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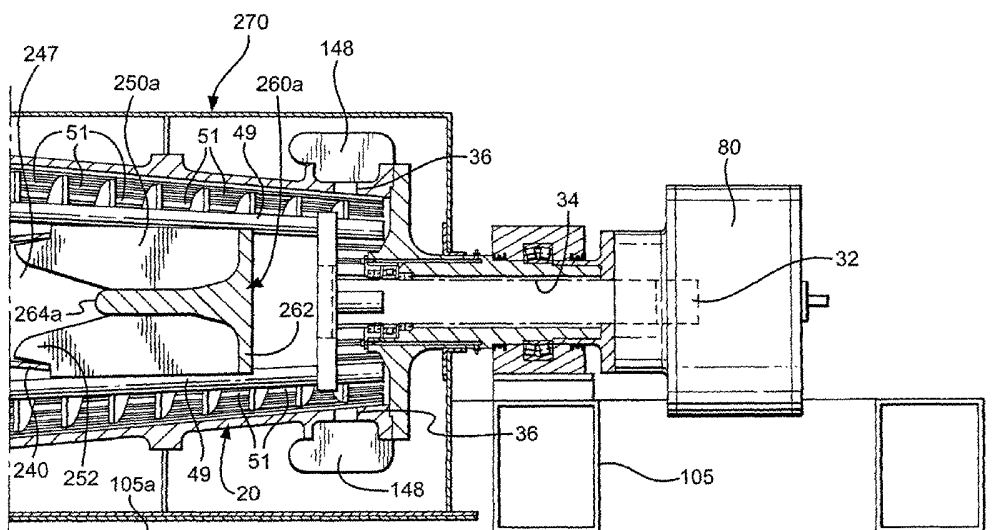
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(54) Title: CENTRIFUGES AND METHODS OF SEPARATING FEED MATERIAL



(57) Abstract: A centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised in that said nose member is at least about 50% of the length of said at least one impeller.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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Centrifuges and Methods of Separating Feed Material

The present invention relates to centrifuges and methods of separating feed material.

Many different industries use decanter centrifuges
5 in varied applications. For example they are used in the
petro-chemical, rendering, environmental, wastewater,
mining and drilling industries. They are used in the oil
industry to separate undesired drilling solids from the
drilling mud. It is advantageous to recover, clean and
10 re-use drilling mud because it is expensive.

The prior art discloses a variety of decanter
centrifuges (or "decanter" as they are known in the art)
that, in many embodiments, include a rotating housing (or
"bowl" as it is known in the art) rotating at one speed
15 and a conveyor (or "scroll" as it is known in the art)
rotating at a different speed in the same direction. The
housing normally comprises a hollow tubular member having
a cylindrical portion and a conical portion. The conveyor
normally comprises an auger type screw, mounted inside
20 the housing, whose thread complements the shape of the
housing. Such centrifuges are capable of continuously
receiving feed in the housing and of separating the feed
into layers of light and heavy phase materials (e.g.
liquids and solids) that are discharged separately from
25 the housing. The conveyor, rotating at a differential
speed with respect to the bowl, moves or "scrolls" an
outer layer of heavy phase or solids slurry material to a
discharge port or ports usually located in a tapered or
conical end portion of the housing. Addition of feed
30 material causes the fluid level to rise in the bowl until
the depth is such that further addition of feed material
causes displacement and discharge of light phase material
through a discharge port (or ports) usually located at an
opposite end of the housing. The light phase material
35 must pass around a path defined by the thread before it

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can be discharged through these ports. Typically the housing is solid. Some housings have port(s) to reject the heavier solids phases.

Centrifugal separation results, preferably, in a discharge containing light phase material with little or no heavy phase material, and heavy phase material containing only a small amount of light phase material. When the light phase material is water and the heavy phase material contains soft solids, it is preferred that fairly dry solids and clean water be separately discharged.

WO 02/18055, co-owned by the present applicant, discloses a centrifuge in accordance with the preamble of claim 1.

Whilst centrifuges in accordance with WO 02/18055 perform extremely well, the applicant has devised modifications with the aim of yet further enhancing performance; this enhanced performance may be measured in terms of volume of feed material processed per unit time whilst maintaining a particular cut point, for example.

According to a first aspect of the present invention there is provided a centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also

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imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised in that said nose member is at least about 50% of the length of said at least one impeller. It is believed that, due the large flow rates of feed material (e.g. $0.032\text{m}^3\text{s}^{-1}$ (500 US liquid gallons per minute)), a large proportion of the feed material moves along and adjacent the longitudinal axis of the centrifuge. By increasing the length of the nose member, this feed material is divided over a greater proportion of the length of the impeller (in other words this feed material will have a longer time in which radial speed may be imparted whilst it moves with axial speed); thus disturbance of solids and fluid in the drying area by the new feed material is further reduced.

Preferably, the nose member is at least about 60%, at least about 90%, or at least about 100% of the length of the at least one impeller. The nose member may be slightly longer than the length of the at least one impeller.

According to another aspect of the present invention there is provided a method of separating feed material into solid and fluid parts, which method comprises the steps of:

- (1) feeding feed material to a centrifuge as set out above; and
- (2) rotating the conveyor and rotatable housing to separate the feed material. Such a speed of rotation may be of the order of several thousand rpm e.g. 3000 rpm.

* * *

According to a second aspect of the present invention there is provided a centrifuge for separating

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feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised by wear inhibiting means for inhibiting wear to said conveyor caused by feed material moving from said at least one impeller to said separating region.

Advantageously, said wear inhibiting means is shaped so as to guide feed material away from a part of the conveyor.

Preferably, said wear inhibiting means is positioned to inhibit feed material impinging on part of a thread of said conveyor.

Advantageously, there is a plurality of wear inhibiting means. In one embodiment, each wear inhibiting means is positioned so as to guide feed material away from a respective part of said conveyor. The wear inhibiting means may be mounted on the at least one impeller and/or on the conveyor.

Preferably, said wear inhibiting means is positioned at or adjacent a feed material exit end of said at least one impeller. The wear inhibiting means may be a

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projection near the leading edge of each impeller.

Advantageously, said at least one impeller has a cross-section of gradually increasing area along a longitudinal axis of the centrifuge. The cross-section
5 may increase in the direction of fluid flow into the centrifuge.

Preferably, the centrifuge further comprises a nose member on which said at least one impeller is mounted, the at least one impeller and the nose member have a
10 respective length, the length of the nose member being at least about 50% of the length of the at least one impeller. Preferably, the nose member is at least about 60%; at least about 90%; or at least about 100% of the length of the at least one impeller. The nose member may
15 be slightly longer than the length of the at least one impeller.

According to another aspect of the present invention there is provided for use with a centrifuge, a conveyor having any of the conveyor features as set out above.

20 According to another aspect of the present invention there is provided a method of separating feed material into solid and fluid parts, which method comprises the steps of:

(1) feeding feed material to a centrifuge as set
25 out above; and

(2) rotating the conveyor and rotatable housing to separate the feed material.

* * *

30

According to a third aspect of the present invention there is provided a centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable
35 housing, the conveyor having at least one impeller and

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the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised by a flow enhancing means adjacent a forward end of said at least one impeller for assisting said at least one impeller in the spreading the feed material at or near said forward end.

Advantageously, the centrifuge further comprises a chamber within the conveyor into which feed material may be fed, said flow enhancing means adjacent a feed material outlet end of said chamber.

Preferably, said flow enhancing means is positioned over part of said pool area adjacent said drying area.

Advantageously, said flow enhancer is of annular configuration with a central opening through which, in use, feed material may pass, and comprises a plurality of circumferential openings defined by a plurality of impellers disposed around the circumference thereof.

Preferably, said plurality of impellers is supported between two rings. Alternatively said plurality of impellers may be supported by (e.g. attached to or formed in) a single ring.

Advantageously, said plurality of impellers comprises a plurality of pins spaced apart around the circumference of said flow enhancing means.

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Preferably, said flow enhancing means comprises a wear resistant material. In one embodiment the impellers and ring(s) may be provided with wear plates constructed from tungsten carbide for example.

5 According to another aspect of the present invention there is provided for use with a centrifuge, a flow enhancer having any of the flow enhancing means features set out above.

10 According to another aspect of the present invention there is provided a centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller mounted on a nose member and the rotatable housing having
15 a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof,
20 the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it
25 moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised by a feed tube extending into said centrifuge and in that said nose member extends substantially up to or into said feed
30 tube.

 According to another aspect of the present invention there is provided a centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable
35 housing, the conveyor having at least one impeller

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mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller, characterised in that said nose member is such that, in use, feed material impinging thereon is guided onto a substantial portion of said at least one impeller. In this way, feed material impinging on the nose member is spread over a substantial portion of the impeller, rather than being concentrated in a smaller area by a shorter nose member. This helps to reduce disturbance of solids in the drying area. A "substantial" portion may mean at least about 30% of the length of the impeller for example. In one embodiment the nose member comprises a portion of substantially uniform cross-sectional area.

According to another aspect of the present invention there is provided a conveyor for a centrifuge, the conveyor having a length and comprising

a plurality of spaced-apart flight members spaced apart along the length of the conveyor,

a plurality of support members extending between, and connected to the spaced-apart flight members, the support members spaced-apart around the plurality of spaced-apart flight members,

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the spaced-apart flight members and plurality of support members defining a plurality of open areas through which fluid to be treated by the centrifuge is flowable from within the conveyor, and

5 at least one accelerating impeller within and connected to the conveyor for accelerating fluid to be treated by the centrifuge.

Preferably, the conveyor further comprises a hollow feed tube with a fluid exit end within the conveyor through which fluid to be treated enters a space within the conveyor.

Advantageously, substantially all of the fluid to be treated is acceleratable by the at least one accelerating impeller.

15 Preferably, the at least one accelerating impeller is a plurality of radially spaced-apart impellers.

Advantageously, the conveyor further comprises a chamber within the conveyor, part of the chamber having a fluid entry end adjacent the fluid exit end of the feed tube, the chamber for receiving fluid exiting from the fluid exit end of the feed tube, the fluid passing into the chamber and exiting therefrom.

Preferably, the conveyor further comprises the at least one accelerating impeller positioned within the chamber.

Advantageously, the conveyor further comprises a central nose member within the conveyor and wherein the at least one accelerating impeller is a plurality of spaced-apart impellers each connected to the central nose member.

Preferably, the chamber, the central nose member, and the at least one impeller are removably connected to the conveyor.

Advantageously, the impellers have an impeller length and the nose member has a nose end with a nose end

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length, the nose end length at least fifty per-cent of the impeller length.

Preferably, the nose member has a nose end and a plate secured to or formed of the nose member, the nose
5 end projecting away from the plate, the plate extending across an inner space of the conveyor to prevent fluid from flowing past the plate.

Advantageously, the nose member has a curved surface to facilitate fluid flow in a direction out from the
10 conveyor.

Preferably, the conveyor has a first end and a second end, the first end having fluid entry apparatus and the second end positionable adjacent fluid exit apparatus of a centrifuge, and the conveyor further
15 comprising

a solid plate disposed across the conveyor so that fluid is not flowable past the solid plate, the conveyor having a last flight member of the plurality of flight members at the second end of the conveyor, the solid
20 plate positioned further from the second end of the conveyor than said last flight member.

Advantageously, the at least one accelerating impeller has at least one flow diverter thereon for diverting fluid that contacts the flow diverter.

Preferably, the at least one flow diverter is positioned so that a flight member of the plurality of spaced-apart flight members is adjacent the at least one flow diverter and the at least one flow diverter is able to divert fluid away from said flight member.

Advantageously, the at least one flow diverter is a plurality of flow diverters, each of the plurality of flow diverters positioned so as to divert fluid flow from a flight member of the plurality of spaced-apart flight members.

Preferably, the conveyor has a conveyor end area

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positionable adjacent a beach end area of a centrifuge bowl and wherein the hollow feed tube is so configured and of sufficient length that the fluid to be treated exits the hollow feed tube adjacent the conveyor end area
5 of the conveyor for flow to a beach end area of a centrifuge bowl.

Advantageously, the at least one accelerating impeller has a shape, viewed on end, that comprises a flowing curve extending out from a central first part of
10 the conveyor and with a distal end on the conveyor at a radially spaced-apart location from the central first part. For example the radial spacing of the central first part and distal end may be between about 80° and 110°; and in one particular aspect, about 90°.

15 Preferably, the at least one accelerating impeller has a front end with a first width, viewed on end, and a rear end with a second width, the first width less than the second width.

Advantageously, the at least one accelerating
20 impeller is a plurality of spaced-apart impellers, each impeller spaced apart about ninety degrees, each of the plurality of spaced-apart impellers having a first part at a centre of the conveyor and a distal end adjacent one of the plurality of spaced-apart flight members, the
25 first part of one impeller substantially diametrically aligned with the distal end of a next-adjacent impeller.

Preferably, the conveyor further comprises
a flow enhancer connected to the at least one accelerating impeller, the flow enhancer for facilitating
30 fluid flow out from the conveyor, the flow enhancer including

ring apparatus,

a plurality of spaced-apart pins secured to the ring apparatus,

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the plurality of pins spaced-apart to define fluid flow passages therebetween,

the ring apparatus having a central opening through which fluid is flowable, fluid flowable through said
5 central opening to the at least one accelerating impeller.

Advantageously, the ring apparatus comprises a first ring and a second ring, the first ring spaced-apart from the second ring by the pins of the plurality of pins, the
10 pins of the plurality of pins secured to the first ring and the second ring and extending between the first ring and the second ring.

According to another aspect of the present invention there is provided a centrifuge comprising

15 a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end,

apparatus for selectively rotating the bowl,

a conveyor rotatably mounted in the bowl, the conveyor comprising a plurality of spaced-apart flight
20 members spaced apart along the length of the conveyor, a plurality of support members extending between, and connected to the spaced-apart flight members, the support members spaced-apart around the plurality of spaced-apart flight members, the spaced-apart flight members and
25 plurality of support members defining a plurality of open areas through which fluid to be treated by the centrifuge is flowable from within the conveyor, and at least one accelerating impeller within and connected to the conveyor for accelerating the fluid.

30 Preferably, the centrifuge further comprises

a flow enhancer connected to the at least one impeller for facilitating fluid flow out from the conveyor, the flow enhancer comprising a flow enhancer connected to the at least one accelerating impeller, the
35 flow enhancer for facilitating fluid flow out from the

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conveyor, the flow enhancer including ring apparatus, a plurality of spaced-apart pins secured to the ring apparatus, the plurality of pins spaced-apart to define fluid flow passages therebetween, the ring apparatus
5 having a central opening through which fluid is flowable, fluid flowable through said central opening to the at least one accelerating impeller.

According to another aspect of the present invention there is provided a flow enhancer for a centrifuge, the
10 flow enhancer for facilitating fluid flow out from the conveyor, the flow enhancer comprising

ring apparatus,
a plurality of spaced-apart pins secured to the ring apparatus,
15 the plurality of pins spaced-apart to define fluid flow passages therebetween,
the ring apparatus having a central opening through which fluid is flowable, fluid flowable through said central opening.

Advantageously, the ring apparatus comprises a first ring and a second ring, the first ring spaced-apart from the second ring by the pins of the plurality of pins, the pins of the plurality of pins secured to the first ring and the second ring and extending between the first ring
20 and the second ring.

Optionally, one of the rings can be deleted and the pins mounted to or formed of a single ring.

According to another aspect of the present invention there is provided a centrifuge comprising
30 a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end,
apparatus for selectively rotating the bowl,
a flow enhancer connected to and within the bowl for facilitating fluid flow out from the conveyor,

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the flow enhancer comprising a flow enhancer connected to the at least one accelerating impeller, the flow enhancer for facilitating fluid flow out from the conveyor, the flow enhancer including ring apparatus, a plurality of spaced-apart pins secured to the ring apparatus, the plurality of pins spaced-apart to define fluid flow passages therebetween, the ring apparatus having a central opening through which fluid is flowable, fluid flowable through said central opening to the at least one accelerating impeller.

Preferably, the centrifuge has a conveyor within the bowl and the flow enhancer is within the conveyor.

According to another aspect of the present invention there is provided a nose member for a centrifuge, the nose member comprising

a plate, and

a nose end secured to or formed of the plate, the nose end projecting away from the plate, the plate extendable across an inner space of a centrifuge to inhibit fluid from flowing past the plate.

According to another aspect of the present invention there is provided a centrifuge comprising

a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end,

apparatus for selectively rotating the bowl,

a central nose member within the bowl,

the central nose member comprising a plate and a nose end secured to or formed of the plate, the nose end projecting away from the plate, the plate extending across an inner space of the centrifuge to inhibit fluid from flowing past the plate.

The nose end of the central nose member is positioned to be contacted by fluid flowing from fluid entry apparatus into the centrifuge to direct and/or distribute fluid flow to enhance centrifugal separation.

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The nose end may have a curved surface that flows from the end of the nose member to the plate to facilitate fluid flow in a direction out from the bowl and/or conveyor.

5 According to another aspect of the present invention there is provided an accelerator apparatus for accelerating fluid in a centrifuge bowl of a centrifuge, the accelerator apparatus comprising

at least one accelerating impeller for accelerating
10 fluid to be treated, and

wherein the at least one accelerating impeller has a shape, viewed on end, that comprises a flowing curve extending out from a first part of a center of the accelerator apparatus and with a distal end radially
15 spaced-apart from said first part.

Advantageously, the at least one accelerating impeller has a front end with a front width, viewed on end, at a first end of the accelerator apparatus and a rear end with a second width, the first width less than
20 the second width.

Preferably, the at least one accelerating impeller is a plurality of spaced-apart impellers, each impeller spaced apart from adjacent impellers, each of the plurality of spaced-apart impellers having a first
25 central end and a distal end radially spaced-apart from the first end, the first end of one impeller substantially diametrically aligned with the distal end of a next-adjacent impeller.

According to another aspect of the present invention
30 there is provided a centrifuge comprising

a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end,

apparatus for selectively rotating the bowl, and
accelerator apparatus within the bowl for
35 accelerating fluid fed into the bowl, the accelerator

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apparatus comprising at least one accelerating impeller for accelerating fluid to be treated, and wherein the at least one accelerating impeller has a shape, viewed on end, that comprises a flowing curve extending out from a first part of a centre of the accelerator apparatus and with a distal end radially spaced-apart from said first part.

According to another aspect of the present invention there is provided a centrifuge comprising

10 a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end, the bowl having a beach area,

apparatus for selectively rotating the bowl,

a conveyor rotatably mounted in the bowl, the conveyor comprising a plurality of spaced-apart flight members spaced apart along the length of the conveyor, a plurality of support members extending between, and connected to the spaced-apart flight members, the support members spaced-apart around the plurality of spaced-apart flight members, the spaced-apart flight members and plurality of support members defining a plurality of open areas through which fluid to be treated by the centrifuge is flowable from within the conveyor, and

15 20

a feed tube for introducing fluid to be treated by the centrifuge into the conveyor, the feed tube having an exit end within the conveyor, the exit end adjacent a portion of the beach area of the bowl.

25

According to another aspect of the present invention there is provided a conveyor for a centrifuge, the conveyor having a length and comprising

30

a plurality of spaced-apart flight members spaced apart along the length of the conveyor,

a plurality of support members extending between, and connected to the spaced-apart flight members, the

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support members spaced-apart around the plurality of spaced-apart flight members,

the spaced-apart flight members and plurality of support members defining a plurality of open areas
5 through which fluid to be treated by the centrifuge is flowable from within the conveyor, and

the plurality of open areas located so that in use the conveyor is positionable so that fluid flows out from the plurality of open areas adjacent a beach area of a
10 centrifuge bowl.

According to another aspect of the present invention there is provided a centrifuge comprising

a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end, the bowl having a
15 beach area at a beach end of the centrifuge,

apparatus for selectively rotating the bowl,

a conveyor rotatably mounted in the bowl, the conveyor comprising a plurality of spaced-apart flight members spaced apart along the length of the conveyor, a
20 plurality of support members extending between, and connected to the spaced-apart flight members, the support members spaced-apart around the plurality of spaced-apart flight members, the spaced-apart flight members and plurality of support members defining a plurality of open
25 areas through which fluid to be treated by the centrifuge is flowable from within the conveyor, and

the plurality of open areas at the beach end of the centrifuge.

According to another aspect of the present invention
30 there is provided a method for separating components of a feed material, the method comprising

introducing feed material into a centrifuge, the centrifuge comprising a bowl with a hollow interior and a first bowl end spaced-apart from a second bowl end,
35 apparatus for selectively rotating the bowl, a conveyor

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rotatably mounted in the bowl, the conveyor comprising a plurality of spaced-apart flight members spaced apart along the length of the conveyor, a plurality of support members extending between, and connected to the spaced-apart flight members, the support members spaced-apart around the plurality of spaced-apart flight members, the spaced-apart flight members and plurality of support members defining a plurality of open areas through which fluid to be treated by the centrifuge is flowable from within the conveyor, and at least one accelerating impeller within and connected to the conveyor for accelerating the fluid,

separating components of the feed material within the centrifuge, and
discharging from the bowl separated components of the feed material.

Preferably, the feed material includes liquid with solids entrained therein and the centrifuge separates solids from the liquid, the solids exiting from the bowl through at least one bowl solids exit port and the liquid exiting from the bowl through at least one bowl liquid exit port which is spaced-apart from the bowl solids exit port.

Advantageously, the at least one accelerating impeller is a plurality of radially spaced-apart impellers each with a central end connected to a central nose member mounted in the conveyor, and wherein the impellers accelerate the fluid to a speed that is at least 95% of the speed of rotation of a pool of fluid to be treated in the bowl, and the method further comprising radially accelerating with the impellers the fluid to at least 95% of the rotational speed of the pool of fluid in the bowl prior to the fluid flowing out from the conveyor into space between the outer edge of the spaced-apart flight members and an interior surface of the bowl.

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For a better understanding of the present invention reference will now be made, by way of example, to the accompanying drawings, in which: -

Fig. 0A' and 0A'' is a side cross-section view of a
5 centrifuge;

Fig. 1 is a schematic side cross-section view of part of a first embodiment of a centrifuge in accordance with the present invention;

Fig. 2 is a schematic side cross-section view of
10 part of a second embodiment of a centrifuge in accordance with the present invention;

Fig. 3A is a schematic side view, partially in cross-section, of an accelerator in accordance with the present invention;

Fig. 3B is a front-end view of the accelerator of
15 Fig. 3A;

Fig. 3C is a rear end view of the accelerator of Fig. 3A;

Fig. 3D is a top view of a first alternative
20 impeller for the accelerator in Fig. 3A;

Fig. 3E is a top view of a second alternative impeller for the accelerator in Fig. 3A;

Fig. 3F is a schematic side cross-section view of part of a third embodiment of a centrifuge in accordance
25 with the present invention;

Fig. 4A is a side cross-section view of a flow enhancer in accordance with the present invention;

Fig. 4B is an end view of the flow enhancer of Fig. 4A;

Fig. 4C is a cross-section view along line 4C-4C of
30 Fig. 4A;

Fig. 4D is a top view of part of the flow enhancer of Fig. 4A;

Fig. 4E is an enlarged view of part of the flow
35 enhancer of Fig. 4A;

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Fig. 4F is a schematic side view, partially in cross-section, of a fourth embodiment of a centrifuge in accordance with the present invention;

5 Fig. 5A is schematic side view, partially in cross-section, of part of a fifth embodiment of a centrifuge in accordance with the present invention;

Fig. 5B is schematic side view, partially in cross-section, of part of a sixth embodiment of a centrifuge in accordance with the present invention;

10 Fig. 5C is schematic side view, partially in cross-section, of part of a seventh embodiment of a centrifuge in accordance with the present invention; and

Fig. 5D is schematic side view, partially in cross-section, of part of an eighth embodiment of a centrifuge
15 in accordance with the present invention.

Referring to Fig. 0A' a centrifuge generally identified by reference numeral 210 has an outer housing 12 within which is rotatably mounted a bowl 20 with a hollow interior 23. Within the hollow interior 23 of the
20 bowl 20 is rotatably mounted a conveyor 40 that has a continuous helical thread or screw 41 that extends from a first end 21 of the bowl 20 to a second end 22 of the bowl 20. Supports 105 on a base 105a support the centrifuge (bowl, conveyor, outer housing, and other
25 components). The supports 105 may themselves be supported on a skid.

A plurality of support rods 49 are disposed within the continuous helical thread 41 and are connected at points of contact to flights 42 of the continuous helical
30 thread 41, e.g. by bolting and/or welding. The flights 42 are sized so that they are separated a desired distance from the interior surface of the bowl 20 along the bowl's length. The edges of the flights may be lined with side-by-side pieces or tiles made of sintered
35 tungsten carbide or the edges themselves may be hard-

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faced (as may any part of the apparatus). An end plate (not shown) is at one end of the continuous helical thread 41, connected e.g. by welding, and an end plate 47 is at the other end.

5 Baffles (not shown) are attached to the rods 49 to provide support and attachment points for the shafts (trunnions) that support the conveyor. Additional baffles may be used at any point in the conveyor for added strength and/or for apparatus attachment points.

10 Areas 51 between the rods 49 and the flights 42 (between each rod part and each flight part) are open to fluid flow therethrough. Alternatively portions of the conveyor may be closed off (i.e. areas between rod parts and flights are not open to fluid flow), e.g. but not
15 limited to, closing off the left one quarter or one-third and/or the right one-quarter or one-third thereof; i.e., all or only a portion of the conveyor may be "caged". Due to the openness of the caged conveyor (and the fact that, in certain aspects, fluid is fed in a non-focused
20 manner and is not fed at a point or points adjacent the pool in the bowl or prior to the beach, and fluid is not fed from within the conveyor through a number of ports or orifices - as in the prior art fluid is fed out through several ports or areas that tend to focus fluid flow from
25 the conveyor), solids in this fluid do not encounter the areas of relatively high turbulence associated with certain of the prior art feed methods and solids tend more to flow in a desired direction toward solids outlet(s) rather than in an undesired direction away from
30 the beach and toward liquid outlets.

 The bowl 20 has a conical or "beach" end with a beach section. The beach section may be (and, preferably, is) at an angle, in certain preferred embodiments, of between 3 and 15 degrees to the
35 longitudinal axis of the bowl 20.

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A flange 26 of the bowl 20 is secured to a bowl head 27 that has a channel 28 therethrough. A flange 29 of the bowl 20 is secured to a bowl head 30 that has a channel therethrough. A shaft 32 is drivingly interconnected with a gear system 81 of a transmission 80. A shaft 31 has a channel 35 therethrough through which fluid is introduced into the centrifuge 10. A motor M (shown schematically) interconnected (e.g. via one or more belts) with a driven sheave 110 selectively rotates the bowl 20 and its head 27 which is interconnected with the gear system 81 of the transmission 80 (and turning the bowl 20 thus results in turning of a shaft 34).

A shaft 32 projecting from the transmission 80 is connected to the shaft 34. The transmission 80 includes a gear system 81 interconnected with pinion shaft 82 which can be selectively backdriven by a Roots XLP WHISPAIR® blower (not shown -- available from Roots Blowers and Compressors: see www.rootsblower.com), or other suitable pneumatic backdrive device connected thereto via a coupling (not shown) to change, via the gear system 81, the rotation speed of the shaft 32 and, therefore, of the conveyor 40. The blower has an adjustable air inlet valve and an adjustable air outlet valve (the conveyor speed is adjustable by adjusting either or both valves). The amount of air intake by the blower determines the resistance felt by the pinion shaft 82 that, via gear system 81, adjusts the speed difference between the conveyor 40 and the bowl 20. Alternatively a non-pneumatic backdrive may be used. The gear system 81 (shown schematically by the dotted line in the transmission 80) may be any known centrifuge gear system, e.g. but not limited to a known two-stage planetary star and cluster gear system.

Optionally, the shaft 82 is coupled to a throttle apparatus (not shown) that, in one aspect includes a

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pneumatic pump, e.g. an adjustable positive displacement pump (e.g. air, pneumatic, or non pneumatic) connected to the shaft 82 to provide an adjustable backdrive.

5 Solids exit through four solids outlet 36 (two shown) in the bowl 20 and liquid exits through liquid outlets 37 in the bowl 20. There may be one, two, three, four, five, six or more outlets 36 and 37. There are, in one aspect, four spaced-apart outlets 37 (two shown).

10 The shaft 34 extends through a pillow block bearing 83 and has a plurality of grease ports 84 in communication with grease channels 85, 86 and 87 for lubrication of the bearings and shafts. Bearings 100 adjacent the shaft 34 facilitate movement of the shaft 34. Internal bearings can be lubricated, ringed, and
15 sealed by seals 102 (that retain lubricant).

An end 109 of the shaft 31 extends through the driven sheave 110.

20 Mount rings 120, 121 secured at either end of the bowl 20 facilitate sealing of the bowl 20 within the housing 12. Two ploughs 148 (one, two, three four or more) on the bowl 20 scrape or wipe the area around solids outlets 36 so the outlets are not plugged and maintain or increase product radial speed as the bowl rotates to facilitate solids exit. The ploughs 148 also
25 reduce bowl drag on the housing by reducing solids accumulation around solids exit points.

A feed tube 230 with a flange 147 extends through the interior of the input shaft 31. The feed tube 230 has an outlet end 231. Fluid to be treated flows into an
30 inlet end (left side in Fig. 2) of the feed tube 230.

Optionally, one or a plurality of spaced-apart pool surface diffusers 125 are secured to the conveyor and diffuse or interrupt the unwanted flow of floating solids away from the beach area. Solids may tend to move in
35 upper layers (slurry-like material with solids therein)

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of material flowing away from the beach area and toward the liquid outlets 37. Diffusers 125 extend into these upper layers so that the solids in the upper slurry layer are pushed down by the diffusers and/or hit the diffusers and fall down and out from the upper flowing slurry layer into lower areas or layers not flowing as fast and/or which are relatively stable as compared to the layers so that the solids can then continue on within the bowl toward the inner bowl wall and then toward the beach.

10 Optionally, a plurality of spaced-apart traction strips or rods 126 facilitate movement of the solids to the beach and facilitate agglomeration of solids and solids build up to facilitate solids conveyance.

15 Material to be processed exits and enters into a conical portion of a chamber 240 through an entrance opening 241. Although the chamber 240 is generally conical, it may be any desired cross-sectional shape, including, but not limited to cylindrical (uniformly round in cross-section from one end to the other) or
20 polygonal (e.g. square, triangular, rectangular in cross-section). Items 230, 240, 242 and 244 may be welded together as a unit.

25 The end of the feed tube 230 within the conveyor 40 extends through a mounting plate 242 and a hollow pipe 243. The pipe 243 and a portion of the chamber 240 are supported in a support member 244. A support ring 246, connected to rods 49 (three shown; four spaced-apart around the conveyor as in Fig. 2), supports the other end of the chamber 240. Impellers 250 secured to (welded, or
30 bolted) (or the impellers and nose member are an integral piece, e.g. cast as a single piece) nose member 260 have forward end portions 252 that abut an end of the chamber 240 and project into a fluid passage end 247 of the chamber 240 from which fluid exits from the chamber 240.
35 In one particular aspect the distance from the exit end

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231 of the feed tube 230 to the fluid passage end 247 of the chamber 240 is about 36 inches (0.91m). In other embodiments this distance is at least 19 inches (0.48m) and preferably at least 20 inches (0.51m). It is also within the scope of this invention for the exit end of the feed tube to be within the pipe 243. Alternatively, the chamber 240 may be omitted and the pipe 243 extended to any distance (to the right of the plate 242) within the conveyor 40 up to the impellers or to a point within them. The nose member 260 has a solid plate portion 262 and a nose 264. In one aspect all parts 240 - 260 are bolted or otherwise removably connected to the conveyor for easy removal and replacement. Alternatively, they may be welded in place.

15 In use, feed material is fed through the feed tube 230 into the centrifuge. The feed material passes through the chamber 240 and impinges on the impellers 250 with a component of velocity substantially parallel to the longitudinal axis of the centrifuge 210. Whilst moving with this velocity the impellers 250 impart a component of velocity in the radial direction (i.e. transverse to the longitudinal axis of the centrifuge) so as to spread the feed material onto the beach section. This enables the feed material to be spread from along substantially the length of the impellers over the beach section, which reduces the turbulent effect that this has on the existing feed material on the beach. Furthermore, feeding the feed material onto the beach has the additional advantage that heavy solids are filtered almost immediately, leaving the fluid and solids in suspension to be treated by the pool area of the centrifuge. In this way, the efficiency of the centrifuge is enhanced as there is a greater amount of time for the pool area to separate solids in suspension as the heavy solids are present to a lesser extent in this region. The

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contamination effect of heavy solids on the liquid is reduced; additionally, the energy required to drive the centrifuge is reduced.

Referring to Fig. 1 a centrifuge generally
5 identified by reference numeral 270 is like the
centrifuge 210, like numerals indicating like parts. A
nose 264a of a nose member 260a projects between the
impellers 250a (which function like the impellers 250,
Figs. 0A' and 0A''). In certain aspects the length of the
10 nose member 264a (the distance from the plate 262 to the
distal end of the nose member 264a) is at least about 50%
of the length of the impellers 250a; in other aspects, at
least about 60%, at least about 90% or is substantially
the length of the impellers 250a. In use, a large
15 proportion of the feed material that has left the feed
tube 230 retains a velocity substantially parallel to the
longitudinal axis of the centrifuge due its high
velocity. Accordingly this large proportion of the feed
material impinges upon the nose member 260a. By making
20 the nose member 260a longer, the radial component of the
velocity can be imparted to the feed material earlier.
This facilitates more even distribution of fluid flow
from the length of the impellers 250a onto the beach. For
example, feed material displaced from but moving
25 substantially parallel to the longitudinal axis of the
centrifuge has less distance to move radially outwardly
before it is deposited on the beach than feed material
moving along or near to the longitudinal axis. Thus, the
feed material is released from the impellers 250a at
30 different points along their length depending on the
distance of the feed material from the longitudinal axis
when it impinges on the impellers. The nearer the feed
material is to the longitudinal axis when it impinges on
the impellers, the further along the length of the
35 impellers it will travel before being deposited on the

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beach.

The plate 262 (like other such plates herein) inhibits fluid flow past the plate facilitating efficient centrifugal treatment of fluid prior to fluid exiting from a bowl exit port. The plate 262 may be used alone
5 without the projecting nose end part.

Referring to Fig. 2 a centrifuge generally identified by reference numeral 271 is similar to the centrifuge 210, like numerals indicating like parts.
10 Impellers 250b have fixed thereto or formed thereof a plurality of spaced apart flow diverters 271a and/or 271b. The flow diverters 271a, 271b are positioned neat the fluid exit part of the impellers 250b on the side facing into the direction of rotation. These flow
15 diverters 271a, 271b are positioned to guide fluid into spaces between the flights 42 and rods 49 thereby inhibiting the direct flow of fluid against inner edges of the flights adjacent the impellers 250b. This inhibits unwanted wear and abrasion of the flights (and of any
20 other structural member adjacent the diverters). The shape of the flow diverters 271a is generally triangular in plan-view cross-section, and the shape of flow diverters 271b is generally semi-circular in plan-view cross-section; however, such diverters may have any
25 desired shape, including, but not limited to, square, rectangular, trapezoidal, etc providing that the diverting function is maintained or substantially maintained. Such diverters can be used at any point adjacent any flight member of a conveyor according to the
30 present invention.

It is to be understood that although the centrifuges 270 and 271 are not shown in their entirety in Figs. 1 and 2, they are substantially like the centrifuge 210 (with the noted differences). A nose member 260a may,
35 according to the present invention, be used with any

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accelerator or impeller apparatus, including, but not limited to, any of those disclosed herein; or such a nose member may be used, according to the present invention, without accelerator or impeller apparatuses.

5 Alternatively, the nose member 260a (and any nose member disclosed herein) may be used in any centrifuge according to the present invention, with or without accelerating impellers and/or in any centrifuge with or without a conveyor; and with or without a conveyor as disclosed

10 herein. Flow diverters 271a, 271b as in the centrifuge 271 may, according to the present invention, be used with any impeller, including, but not limited to, those disclosed herein. All the flow diverters for all impellers of an accelerator may be like the flow

15 diverters 271a, or 271b, or like any diverters disclosed herein. It is within the scope of the present invention to position the impellers, or any of them, on the structural members of a conveyor rather than on the impellers, or on both the impellers and on the structural

20 members of a conveyor. In certain aspects the diverters are secured to or formed of either an inner edge of a conveyor flight or secured to or formed of rods 49 or other structural parts of the conveyor.

Referring to Figs. 3A - 3D an accelerator generally

25 identified by reference numeral 280 (for use in a centrifuge such as any described herein) has four curved impellers 281 (curved as viewed on end) each with a plurality of flow diverters 282. A nose member 283 has a nose 284 that projects between the impellers 281.

30 Optionally, the nose member is deleted. As with the flow diverters 271a, 271b in Fig. 2, the flow diverters 282 are positioned to guide fluid flow away from flights of a conveyor adjacent the impellers to reduce wear thereof. The impellers 281 are thinner (as viewed in Fig. 3B) at a

35 front end 281a thereof and thicker at a rear end 281b

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thereof; although it is within the scope of the present invention for them to be a uniform thickness from front to rear. It will be noted from Figs. 3B and 3C that the thicker section of each impeller extends radially outwardly only so far as the circumference of the plate of the nose member 283 (when viewed on end). This allows the extremity of each impeller to extend into the gap between each rod 49 of the conveyor without impeding flow of feed material. In use, the accelerator 280 is rotated in a clockwise sense as viewed in Fig. 3B. The accelerator 280 (and any accelerator according to the present invention) preferably accelerates fluid to about 110% of the speed of a conveyor in which the accelerator is used.

Referring to Fig. 3D, first alternative flow diverters 282 are shown on an impeller 281. The flow diverters 282 are each generally rectangular in side view and in plan view and are welded or otherwise secured to or formed in the impeller 281.

Referring to Fig. 3E, second alternative flow diverters 285 are shown on an impeller. The flow diverters 285 are each generally semi-circular in side view and circular in plan view (alternatively they may be rectangular in plan view).

Referring to Fig. 3F flow diverters 282a, like the diverters 282 of Fig. 3D are secured to (or formed in) a rod 49 of a conveyor and serve the same purpose as the flow diverters described above.

Referring to Figs. 4A - 4E a flow enhancer generally identified by reference numeral 290 comprises a plurality of pins 292 that extend between two rings 295 and 296 so as to form a plurality of openings 294 around the circumference of the flow enhancer 290. The rings 295, 296 have a respective central opening 293.

Fig. 4E shows an optional securement for securing

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the pins 292 to the rings 295, 296. Each pin's ends are encompassed by tungsten carbide wear plates 297a, 297b and tungsten carbide parts 298a, 298b are positioned beneath the wear plates. The pins 292 have a circular cross-section of 3/8" (9.5mm) diameter, a length of 3" (76.2mm) and they are spaced apart from each other about 1/2" (12.7mm); the rings 295, 296 are about 11.5" (0.29m) in diameter with the central openings 293 about 10" in diameter. Although the flow enhancer 290 as shown has 32 pins 292, any desired number of such pins (e.g. but not limited to 10, 20, 25, 30, 35 or more), of any desired cross-sectional shape (e.g. triangular, square, semicircular, circular, rectangular, trapezoidal, pentagonal, etc.) may be used.

Referring to Fig. 4F a centrifuge generally similar to the centrifuge 271 in Fig. 1, like numerals indicating like parts, comprises a flow enhancer 290 as described above. The flow enhancer 290 is mounted adjacent the outlet of the chamber 240 with the central openings 293 substantially in alignment with the outlet of the chamber. The flow enhancer 290 surrounds part of the front of the impellers of the accelerator 280. The flow enhancer 290 is useful *inter alia* when the centrifuge is used in a "low flow" mode: e.g. a flow rate of less than approximately $0.006\text{m}^3\text{s}^{-1}$ (100 US liquid gallons per minute); but it is within the scope of this invention to use such a flow enhancer in any centrifuge at any desired flow rate. With flow rates of this magnitude, some of the feed material may impinge upon the inner surface of the chamber 240 before it reaches the accelerator 280. Accordingly, some of the feed material will leave the chamber 240 near the outer circumference of the chamber outlet where it is acted on by the flow enhancer 290 and the accelerator 280. The feed material may flow through the openings 294 and/or the central opening 293; radial

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and rotational velocity is imparted to feed material flowing through the openings 294 by the pins 292. The flow enhancer 290 functions in a similar manner to the accelerator 280 and helps to inhibit disturbance of separated liquid and solids in the pool/beach area.

In the centrifuges 210, 270, 271, due to the length and position of the conical chamber 240 (which may be cylindrical for example), feed to the centrifuge exits the chamber 240 at the beach end area of the bowl. Optionally, the chamber 240 may be deleted and fluid flows out from the conveyor at locations in addition to those adjacent the beach area.

Referring to Fig. 5A a part of a centrifuge generally identified by reference numeral 301 is similar to the corresponding part of centrifuge 210, with like numerals indicating like parts. A feed tube 230a, similar to the feed tube 230, Figs. 0A' and 0A'') has an exit end 231a adjacent the end of the nose member 264 so that fluid to be treated exits within impellers 250. Alternatively, the exit end 231a may be adjacent the end of the nose member 231a, but fluid to be treated does not exit with the impellers 250 (i.e. the feed tube extends substantially up but does not extend beyond the end of the impellers 250). It is within the scope of this invention to employ a feed tube of any desired length with an exit end located longitudinally at any point adjacent the impellers 250 or at any point in the chamber 240; and to use a feed tube of any desired internal and external diameter.

Referring to Fig. 5B part of a centrifuge generally identified by reference numeral 305 is similar to the corresponding part of centrifuge 210, with like numerals indicating like parts. The centrifuge 305 has no chamber like the chamber 240. The centrifuge 305 comprises a feed tube 230b, like the feed tube 230, Figs. 0A' and 0A''),

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but of longer length. The feed tube 230b has a fluid exit end 231b that is longitudinally adjacent a part of the beach area of the bowl 20. It is within the scope of this invention for the feed tube 230b (and any feed tube
5 disclosed herein) to be of any desired length and, in certain aspects, for the feed tube's fluid exit end 231b to be adjacent any point on the beach area or a point not on the beach area.

Referring to Fig. 5C part of a centrifuge generally
10 identified by reference numeral 310 is similar to the corresponding part of centrifuge 210, with like numerals indicating like parts. The centrifuge 310 has a feed tube 230c, like the feed tube 230, Figs. 0A' and 0A'', but of longer length. The feed tube 230c has a fluid exit end
15 231c into which projects an end 264c of a nose member 264d which has a plate 260a like the plate 260, Figs. 0A' and 0A''. Fluid near the end of the feed tube 230c is forced around and along that part of the nose member 264d within the feed tube. Accordingly, fluid is guided by the
20 nose member 264d prior to leaving the feed tube 230c such that it has less opportunity to become agitated before it reached the impellers. That part of the nose member 264d that extends into the feed tube 230c may be forward of the front receiving end of the impellers 250 and the
25 fluid exit end 231c of the feed tube is just before the forward end of impellers 250 and not within them. It is within the scope of this invention to use a nose end of any size and diameter (and of any desired cross-sectional shape, including, but not limited to circular,
30 triangular, square, rectangular, trapezoidal, pentagonal, or hexagonal) and of any length; and any such nose end may project any desired distance into a feed tube exit end.

Referring to Fig. 5D part of a centrifuge generally
35 identified by reference numeral 320 is similar to the

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corresponding part of centrifuge 210, with like numerals indicating like parts. However, the centrifuge 320 has an inner cylindrical shell 240a that closes off the conveyor from the fluid entry end (to the left in Fig. 8D) of the centrifuge up to the bowl's beach area. Thus fluid flowing out from the chamber can only exit from the conveyor adjacent the far end (to the right in Fig. 8D) of the bowl and the only open areas 51 are at this far end of the conveyor. It is within the scope of the present invention to employ a shell 240a of any desired length and thus to close off any opening 51 or openings 51 in the centrifuge 210 of Fig. 5A or openings of any conveyor according to the present invention. In the centrifuge 320, the chamber 240 may be deleted. It is to be understood that the items and structures of the centrifuge 210 not shown in Fig. 8A may be used with the centrifuge 320 (or similar items and structures - as is true for the centrifuges 270, 271, 291, 301, 305, and 310).

In certain embodiments of the present invention, the turbulence associated with prior art centrifuges due to the relatively high velocity of fluid exiting from a conveyor's feed ports into a bowl is reduced or substantially eliminated. With preferred embodiments of centrifuges according to the present invention accelerated feed is introduced at bowl's beach end (primarily or only) which allows the fluid stream to enter the bowl above or in a relatively shallow pool and solids are deposited at or near the bottom of the shallow pool and they do not have to settle through the main pool body. By spreading fluid feed over a relatively larger area, turbulent jetting effects associated with prior art feed ports that focus feed are reduced or eliminated. In some prior art machines some solids separated between feed zones and a liquid effluent end must pass through a

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turbulent area, compromising their separation. Using conveyors according to the present invention, high velocity axial fluid feed is converted to radial motion and the feed is spread over substantially the width and length of the impellers; and the tangential speed of the fluid is increased slightly faster than the speed of the pool surface caused by bowl rotation, thus allowing the feed to fall into the bowl with reduced or no turbulence. Also, by feeding at a bowl beach area, the distance solids need to travel to reach a bowl wall is reduced and transport of solids to a solids discharge port is enhanced; and thus solids removal is not so dependent on fluid retention time. A thin sheet of fluid feed material slides off the faces of the impellers and is deposited axially along substantially the length of the beach. Depending on the pool depth being used, some of the thin sheet of accelerated feed material enters the leading edge of the pool, some enters at the transition of the pool to the beach and the balance enters on the dry beach. As this thin layer comes in contact with the bowl wall or pool surface it is already accelerated to the full or nearly-full G-force. Solids particles have only to move through the fluid that they entered with to be discharged. Allowing much of the separation to occur on the beach reduces the amount of solids that normally would be held and transported from the cylinder section of the bowl; thus lowering torque, reducing the amount of solids held in the bowl and reducing the work load of the gearbox.

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CLAIMS: -

1. A centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor
5 having at least one impeller mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being such that, in use, on entry to the centrifuge said feed
10 material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region,
15 said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller,
characterised in that said nose member is at least
20 about 50% of the length of said at least one impeller.
2. A method of separating feed material into solid and fluid parts, which method comprises the steps of:
- (1) feeding feed material to a centrifuge as set out in claim 1; and
25 (2) rotating the conveyor and rotatable housing to separate the feed material.

* * *

- 30 3. A centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller and the rotatable housing having a separating region comprising a pool area and a
35 drying area between the conveyor and a rotatable housing,

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the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller,

characterised by wear inhibiting means for inhibiting wear to said conveyor caused by feed material moving from said at least one impeller to said separating region.

4. A centrifuge as claimed in claim 3, wherein said wear inhibiting means is shaped so as to guide feed material away from a part of the conveyor.

5. A centrifuge as claimed in claim 3 or 4, wherein said wear inhibiting means is positioned to inhibit feed material impinging on part of a thread of said conveyor.

6. A centrifuge as claimed in any of claims 3 to 6, wherein there is a plurality of wear inhibiting means.

7. A centrifuge as claimed in any of claims 3 to 6, wherein said wear inhibiting means is positioned at or adjacent a feed material exit end of said at least one impeller.

8. A centrifuge as claimed in claim 7, wherein said at least one impeller has a cross-section of gradually increasing area along a longitudinal axis of the centrifuge.

9. A centrifuge as claimed in claim 7 or 8, further comprising a nose member on which said at least one impeller is mounted, the at least one impeller and the nose member have a respective length, the length of the

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nose member being at least about 50% of the length of the at least one impeller.

10. For use with a centrifuge, a conveyor having any of the conveyor features as set out in claims 3 to 9.

5 11. A method of separating feed material into solid and fluid parts, which method comprises the steps of:

(1) feeding feed material to a centrifuge as set out in any of claims 3 to 9; and

10 (2) rotating the conveyor and rotatable housing to separate the feed material.

* * *

12. A centrifuge for separating feed material into solid
15 and fluid parts, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, the conveyor having at least one impeller and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing,
20 the arrangement being such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by
25 said at least one impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at
30 least one impeller,

characterised by a flow enhancing means adjacent a forward end of said at least one impeller for assisting said at least one impeller in the spreading the feed material at or near said forward end.

35 13. A centrifuge as claimed in claim 12, further

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comprising a chamber within the conveyor into which feed material may be fed, said flow enhancing means adjacent a feed material outlet end of said chamber.

14. A centrifuge as claimed in claim 13, wherein said
5 flow enhancing means is positioned over part of said pool area adjacent said drying area.

15. A centrifuge as claimed in claim 12, 13 or 14, wherein said flow enhancer is of annular configuration with a central opening through which, in use, feed
10 material may pass, and comprises a plurality of circumferential openings defined by a plurality of impellers disposed around the circumference thereof.

16. A centrifuge as claimed in claim 15, wherein said plurality of impellers is supported between two rings.

15 17. A centrifuge as claimed in claim 15 or 16, wherein said plurality of impellers comprises a plurality of pins spaced apart around the circumference of said flow enhancing means.

18. A centrifuge as claimed in any of claims 12 to 17,
20 wherein said flow enhancing means comprises a wear resistant material.

19. For use with a centrifuge, a flow enhancer having any of the flow enhancing means features of any of claims 12 to 18.

25

* * *

20. A centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor
30 rotatably mounted in a rotatable housing, the conveyor having at least one impeller mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being
35 such that, in use, on entry to the centrifuge said feed

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material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one
5 impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller,

10 characterised by a feed tube extending into said centrifuge and in that said nose member extends substantially up to or into said feed tube.

21. A centrifuge for separating feed material into solid and fluid parts, which centrifuge comprises a conveyor
15 rotatably mounted in a rotatable housing, the conveyor having at least one impeller mounted on a nose member and the rotatable housing having a separating region comprising a pool area and a drying area between the conveyor and a rotatable housing, the arrangement being
20 such that, in use, on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, the feed material passing through the interior of said conveyor with rotational speed being imparted thereto by said at least one
25 impeller prior to treatment in said separating region, said at least one impeller also imparting radial speed to said feed material whilst it moves with axial velocity such that feed material is spread onto the drying area adjacent the length of the at least one impeller,

30 characterised in that said nose member is such that, in use, feed material impinging thereon is guided onto a substantial portion of said at least one impeller.

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Fig. 00A/

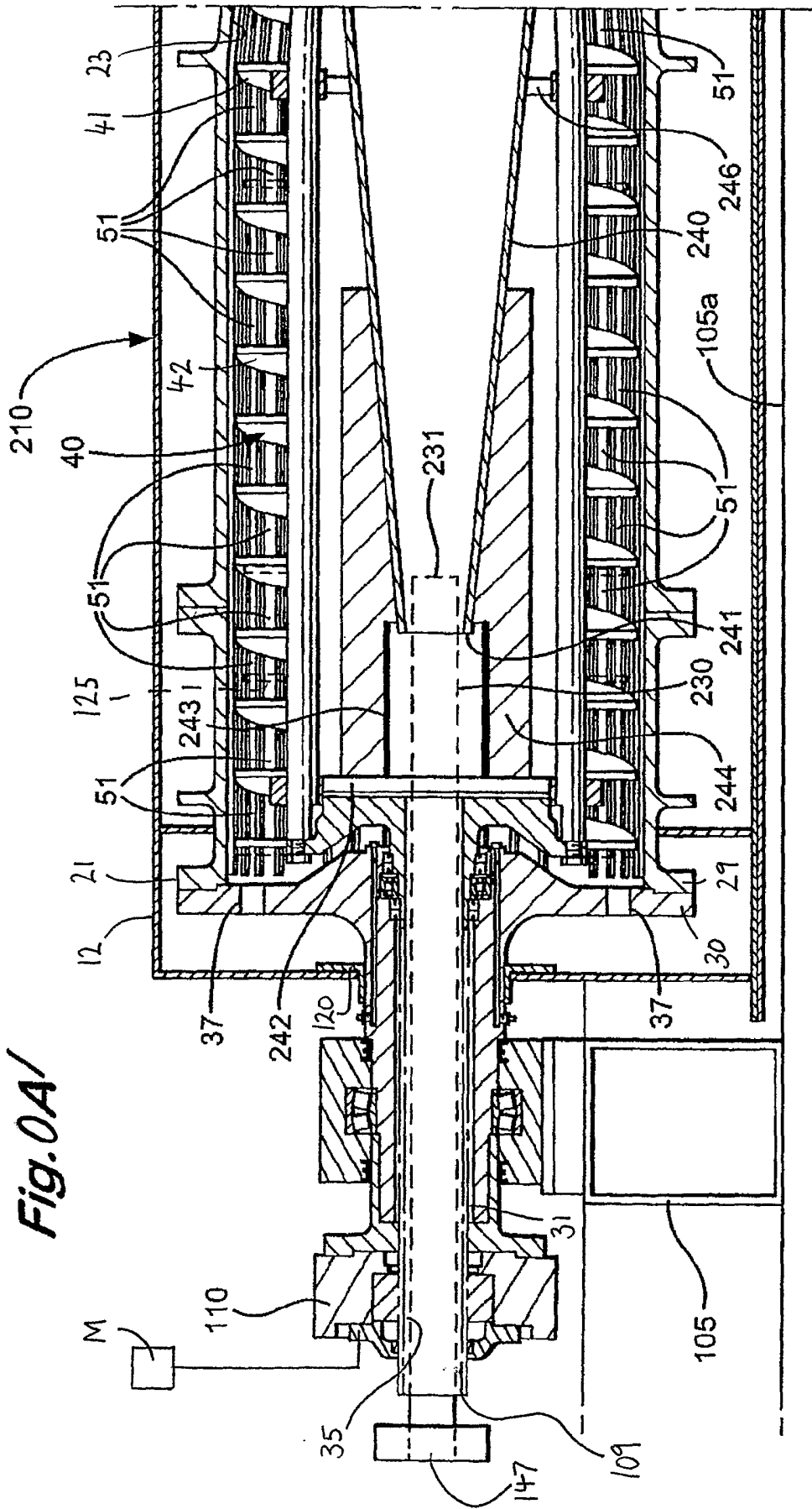
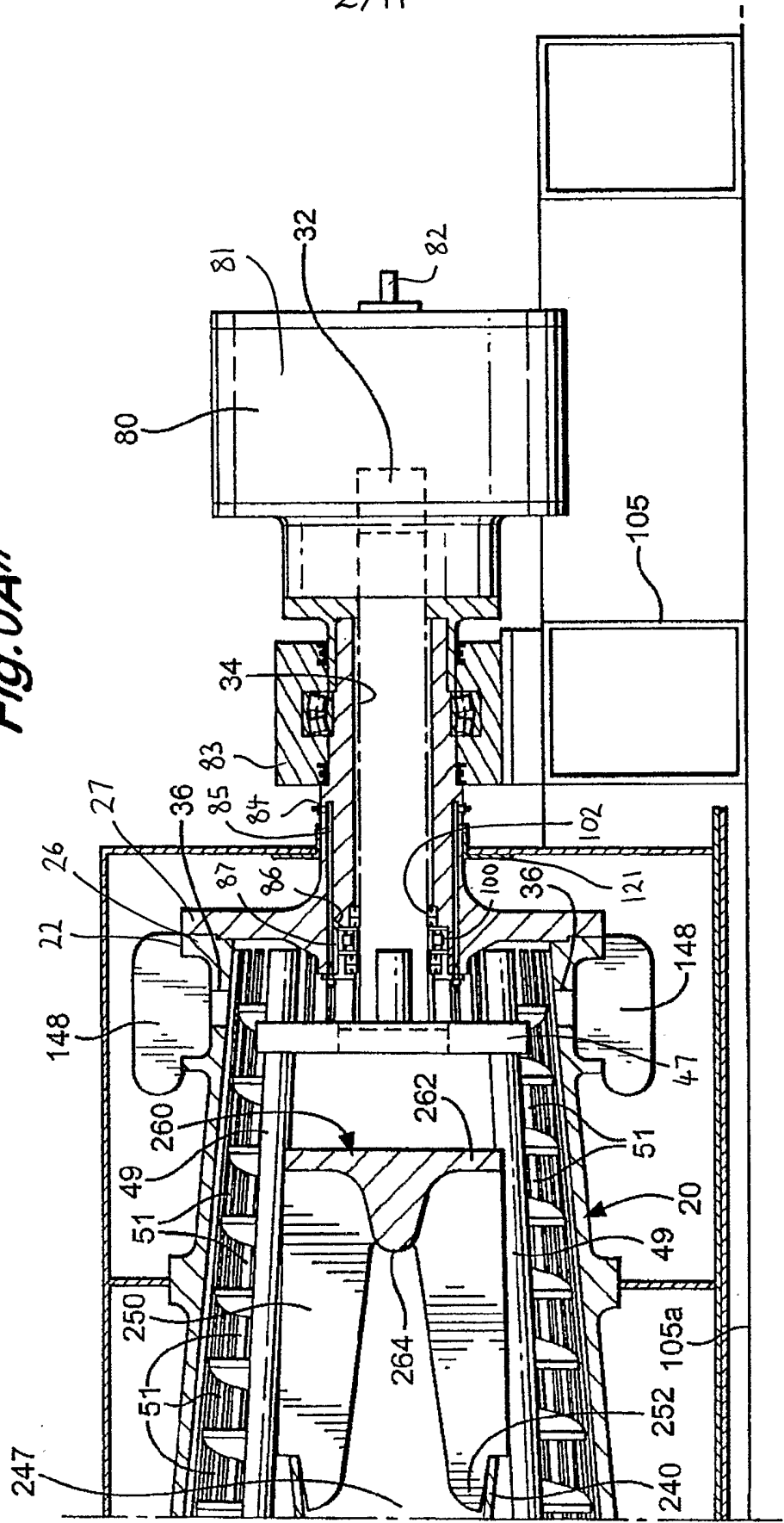
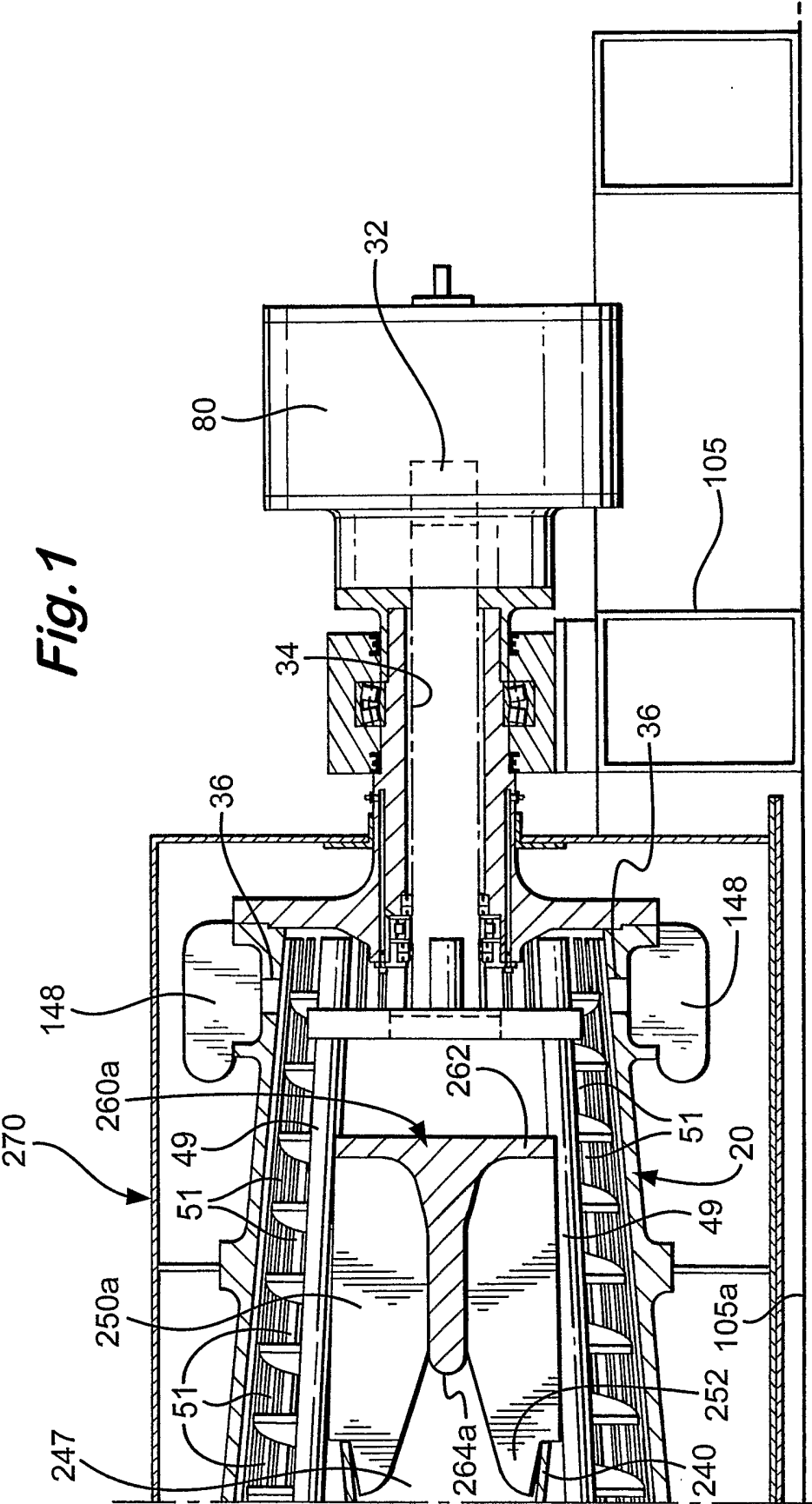
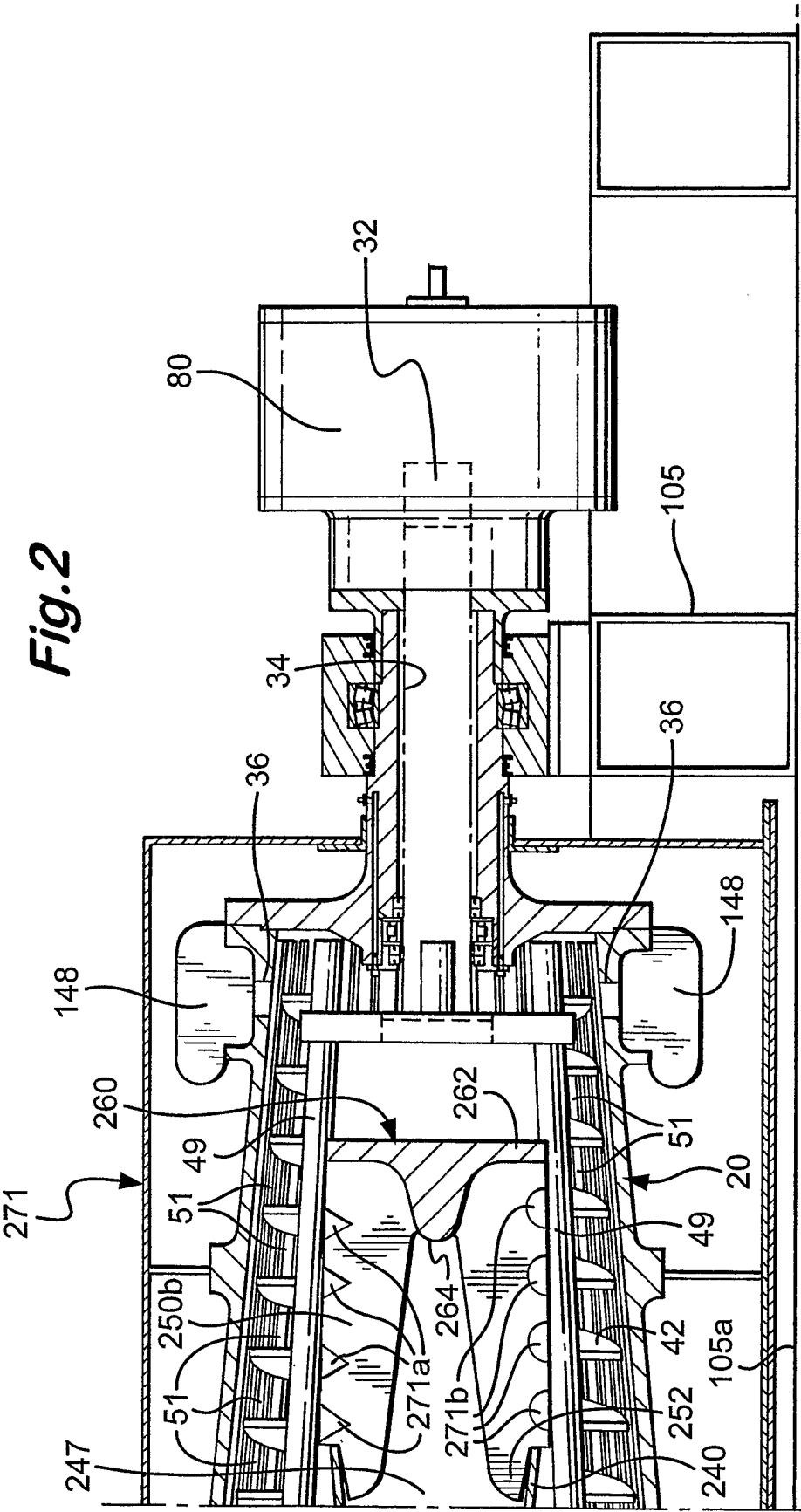


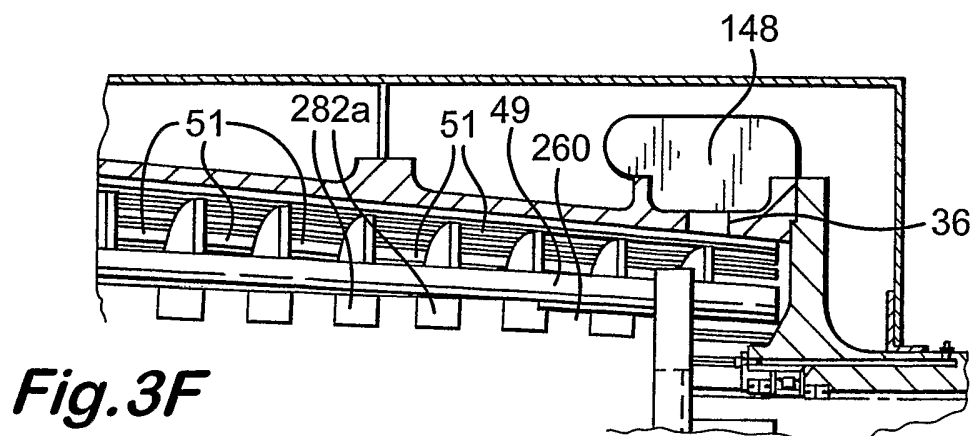
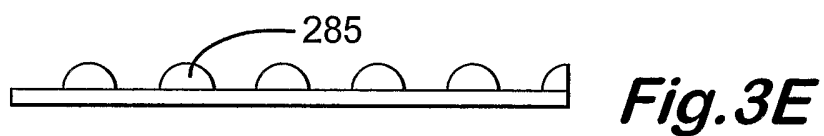
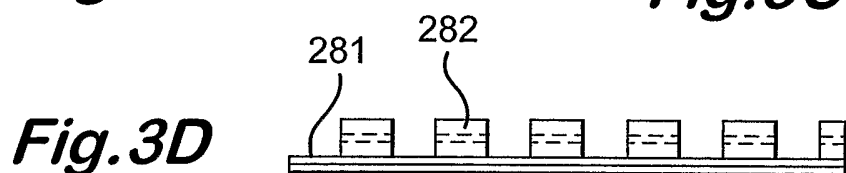
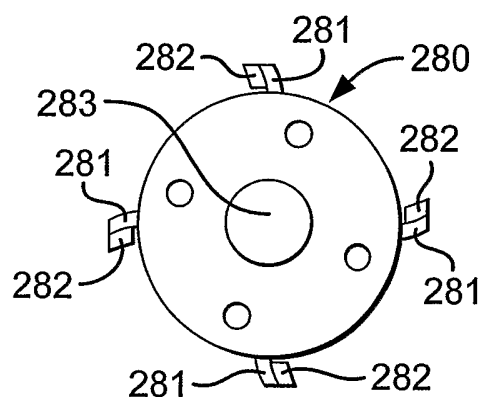
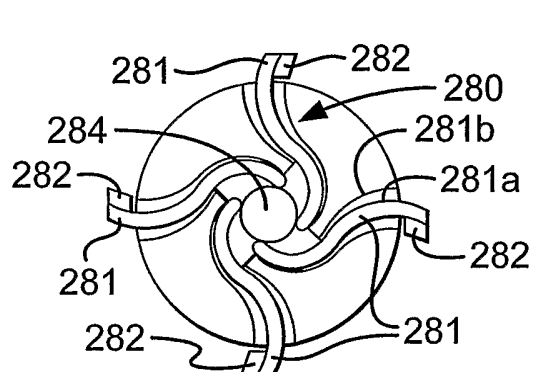
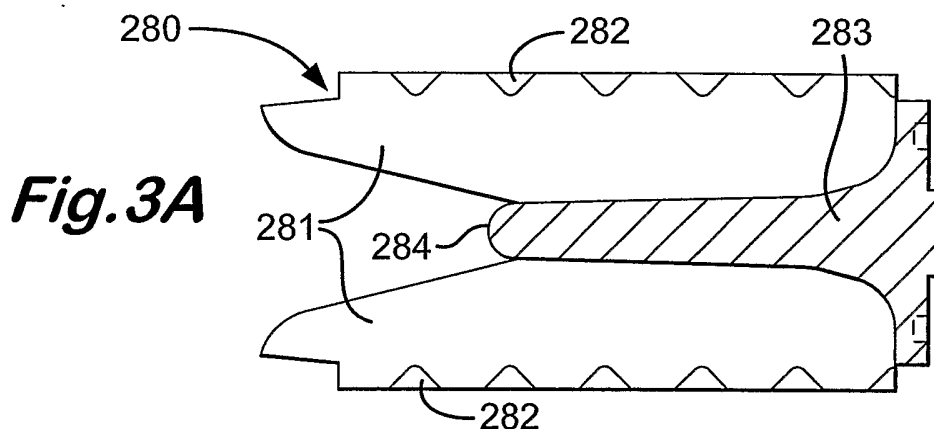
Fig. 0A//



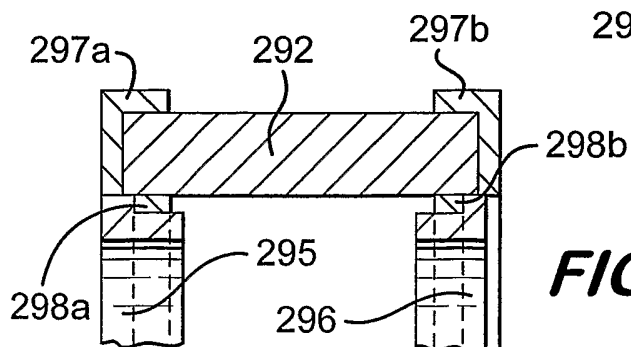
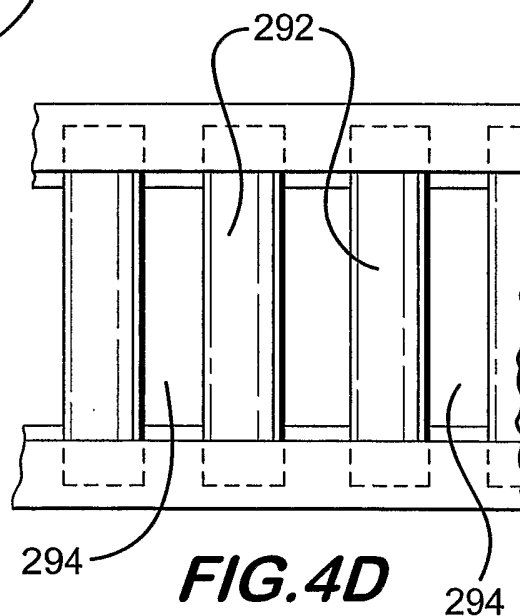
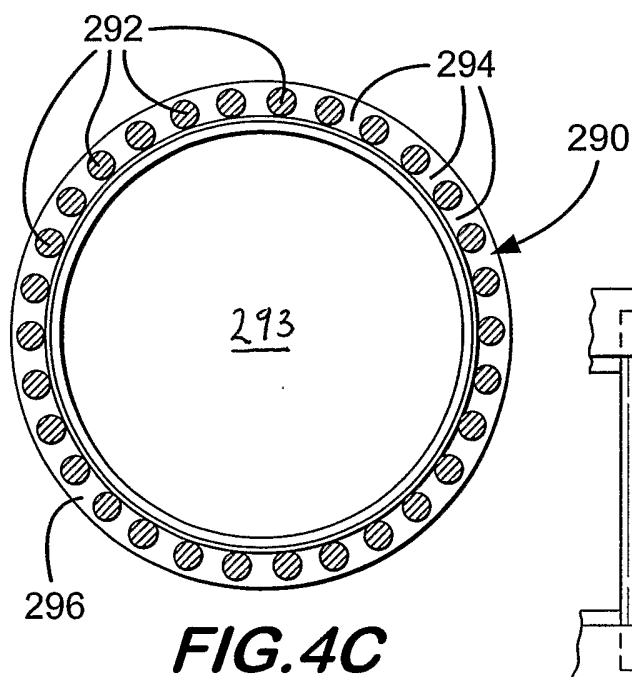
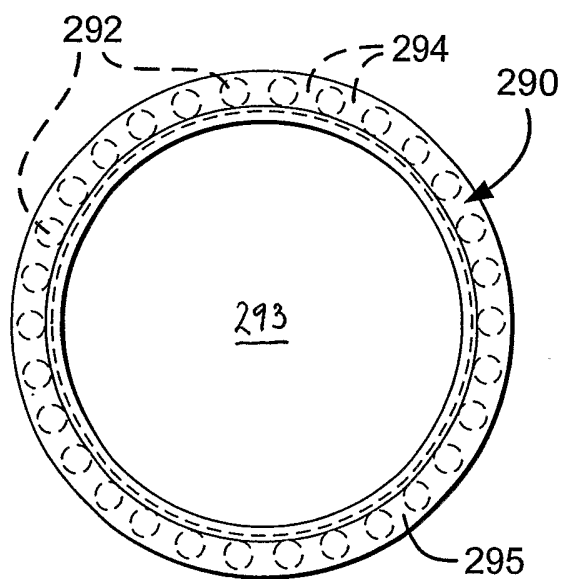
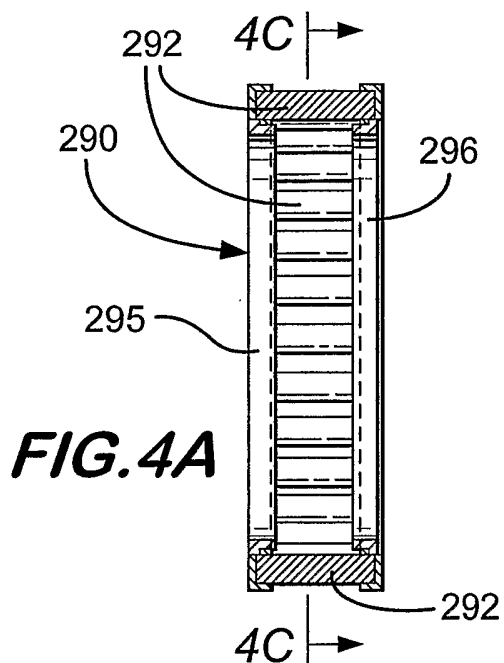




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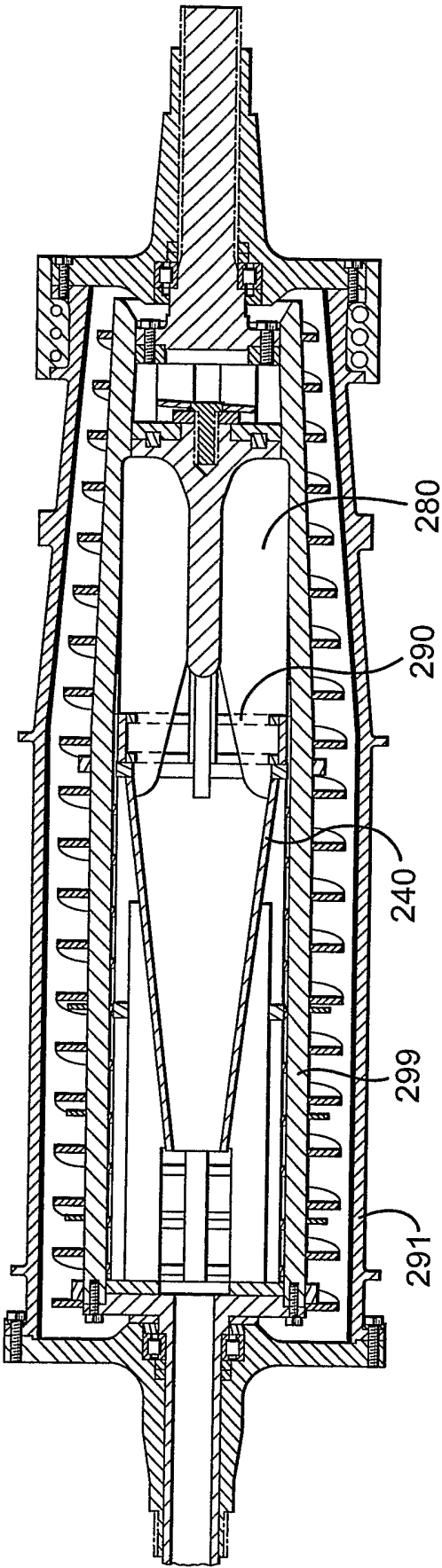


Fig. 4F

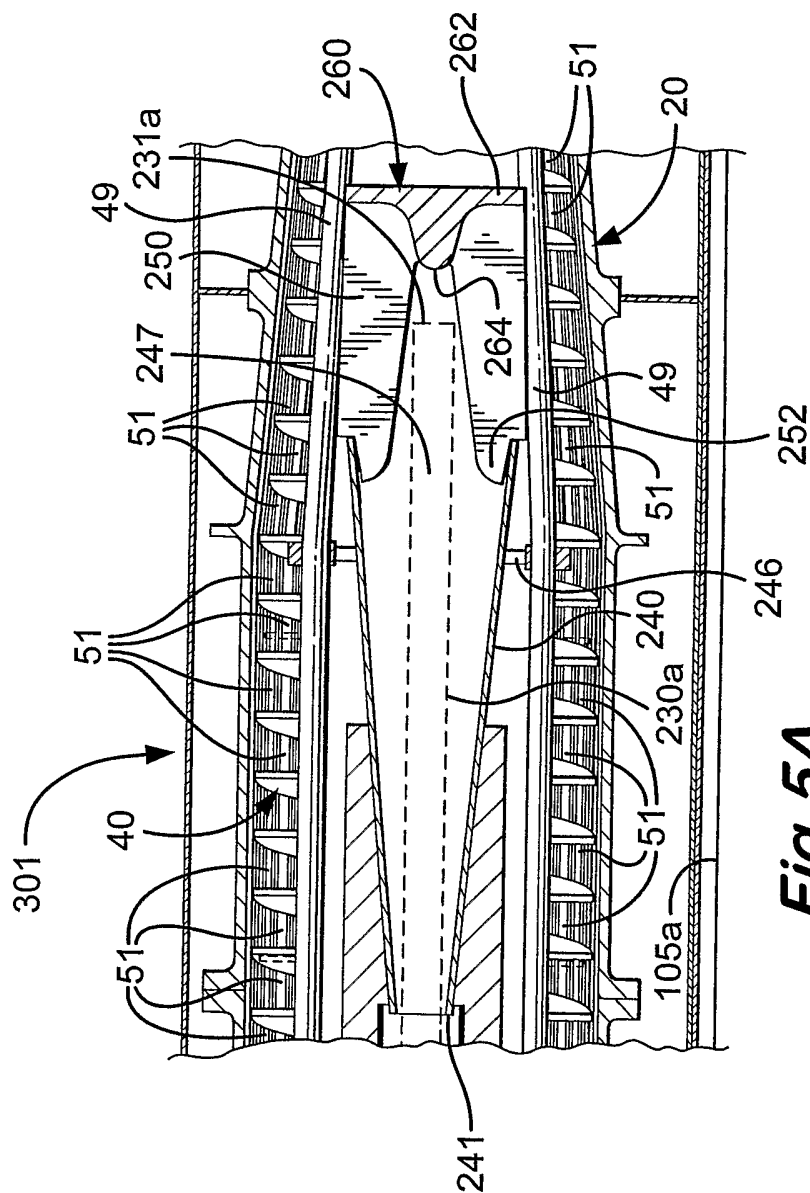


Fig. 5A

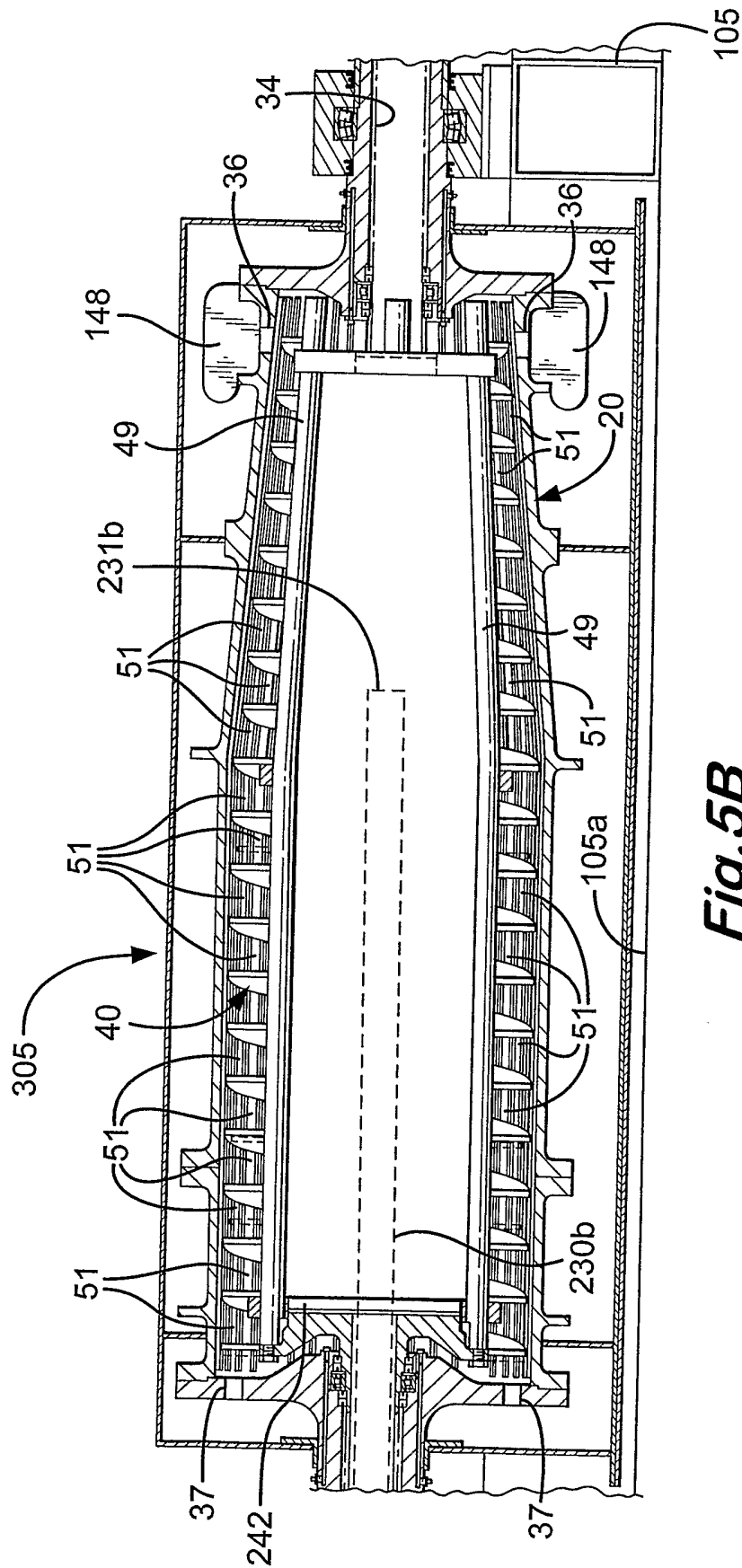
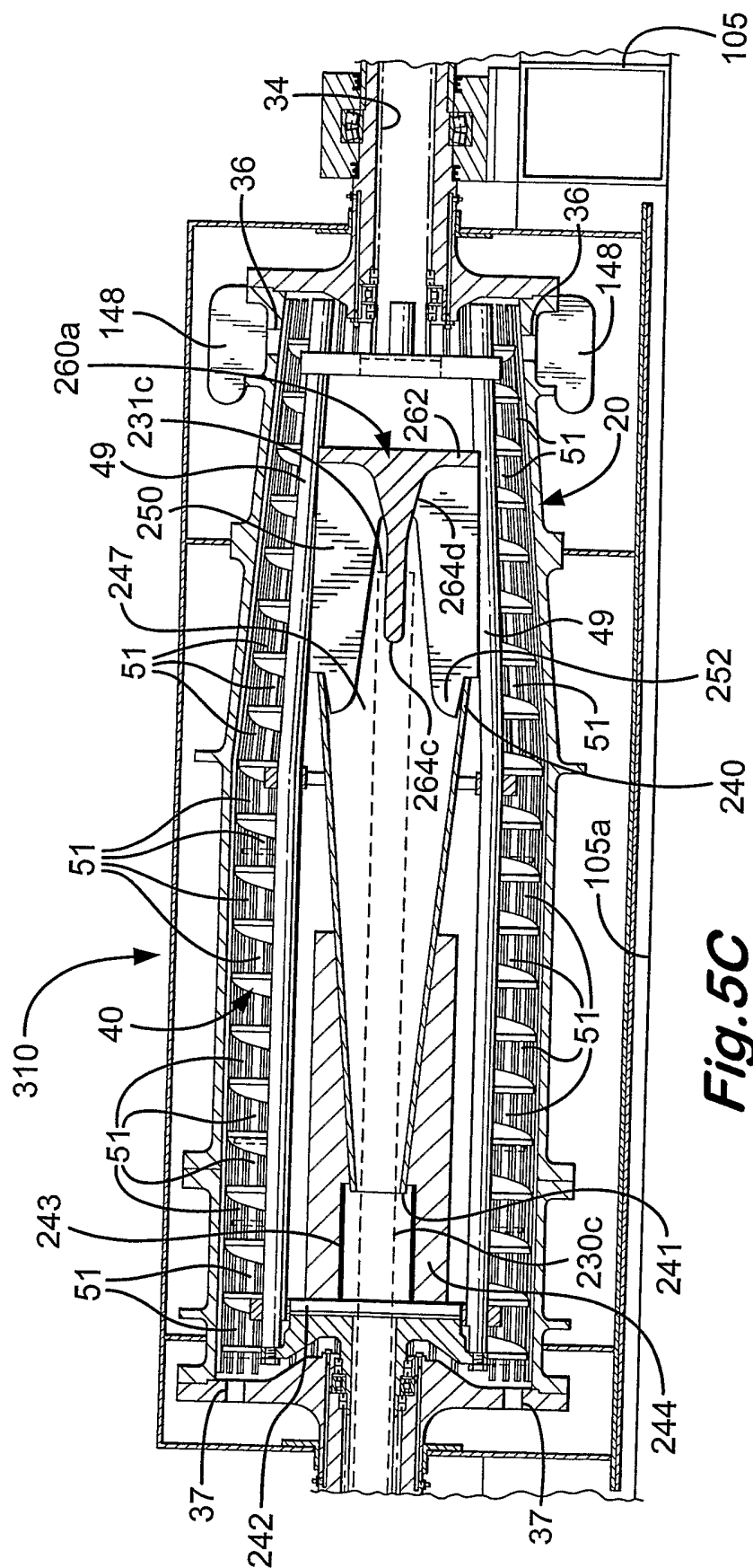


Fig. 5B

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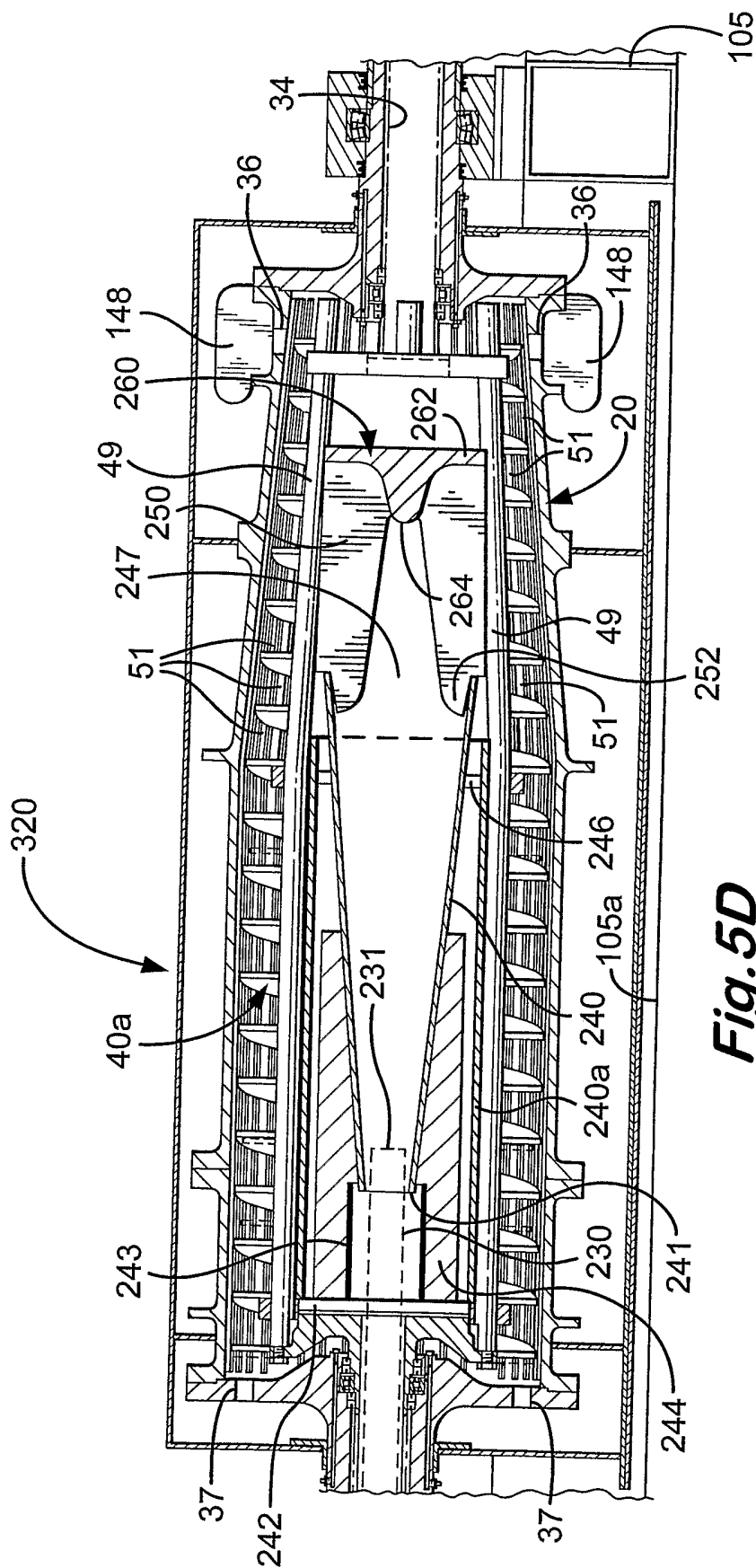


Fig. 5D