difference in radii between the inside wall of the drum and the discharge aperture, said discharge aperture is blocked to prevent further admission of the liquid mixture into the drum. To collect the overflow liquid mixture, an overflow collector is operatively connected to the inlet chamber of the modified centrifuge.

For further mixture component separation, when the heaviest mixture component layer accumulates to the limit thickness, as indicated from an alarm responsive to overflow, or otherwise, the rotation of the centrifuge drum is stopped and the heaviest component will assume a horizontal interface layer configuration, supported by the bottom of the drum, so that it can be drained off or removed by any suitable conventional means to permit resumption of centrifuging. Where a large quantity of liquid mixture is to be separated, the separation will obviously have to be performed in several stages of centrifuge operation, with the removal of the collected heavy component between each stage of operation.

For reasons well known to those skilled in the art, the centrifuge drum 21 is preferably rotated about a vertical axis $x-x$, and its associated inlet conduit discharge aperture 24 is advantageously located at a radial position adjacent to the bottom of the drum 21.

The apparatus and method of the instant invention is by no means limited to two-component mixtures, but can be applied as well to mixtures having three or more components which are separable by centrifuging, such as, for example, multi-component mixtures of substantially immiscible components.

Also, the improved centrifuging method according to the invention is not limited to the specific apparatus shown and described herein by way of example, but can be applied generally.

Essentially the method of centrifuge separation of the individual components of a multi-component liquid mixture, or any mixture having physical properties similar to liquids, can be applied in accordance with the invention by carrying out the following steps in the operation of a rotatable container having an inlet aperture for introducing the liquid mixture:

(a) Rotating the container to separate the components of the mixture into concentric radial layers within said container, such that each layer contains a single component and the component of highest specific gravity being in the outermost layer, with the layers containing the remaining components being arranged radially inward with respect to the axis of rotation in the order of progressively decreasing specific gravity;

(b) Monitoring the flow of liquid mixture into the container;

(c) Stopping the rotation of the container when the flow of the liquid mixture as mentioned indicates that the layer containing the highest specific gravity component has attained a thickness such that it blocks the inlet aperture; and

(d) Removing the separated component of highest specific gravity from the container.

This basic procedure can be repeated either to remove only the heaviest specific gravity component from a liquid

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mixture or after the heaviest component has been so removed, to remove the next heaviest component, in succession, until all of the separated components of an original mixture have been removed.

I claim:

1. A method of resolving a liquid mixture into individual components thereof by means of centrifugation in a centrifuge comprising a rotatable drum, an axially disposed inlet chamber, a plate stack having means to permit removal of the lightest component of said liquid there-
through, inlet conduit means from said inlet chamber into
said drum having an exit aperture communicating with
said drum interior proximate the drum interior bottom
surface and radially disposed a greater distance from the
axis of said centrifuge than the outer periphery of said
plate stack, and an overflow collector to receive the dis-
charge from said inlet chamber when said aperture is ob-
structed; which process comprises feeding said liquid to
said centrifuge, rotating said centrifuge during said feed-
ing, resolving said liquid into its components on a specific
gravity basis within the said drum of said centrifuge, in-

creasing the thickness of the layer of the heaviest component of said liquid from the periphery of said drum inwardly until the inside diameter of said heaviest liquid reaches said orifice, and thereupon causing said input liquid to flow into said overflow collector.

2. The method claimed in claim 1, including permitting said liquid in said overflow collector to activate a monitoring means, whereby said monitoring means effects the cessation of liquid feed to said centrifuge and rotation of said centrifuge.

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