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CA 2419997 C 2007/01/09

(11)(21) 2 419 997

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2001/08/31
(87) Date publication PCT/PCT Publication Date: 2002/03/07
(45) Date de délivrance/Issue Date: 2007/01/09
(85) Entrée phase nationale/National Entry: 2003/02/18
(86) N° demande PCT/PCT Application No.: GB 2001/003891
(87) N° publication PCT/PCT Publication No.: 2002/018055
(30) Priorité/Priority: 2000/08/31 (US09/652,418)

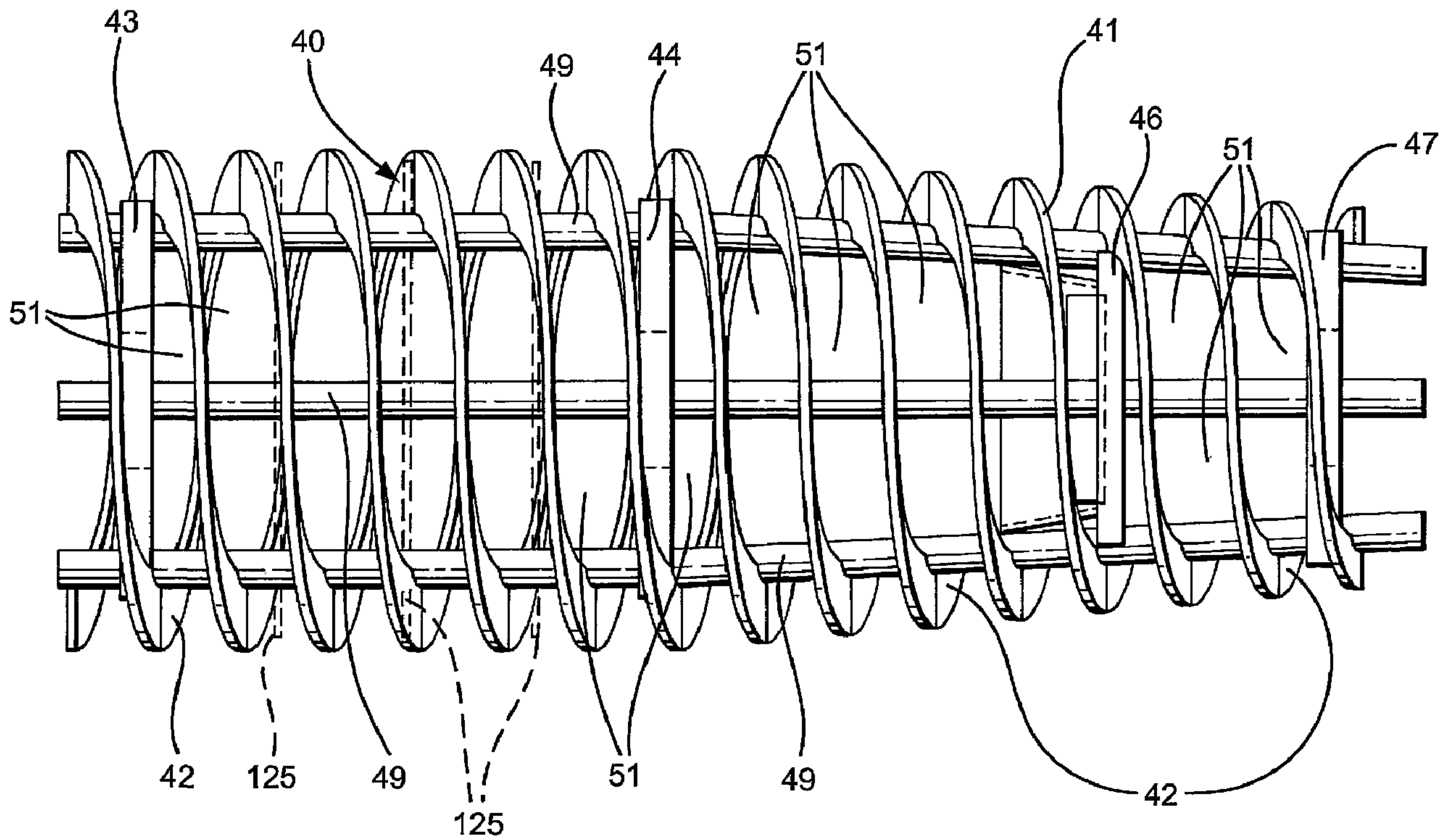
(51) Cl.Int./Int.Cl. *B04B 1/20* (2006.01)

(72) Inventeurs/Inventors:
KOCH, RICHARD JAMES, US;
MITRA, SUBRATA, US;
SEYFFERT, KENNETH WAYNE, US;
WRIGHT, JOHN PATRICK, US

(73) Propriétaire/Owner:
VARCO I/P, INC., US

(74) Agent: MCFADDEN, FINCHAM

(54) Titre : CONVOYEUR POUR CENTRIFUGEUSE ET METHODE DE SEPARATION
(54) Title: CONVEYOR FOR A CENTRIFUGE AND METHOD OF SEPARATION



(57) Abrégé/Abstract:
A conveyor (40) for a centrifuge (10; 210), the conveyor comprising a thread (41), a support (49) therefor, and a plurality of open areas (51) that (a) extend along a substantial portion of the length of the support and (b) through which feed material to be treated by the centrifuge (10; 210) can pass.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 March 2002 (07.03.2002)

PCT

(10) International Publication Number
WO 02/18055 A1

(51) International Patent Classification[7]: B04B 1/20

(21) International Application Number: PCT/GB01/03891

(22) International Filing Date: 31 August 2001 (31.08.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/652,418 31 August 2000 (31.08.2000) US

(71) Applicants (*for all designated States except US*): **VARCO I/P, INC.** [US/US]; 2835 Holmes Road, Houston, TX 77051 (US). **LUCAS, Brian, Ronald** [GB/GB]; 135 Westhall Road, Warlingham, Surrey CR6 9HJ (GB).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **KOCH, Richard, James** [US/US]; 7202 Shag Bark, Magnolia, TX 77354 (US). **MITRA, Subrata** [US/US]; 62 South Dreamweaver Circle, The Woodlands, TX 77380 (US). **SEYFFERT, Kenneth, Wayne** [US/US]; 1019 LaMonte Lane, Houston, TX 77018 (US). **WRIGHT, John, Patrick** [US/US]; PO Box 1412, Ingram, TX 78025 (US).

(74) Agent: **LUCAS, Brian, Ronald**; Lucas & Co., 135 Westhall Road, Warlingham, Surrey CR6 9HJ (GB).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

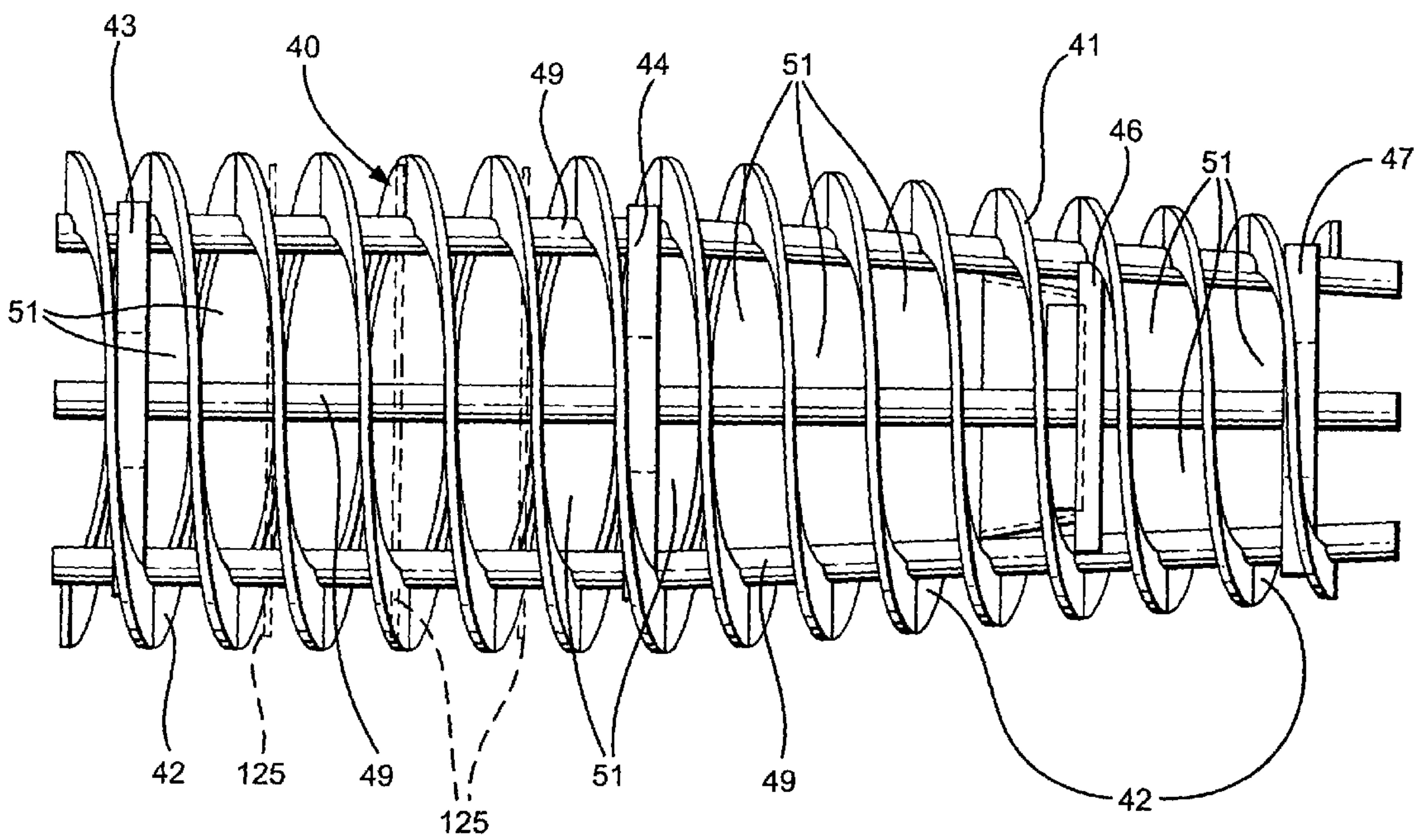
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*

[Continued on next page]

(54) Title: CONVEYOR FOR A CENTRIFUGE, CENTRIFUGE AND METHOD OF SEPARATION



(57) Abstract: A conveyor (40) for a centrifuge (10; 210), the conveyor comprising a thread (41), a support (49) therefor, and a plurality of open areas (51) that (a) extend along a substantial portion of the length of the support and (b) through which feed material to be treated by the centrifuge (10; 210) can pass.

WO 02/18055 A1

A Conveyor for a Centrifuge, A Centrifuge and Method of Separation

This invention relates to a conveyor for a centrifuge, a centrifuge provided with such a conveyor, to a method of separating the components of a feed material with a centrifuge, and more particularly, but not exclusively, to a such a conveyor for use in "decanting" type centrifuges used in the oil industry.

Many different industries use decanter centrifuges 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 re-use drilling mud because it is expensive.

The prior art discloses a variety of decanter centrifuges (or "decanters" 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 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 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) which are discharged separately from 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 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 must pass around a path defined by the thread before it 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.

Often the solids/liquid mixture is processed at extraordinarily high feed rates. To accommodate such feed rates, high torques are encountered, much energy is required to process the mixture, and the physical size of the centrifuge can become relatively large, which is important *inter alia* on oil rigs where space is at a premium.

Fig. 1 shows one typical prior art decanting centrifuge that removes free liquid from separated solids. Fluid to be processed is fed, usually at high speed, by a feed tube into an interior acceleration chamber of a conveyor. Exit ports on the conveyor permit fluid to flow from the chamber into the annular space between the conveyor and the housing. Other than these exit ports the exterior of the shaft of the conveyor is solid. The rotating housing or "bowl" creates very high G-forces and forms a liquid pool inside the bowl. The free liquid and finer solids flow around the path defined by the thread of the conveyor towards the larger end of the centrifuge and are removed through effluent overflow weirs. Larger solids settle against the wall of the housing, forming a "cake" (as it is known in the art). These solids are pushed by a conveyor up out of the pool and across a drainage deck (conical section), or "beach", of the housing. Dewatering or drying takes place during the process of the solids moving up the beach, with the deliquified solids discharged through a series of underflow solids ports.

However, as larger feed volumes are processed in such a centrifuge, the clarification capability of the centrifuge decreases due to: decreased retention or residence time in the bowl; partial-acceleration or non-acceleration (slippage) of the feed fluid (the solids/liquid mixture); radial deceleration of the fluid moving axially through the conveyor; and turbulence created by the movement and/or focusing of large volumes of fluid through the exit ports on the conveyor at high radial speed that tend to transmit and/or focus a high volume flow in an area exterior to the conveyor. This induces undesirable turbulence in that area and results in excess wear and abrasion to parts that are impacted by this flow. The turbulent fluid exiting from the exit ports also impedes or prevents solids from flowing to solids exit ports, and fluid exiting the exit ports near the centrifuge's drainage deck or "beach" impedes solids flow up the beach.

The end of the feed tube inside the conveyor is relatively close to a wall or member defining an end of an acceleration chamber, thus fluid exiting from the feed tube into the acceleration chamber has relatively little space in which to slow down axially. This relatively high speed fluid is, therefore, turbulent and can wear away parts of the acceleration chamber necessitating maintenance and causing down time of the centrifuge.

Rather than dispersing and slowing down the fluid exiting from the acceleration chamber, the exit ports focus and/or speed up the fluid flow.

Another problem with such centrifuges is that some heavy phase material becomes entrained in a layer of slurry on top of the pool. Such heavy phase material is difficult to remove from the light phase material.

A gearbox connects the conveyor to the bowl, and enables the conveyor to rotate in the same direction as the bowl, but at a different speed. This speed differential is required to convey and discharge solids. However, due to friction between the solids and the conveyor, the conveyor is urged to rotate at the same speed as the housing. This is obviously undesirable, as solids removal would then cease. Accordingly, measures have been taken in the prior art to maintain the speed differential between the housing and the conveyor. One of these methods utilises a motor to apply a braking force to the conveyor to maintain the speed differential. Such known motors are mechanically, electrically or hydraulically powered. These motors are relatively high maintenance, generate unwanted heat, and some electrical motors have explosion potential.

It is an aim of at least preferred embodiments of the present invention to alleviate at least some of the aforementioned disadvantages.

According to the present invention there is provided a conveyor for a centrifuge, the conveyor comprising a thread, a support therefor, and a plurality of open areas (a) that extend along a substantial portion of the length of the support and (b) through which feed material to be treated by the centrifuge can pass.

In one embodiment the support is provided with the plurality of open areas. For example, the support might comprise a cylinder provided with a plurality of apertures. In another embodiment the support comprises a plurality of support members that, with the thread, define the plurality of open areas (in other words the support member does not have any holes itself). For example, the support members might comprise a plurality of rods.

It should be understood that "a substantial portion" is intended to mean that the holes extend over at least 10% of the length of the conveyor. Advantageously, the holes extend over at least 20%, preferably at least 30%, more preferably at least 40%, advantageously at least 50%, more advantageously at least 60%, preferably at least 70%, more preferably at least 80%, and advantageously at least 90% or 100% of the length of the conveyor.

In accordance with one embodiment of the present invention there is provided a conveyor for use with a centrifuge, which conveyor has a substantially cylindrical outer portion and a substantially tapered outer portion, the conveyor comprising a thread and a plurality of support members defining a plurality of open areas that extend along substantially the entire length and around substantially the entire circumference of the conveyor, each support member extending along the length of both the substantially cylindrical and tapered portions, the arrangement being such that the thread and the plurality of support members define an open space within the conveyor that, in use, receives feed material and from which the feed material passes out through said open areas to be treated by the centrifuge.

Preferably, the thread comprises a plurality of flight members. The flight members form a thread of the conveyor for conveying solids separated from fluid to be treated by the centrifuge from one end of the bowl to the other (at which there are one or more solids outlets).

Advantageously, the plurality of open areas extends along substantially the entire length of the conveyor.

Preferably, the plurality of open areas extends around substantially all of the circumference of the conveyor.

Advantageously there is a chamber within the conveyor, the chamber having an entry end for receiving feed material from a feed tube, the feed material passing through the chamber and exiting from an exit end of the chamber that is spaced-apart from the entry end and within the conveyor. Such an arrangement helps to reduce the axial velocity of the feed material after it has entered the conveyor.

In one embodiment at least one or more open area of the plurality of open areas is adjacent the outer surface of the chamber.

Preferably, the shape of the chamber is such that, in use, the feed material entering the chamber has an entry velocity and the feed material leaving the chamber has an exit velocity, and the entry velocity is greater than the exit velocity.

Advantageously, the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

Preferably the conveyor further comprises at least one impeller for imparting rotation to the feed material prior to the feed material flowing out from the conveyor. This helps to reduce the disturbance caused by feed material entering the pool.

Advantageously, the at least one impeller can increase the rotational speed of the feed material to a speed that is at least 95%, and preferably 99%, of the speed of rotation of a pool of feed material around the conveyor. The impellers may be axially spaced.

Preferably, the at least one impeller is a plurality of spaced-apart impellers each with a central end connected to a central nose member mounted in the conveyor. The impellers can be spaced axially along the length of part of the conveyor.

In one embodiment the chamber, the central nose member, and the at least one impeller are permanently secured to the conveyor.

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

The impellers (and related parts such as a nose member, chamber, and base) can be made of material from the group of steel, stainless steel, hard-faced or carbide covered metal, plastic, moulded polyurethane, fibreglass, polytetrafluoroethylene, aluminium, aluminium alloy, zinc, or zinc alloy, stellite, nickel, chrome, boron and/or alloys of any of these.

Advantageously, the conveyor further comprises at least one pool surface solids diffuser. This helps to disburse solids caught on the surface of the pool.

In one embodiment the pool surface solids diffuser is a ring with an opening therethrough.

Preferably, the at least one pool surface solids diffuser is a plurality of spaced-apart pool surface solids diffusers.

In one embodiment the pool surface solids diffusers are spaced axially along the conveyor.

Advantageously, the conveyor has a distal end smaller in diameter than a proximal end at which proximal end, in use, feed material enters the conveyor, and wherein at least one of the plurality of open areas is adjacent the distal end.

In one embodiment the length of the plurality of open areas extends to substantially the length of the impeller or impellers.

According to another aspect of the present invention there is provided a centrifuge comprising a conveyor in accordance with the present invention.

In accordance with one embodiment of the present invention, the 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, feed material passes through the interior of the conveyor, rotational speed being imparted thereto by the at least one impeller prior to treatment in the separating region, and the at least one impeller spreads feed material onto the drying area, characterised in that on entry to the centrifuge the feed material has an axial velocity substantially parallel to the longitudinal axis thereof, and in that the at least one impeller imparts radial speed to the 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.

Preferably, the centrifuge comprises a rotatable housing within which the conveyor is rotatably mounted and a feed tube having an outlet within the conveyor through which, in use, feed material to be treated by the centrifuge enters a space within the conveyor.

In a preferred embodiment, the conveyor comprises a thread, a support therefor, and a plurality of open areas that (a) extend along substantially the length of the impeller or impellers and (b) through which feed material to be treated by the centrifuge can pass.

Advantageously, at least one of the plurality of open areas is located adjacent said outlet.

Preferably, said outlet has an internal diameter and the space within the conveyor includes an unobstructed space adjacent the outlet, the length of said unobstructed space having a ratio of at least 7:1 of an internal diameter of the outlet.

In one embodiment the ratio is at least 10:1.

Advantageously the centrifuge further comprises control apparatus for selectively adjusting the speed of rotation of the conveyor relative to the rotatable housing.

Preferably, the control apparatus is a backdrive apparatus.

Advantageously, the backdrive apparatus is pneumatic.

Preferably, the rotatable housing has a beach area, and at least one of the plurality of open areas is adjacent the beach area.

Advantageously, there is a plurality of the open areas adjacent the beach area.

According to another embodiment of the present invention there is provided a method of separating feed material into solid and fluid parts with a centrifuge comprising a conveyor rotatably mounted within a housing, which method comprises the steps of: (1) rotating the housing at a first speed and the conveyor at a second speed different to the first speed; (2) introducing feed material into the interior of the conveyor; (3) imparting rotational speed to the feed material with at least one impeller prior to treatment in a separating region that comprises a pool area and a drying area between the conveyor and the housing; and (4) spreading feed material onto the drying area with the at least one impeller; characterised in that step (2) is performed so that feed material has an axial velocity substantially parallel to the longitudinal axis of the centrifuge and in that step (4) is performed by the at least one impeller imparting radial speed to the feed material whilst it moves with axial velocity such that the feed material is spread onto the drying area adjacent the length of the at least one impeller.

Preferably, the method further comprises the step of permitting feed material to pass out along substantially the entire length of the conveyor.

Advantageously, step (4) further comprises the step of permitting fluid to pass out around substantially all of the circumference of the conveyor.

Preferably, the conveyor further comprises a chamber having an entry end for receiving feed material from a feed tube, and an exit end spaced-apart from the entry end within the conveyor, the method further comprising the step of passing the feed material through the chamber.

. Advantageously, fluid entering the chamber has an entry velocity and the fluid leaving the chamber has an exit velocity, and the method further comprises the step of ensuring that the entry velocity is greater than the exit velocity.

Preferably, the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

Advantageously, the method further comprises the step of imparting rotation to the feed material prior to the feed material passing out from the conveyor.

Preferably, the rotational speed of the feed material is increased to a speed that is at least 95%, and preferably 99%, of the speed of rotation of a pool of fluid around the conveyor.

Advantageously, the method further comprising the step of diffusing solids resident on the pool surface.

Preferably, the conveyor has a distal end smaller in diameter than a proximal end at which proximal end, in use, feed material enters the conveyor, the method further comprising the step of permitting feed material to pass out through the plurality of open areas located adjacent the distal end.

Advantageously, the method further comprises the step of selectively adjusting the speed of rotation of the conveyor relative to the housing, or the housing relative to the conveyor.

Preferably, this step is carried out by a backdrive apparatus.

Advantageously, the method further comprises the step of pneumatically powering the backdrive apparatus.

Preferably, the housing has a beach area, and the method further comprises the step of permitting feed material to pass out through the plurality of open areas located adjacent the beach area.

According to another aspect of the present invention there is provided a centrifuge for filtering feed material, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing and means that, in use, reduce the speed of feed material in the conveyor before it passes from the conveyor into an annulus between the conveyor and the rotatable housing, characterised in that, said means has an entry end and an exit end within the conveyor.

Advantageously, said means comprises a chamber within the conveyor, wherein, in use, the entry end of the chamber receives feed material from a feed tube, the feed material passing through the chamber and exiting from the exit end of the chamber.

Preferably, the shape of the chamber effects said speed reduction.

Advantageously, the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

Preferably, there is at least one impeller for increasing the radial speed of and imparting rotation to the feed material prior to the feed material flowing out from the conveyor.

Advantageously, the at least one impeller can increase the rotational speed of the feed material to a speed that is at least 95%, and preferably 99%, of the speed of rotation of a pool of feed material around the conveyor.

Preferably, the at least one impeller is a plurality of spaced-apart impellers each with a central end connected to a central nose member mounted in the conveyor. The impellers may be spaced axially along the conveyor.

In one embodiment the chamber, the central nose member, and the at least one impeller are permanently secured to the conveyor.

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

Advantageously, the centrifuge further comprises at least one pool surface solids diffuser.

In one embodiment the pool surface solids diffuser is a ring with an opening therethrough.

Preferably, the at least one pool surface solids diffuser is a plurality of spaced-apart pool surface solids diffusers.

In one embodiment the pool surface solids diffusers are spaced axially along the conveyor.

Advantageously, the conveyor has a distal end smaller in diameter than a proximal end at which proximal end, in use, feed material enters the conveyor, and at least one of the plurality of open areas is adjacent the distal end.

According to another aspect of the present invention there is provided a centrifuge for filtering feed material, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, characterised by means that, in use, imparts rotational speed to the feed material before it moves out of the conveyor.

Preferably, said means comprises at least one impeller.

Advantageously, the at least one impeller can increase the rotational speed of the feed material to a speed that is at least 95%, and preferably 99%, of the speed of rotation of a pool of feed material around the conveyor.

Preferably, the at least one impeller is a plurality of spaced-apart impellers each with a central end connected to a central nose member mounted in the conveyor. The impellers may be spaced axially along the conveyor.

In one embodiment the chamber, the central nose member, and the at least one impeller are permanently secured to the conveyor.

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

Advantageously, the centrifuge further comprises at least one pool surface solids diffuser.

Preferably, the at least one pool surface solids diffuser is a plurality of spaced-apart pool surface solids diffusers.

Advantageously, the conveyor has a distal end smaller in diameter than a proximal end at which proximal end, in use, feed material enters the conveyor, and wherein at least one of the plurality of open areas is adjacent the distal end.

Preferably, the centrifuge further comprises a chamber within the conveyor, the chamber having an entry end for receiving feed material from a feed tube, the feed material passing through the chamber and exiting from an exit end of the chamber that is spaced-apart from the entry end and within the conveyor.

Advantageously, the shape of the chamber is such that, in use, the feed material entering the chamber has an entry velocity and the feed material leaving the chamber has an exit velocity, and the entry velocity is greater than the exit velocity.

Preferably, the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

According to another aspect of the present invention there is provided a centrifuge for filtering feed material, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, characterised by means that, in use, diffuse solids residing on a surface layer of the feed material that is in an annulus between the conveyor and the rotatable housing.

According to another aspect of the present invention there is provided a centrifuge for filtering feed material, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, means for controlling the rotational speeds of the conveyor and the rotatable housing, characterised in that said means for controlling operate pneumatically.

According to another aspect of the present invention there is provided a centrifuge for filtering feed material, which centrifuge comprises a conveyor rotatably mounted in a rotatable housing, characterised by means that, in use, supply the feed material in an unfocused state from within the conveyor to an annulus between the conveyor and the rotatable housing.

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, 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.

In accordance with yet another embodiment of the present invention, there is provided a method of separating components of a feed material with a centrifuge that comprises a conveyor rotatably mounted within a housing, the conveyor comprising a substantially cylindrical outer portion and a substantially tapered outer portion, the conveyor comprising a thread and a plurality of support members defining a plurality of open areas that extend along substantially the entire length and around substantially the entire circumference of the conveyor, each support member extending along the length of both the substantially cylindrical and tapered portions, the arrangement being such that the thread and the plurality of support members define an open space within the conveyor, which method comprises the steps of: (1) rotating the housing at a first speed and the conveyor at a second speed different to the first speed;

(2) introducing the feed material into the interior of the conveyor; (3) allowing the feed material to pass from within the conveyor to an annulus between the conveyor and the housing; and (4) discharging separated components of the feed material from the housing; wherein at step (2) the feed material is fed into the space and at step (3) the feed material is caused to pass out from the conveyor through the open areas for treatment by the centrifuge.

For a better understanding of the present invention reference will no be made, by way of example, to the accompanying drawings in which:

Fig. 1 is a side cross-section of a prior art "decanting" type centrifuge;

Figs. 2A and 2B are a side view of a first embodiment of a conveyor in accordance with the present invention shown in place within a centrifuge that is shown in cross-section;

Fig. 3A is a side cross-section view of the housing of the centrifuge of Figs. 2A and 2B;

Figs. 3B and 3C are end views of the housing of Fig. 3A;

Fig. 4A is a side view of the conveyor of the centrifuge of Fig. 2A and 2B, and Fig. 4B is an end view of the conveyor of Fig. 4A;

Figs. 5A′ and 5A′′ is a side cross-section view of part of a second embodiment of a conveyor in accordance with the present invention shown in place within a centrifuge that is shown in cross-section;

Fig. 5B is a cross-section through the conveyor along line 5B-5B of Fig. 5A′; and

Fig. 5C is an enlargement of the impeller of the conveyor of Fig. 5A.

Referring to Fig. 2 a centrifuge is generally identified by reference numeral 10 and 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 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 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 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 tungsten carbide or the edges themselves may be hard-faced (as may any part of the apparatus). An end plate 43 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.

Baffles 43, 44, and 46 are attached to the rods 49. Viewed on end these baffles are similar to the section of the conveyor 40 shown in Fig. 4B. The end baffles 43, 46 and plate 47 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.

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 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 nonfocused 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 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 the beach and toward liquid outlets. Consequently, in certain embodiments according to the present invention the relative absence or diminished presence of turbulence in the pool in the bowl permits the centrifuge to be run at relatively lower speed to achieve desired separation; e.g. in certain aspects of centrifuges according to the present invention a bowl may be run at between 900 and 3500 rpm and a conveyor at between 1 and 100 rpm.

The bowl 20 has a conical or "beach" end 24 with a beach section 25. The beach section 25 may be (and, preferably, is) at an angle, in certain preferred embodiments, of between 3 and 15 degrees to the longitudinal axis of the bowl 20.

A flange 26 of the bowl 20 is secured to a bowl head 27 which has a channel 28 therethrough. A flange 29 of the bowl 20 is secured to a bowl head 30 which 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 140 (available from Roots Blowers and Compressors: see www.rootsblower.com), or other suitable pneumatic backdrive device (shown schematically in Fig. 2) connected thereto via a coupling 142 to change, via the gear system 81, the rotation speed of the shaft 32 and, therefore, of the conveyor 40. The blower 140 has an adjustable air inlet valve 144 and an adjustable air outlet valve 146 (the conveyor speed is adjustable by adjusting either or both valves). The amount of air intake by the blower 140 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) which, in one aspect includes a pneumatic pump, e.g. an adjustable positive displacement pump [e.g. air, pneumatic, (according to the present invention) or non pneumatic] connected to the shaft 82 to provide an adjustable backdrive.

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).

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 sealed by seals 102 (that retain lubricant).

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

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 also reduce bowl drag on the housing by reducing solids accumulation around solids exit points.

A feed tube 130 with a flange 147 extends through the interior of the input shaft 31. The feed tube 130 has an outlet end 131. Fluid to be treated flows into an inlet end (left side in Fig. 2) of the feed tube.

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 24. The diffusers 125 are shown in Figs. 2 and 5B. Solids may tend to move in upper layers (slurry-like material with solids therein) 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.

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.

Fig. 5A illustrates a decanting centrifuge 210 like the centrifuge 10 of Fig. 2 (and like numerals indicate the same parts). The centrifuge 210 has a feed tube 230 with an exit opening 231 from which 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 polygonal (e.g. square, triangular, rectangular in cross-section). Items 230, 240, 242 and 244 may be welded together as a unit.

The end of the feed 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 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. In one particular aspect the distance from the exit end 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. Fig. 5B illustrates (with dotted lines 125a, 125b, respectively) an outer edge and an inner edge of one of the generally circular pool surface solids diffusers.

Figs. 5B and 5C show the spaced-apart impellers 250 which are designed to radially and rotationally accelerate fluid exiting the conveyor to pool surface speed to minimize pool disturbance by such feed. In another embodiment, the chamber 240 is omitted and the impellers 250 are extended toward the end of the feed tube (to the left in Fig. 5A) and, in one such embodiment, the end of the feed tube is within the impellers. Optionally, the parts related to the internal feed chamber (including mounting plate and pipe), impellers and nose member are all removably bolted to the conveyor so that they can be replaced. Alternatively, in one aspect, they are all permanently welded in place. The same drive motor transmission, driven sheave, backdrive apparatus, bearings etc. as in Fig. 2 may be used with the centrifuge of Fig. 5A.

In a typical prior art centrifuge the ratio of the internal diameter of the exit end of the feed tube to the length of free fluid travel within the conveyor (e.g. within a prior art acceleration chamber from the feed tube exit to the far end wall of the acceleration chamber) is about 4:1 or less. In certain embodiments according to the present invention this ratio is 7:1 or greater and in other aspects it is 10:1 or greater. In one particular centrifuge according to the present invention the internal feed tube exit diameter is about 2.25 inches (0.057m) and the distance from the feed tube exit to the leading edge 252 of an impeller (as in Fig.

5A) is about 36 inches (0.91m).

Any part of a conveyor or centrifuge disclosed herein, especially parts exposed to fluid flow, may be coated with a protective coating, hardfaced, and/or covered with tungsten carbide or similar material.

A "velocity decrease" chamber or area, in certain embodiments, is, optionally, located past the nozzle (feed tube) (e.g. to the right of the interior end of the feed tube in Figs. 2A, 2B and 5A). This unobstructed area may include space within a chamber (e.g. within a solid-walled hollow member open at both ends) disposed between the feed tube exit and either conveyor fluid exit areas or a radial acceleration apparatus (e.g. impeller) within the conveyor. Fluid from the feed tube moves through a chamber that disperses flowing fluid; provides a space to allow the fluid's velocity to decrease (velocity in the general direction of the horizontal or longitudinal axis of the centrifuge); and directs fluid to impact the impellers. Different interchangeable nozzles may be used on the feed tube. The nozzle exit end may be non-centrally located within the conveyor - i.e. not on the conveyor's longitudinal axis. The chamber may be any suitable shape - e.g. but not limited to, conical, cylindrical, and/or triangular, square, rectangular, or polygonal in cross-section and any number of any known impellers, blades, or vanes may be used.

In certain embodiments fluid flows through the chamber and impacts a plurality of impellers that are connected to and rotate with the conveyor. The fluid impacts the impellers and is then moved radially outward by the blades toward the conveyor's flights. The impellers are configured and positioned to rotationally accelerate the fluid so that as the fluid passes the impellers outer edges, the fluid's rotational speed is near or at the speed of a pool of material within the bowl - thus facilitating entry of this fluid into the pool or mass of fluid already in the bowl. By reducing or eliminating the speed differential between fluid flowing from the acceleration chamber and fluid already present in the bowl, turbulence is reduced, entry of solids of the entering fluid into the pool in bowl is facilitated, and more efficient solids separation results.

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 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, feed material passes through the interior of said conveyor, rotational speed being imparted thereto by said at least one impeller prior to treatment in said separating region, and said at least one impeller spreads feed material onto said drying area, characterised in that on entry to the centrifuge said feed material has an axial velocity substantially parallel to the longitudinal axis thereof, and in that said at least one impeller imparts 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.

2. The centrifuge as claimed in claim 1, wherein the at least one impeller can increase the rotational speed of the feed material to a speed that is at least 95%, and preferably 99%, of the speed of rotation of feed material in said separating region.

3. The centrifuge as claimed in claim 1 or 2, wherein the at least one impeller is a plurality of spaced-apart impellers each with a central end connected to a central nose member mounted in the conveyor.

4. The centrifuge as claimed in claim 1, 2 or 3, wherein the or each impeller comprises a curved forward end, a portion of gradually increasing width in the direction of said axial velocity, and is of curved cross section.

5. The centrifuge as claimed in any one of claims 1 to 4, wherein the conveyor further comprises at least one pool surface solids diffuser.

6. The centrifuge as claimed in claim 5, wherein the at least one pool surface solids diffuser is a plurality of spaced-apart pool surface solids diffusers.

7. The centrifuge as claimed in any one of claims 1 to 6, the conveyor comprising a thread, a support therefor, and a plurality of open areas that (a) extend along substantially the length of the impeller or impellers and (b) through which feed material to be treated by the centrifuge can pass.

8. The centrifuge as claimed in claim 7, wherein said plurality of open areas extend along a substantial portion of the length of the conveyor.

9. The centrifuge as claimed in claim 7 or 8, wherein the plurality of open areas extends along substantially the entire length of the conveyor.

10. The centrifuge as claimed in claim 7, 8 or 9, wherein the plurality of open areas extends around substantially the entire circumference of the conveyor.

11. The centrifuge as claimed in any one of claims 1 to 10, wherein the conveyor has a distal end smaller in diameter than a proximal end at which proximal end, in use, feed material enters the conveyor, and at least one of the plurality of open areas is adjacent the distal end.

12. The centrifuge as claimed in any of claims 7 to 11, wherein the thread comprises a plurality of flight members.

13. The centrifuge as claimed in any one of claims 1 to 12, the centrifuge having a feed tube for delivering feed material into the conveyor and said at least one impeller having a forward end, wherein said feed tube

has an outlet at or within said forward end.

14. The centrifuge as claimed in any one of claims 1 to 12, further comprising a chamber within the conveyor, the chamber having an entry end for receiving feed material from a feed tube, the feed material passing through the chamber and exiting from an exit end of the chamber that is spaced-apart from the entry end and within the conveyor.

15. The centrifuge as claimed in claim 14, said at least one impeller having a forward end that abuts said exit end and that projects into said chamber.

16. The centrifuge as claimed in claim 14 or 15, wherein the shape of the chamber is such that, in use, the feed material entering the chamber has an entry velocity and the feed material leaving the chamber has an exit velocity, and the entry velocity is greater than the exit velocity.

17. The centrifuge as claimed in claim 14, 15 or 16, wherein the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

18. The centrifuge as claimed in claim 14, 15, 16 or 17, wherein a distance between said entry end and said exit end has a ratio of at least 7:1, and preferably at least 10:1, to an internal diameter of said entry end.

19. A conveyor for use with a centrifuge, which conveyor has a substantially cylindrical outer portion and a substantially tapered outer portion, the conveyor comprising a thread and a plurality of support members defining a plurality of open areas that extend along substantially the entire length and around substantially the entire circumference of the conveyor, each support member extending along the length of both said substantially cylindrical and tapered portions, the arrangement being such that said thread and said plurality of support members define an open space within the conveyor that, in use, receives feed

material and from which the feed material passes out through said open areas to be treated by the centrifuge.

20. The conveyor as claimed in claim 19, further comprising at least one impeller, 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, and in that said at least one impeller imparts radial speed to said feed material whilst it moves with axial velocity so as to cause the feed material to pass out through open areas adjacent said at least one impeller.

21. The conveyor as claimed in claim 20, wherein said at least one impeller is mounted on said conveyor so as to deliver feed material to a drying area in a bowl of the centrifuge.

22. The conveyor as claimed in claim 21, wherein said at least one impeller spreads said feed material over the length of said drying area and around a circumference of that part of said bowl forming said drying area.

23. A method of separating feed material into solid and fluid parts with a centrifuge comprising a conveyor rotatably mounted within a housing, which method comprises the steps of:

(1) rotating the housing at a first speed and the conveyor at a second speed different to said first speed;

(2) introducing feed material into the interior of the conveyor;

(3) imparting rotational speed to the feed material with at least one impeller prior to treatment in a separating region that comprises a pool area and a drying area between the conveyor and the housing; and

(4) spreading feed material onto said drying area with the at least one impeller;

characterised in that step (2) is performed so that feed material has an axial velocity substantially parallel to the longitudinal axis of the centrifuge and in that step (4) is performed by said at least one impeller imparting radial speed to said feed material whilst it moves with axial velocity such that the feed material is spread onto the drying area adjacent the length of the at least one impeller.

24. The method as claimed in claim 23, wherein the rotational speed of the feed material is increased to a speed that is at least 95%, and preferably 99%, of the speed of rotation of feed material in said separating region.

25. The method as claimed in claim 23 or 24, further comprising the step of diffusing solids resident on the pool surface.

26. The method as claimed in claim 23, 24 or 25, wherein at step (4) the feed material can pass out from the conveyor through a plurality of open areas that are spaced axially along substantially the length of the at least one impeller.

27. The method as claimed in claim 26, further comprising the step of permitting feed material to pass out along at least a substantial portion of the length conveyor.

28. The method as claimed in claim 26 or 27, further comprising the step of permitting feed material to pass out along substantially the entire length of the conveyor.

29. The method as claimed in claim 26, 27 or 28, wherein step (4) further comprises the step of permitting fluid to pass out around substantially the entire circumference of the conveyor.

30. The method as claimed in any one of claims 23 to 29, wherein the conveyor has a distal end smaller in diameter than a proximal end at which, in use, feed material

enters the conveyor, the method further comprising the step of permitting feed material to pass out through the plurality of open areas located adjacent the distal end.

31. The method as claimed in any one of claims 23 to 30, the centrifuge having a feed tube for delivering feed material into the conveyor and said at least one impeller having a forward end, further comprising the step of delivering said feed material through an outlet of said feed tube that is at or within said forward end.

32. The method as claimed in any one of claims 23 to 31, wherein the conveyor further comprises a chamber having an entry end for receiving feed material from a feed tube, and an exit end spaced-apart from the entry end within the conveyor, the method further comprising the step of passing the feed material through the chamber.

33. The method as claimed in claim 23, wherein the fluid entering the chamber has an entry velocity and the fluid leaving the chamber has an exit velocity, the method further comprising the step of ensuring that the entry velocity is greater than the exit velocity.

34. The method as claimed in claim 32 or 33, wherein the chamber is substantially conical in shape with the entry end smaller in diameter than the exit end.

35. A method of separating components of a feed material with a centrifuge that comprises a conveyor rotatably mounted within a housing, said conveyor comprising a substantially cylindrical outer portion and a substantially tapered outer portion, the conveyor comprising a thread and a plurality of support members defining a plurality of open areas that extend along substantially the entire length and around substantially the entire circumference of the conveyor, each support member extending along the length of both said substantially cylindrical and

tapered portions, the arrangement being such that said thread and said plurality of support members define an open space within the conveyor, which method comprises the steps of:

(1) rotating the housing at a first speed and the conveyor at a second speed different to said first speed;

(2) introducing the feed material into the interior of the conveyor;

(3) allowing the feed material to pass from within the conveyor to an annulus between the conveyor and the housing; and

(4) discharging separated components of the feed material from the housing;

wherein at step (2) the feed material is fed into said space and at step (3) the feed material is caused to pass out from the conveyor through the open areas for treatment by the centrifuge.

36. The method as claimed in claim 35, the centrifuge having at least one impeller, the method further comprising the step of introducing the feed material into the centrifuge such that it has an axial velocity substantially parallel to the longitudinal axis thereof, and imparting radial speed to said feed material whilst it moves with axial velocity so as to cause the feed material to pass out through open areas adjacent said at least one impeller.

37. The method as claimed in claim 35 or 36, further comprising the step of delivering feed material to a drying area in a bowl of the centrifuge.

38. The method as claimed in claim 37, further comprising the step of spreading said feed material over the length of said drying area and around a circumference of said bowl forming said drying area.

39. The method as claimed in any one of claims 23 to

38, wherein said feed material is a mixture of drilling solids and drilling mud, and the method further comprises the steps of substantially separating said drilling solids from said drilling mud.

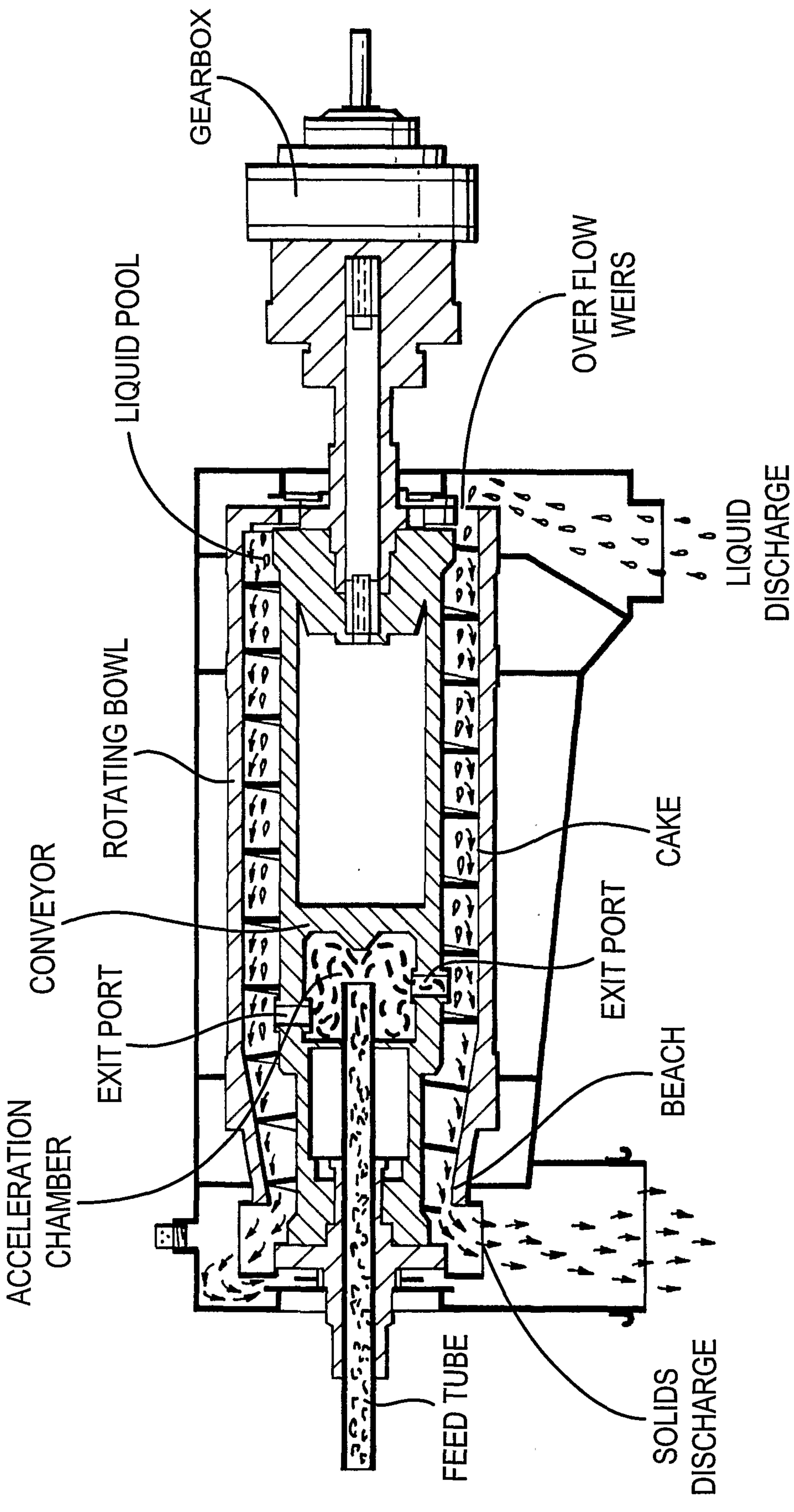


Fig.1 PRIOR ART

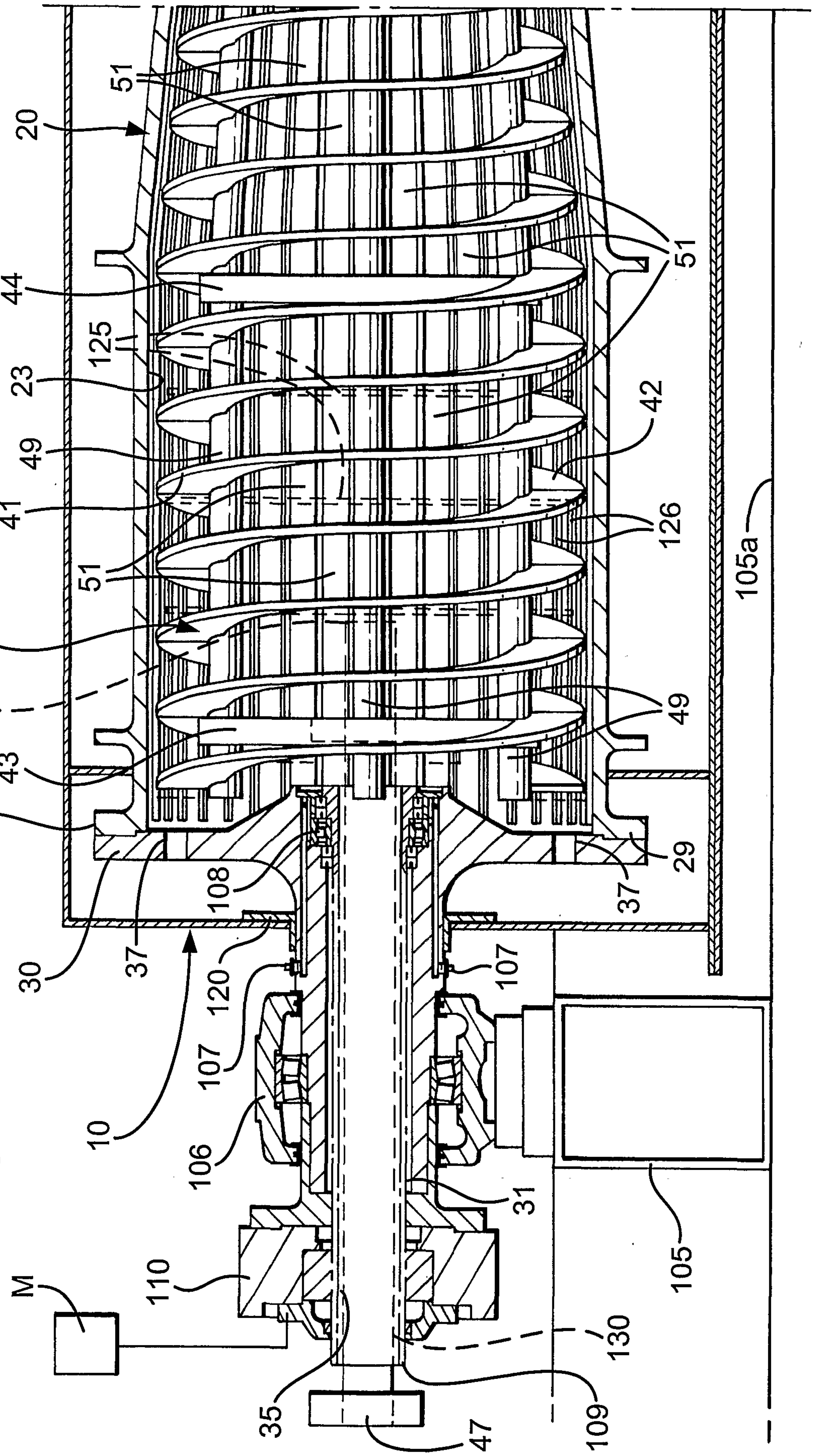

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Fig.2A

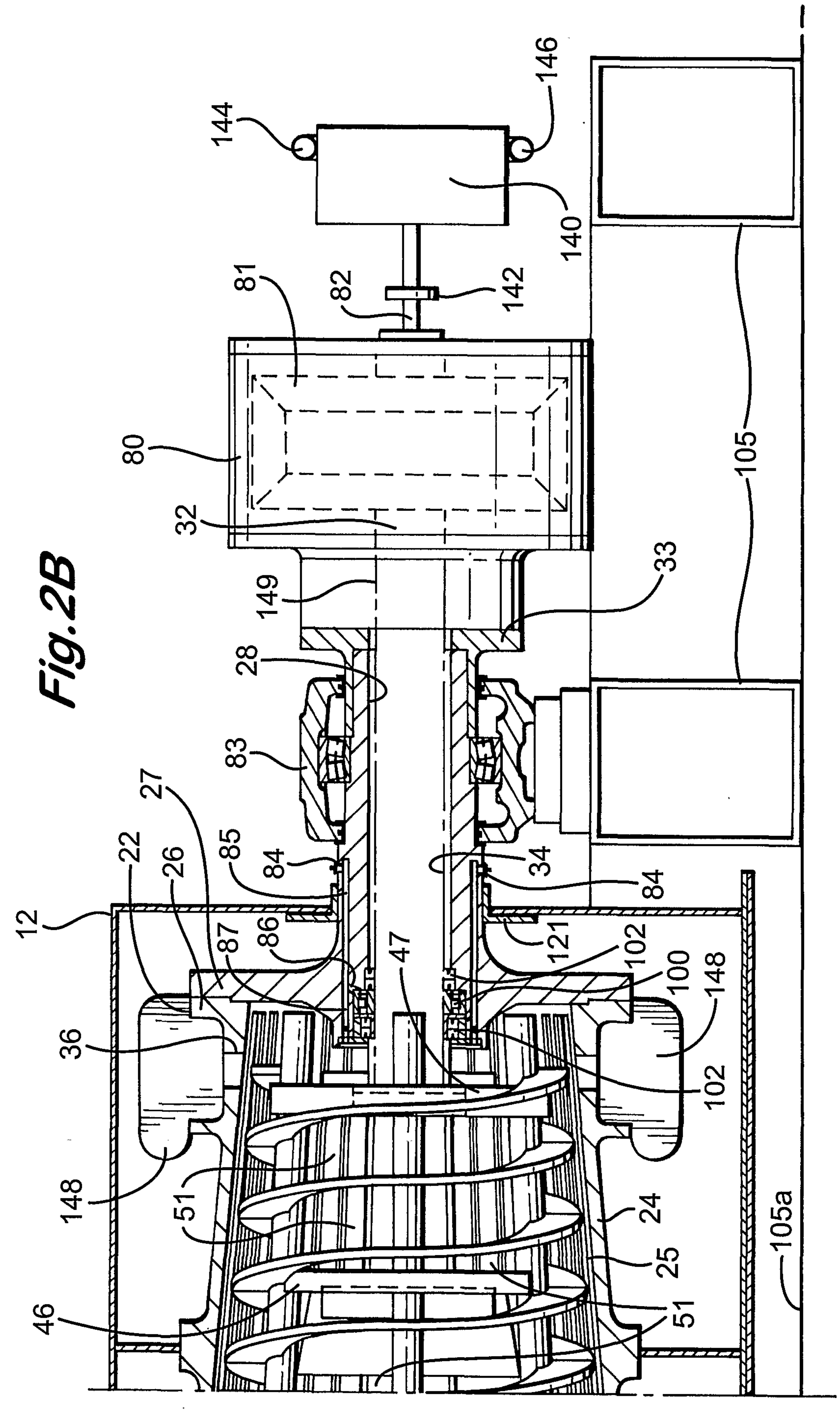
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Fig.2B

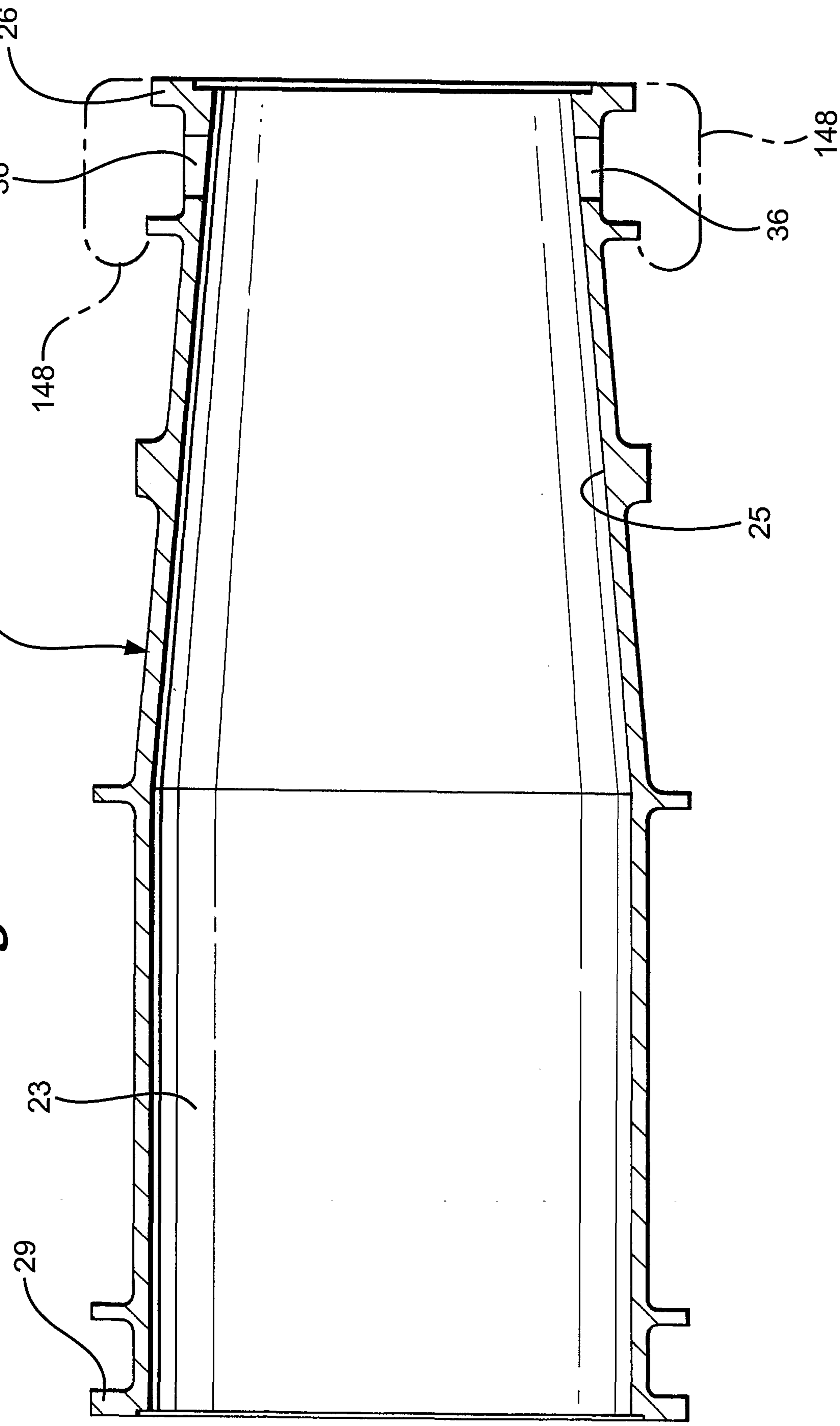


Fig.3A

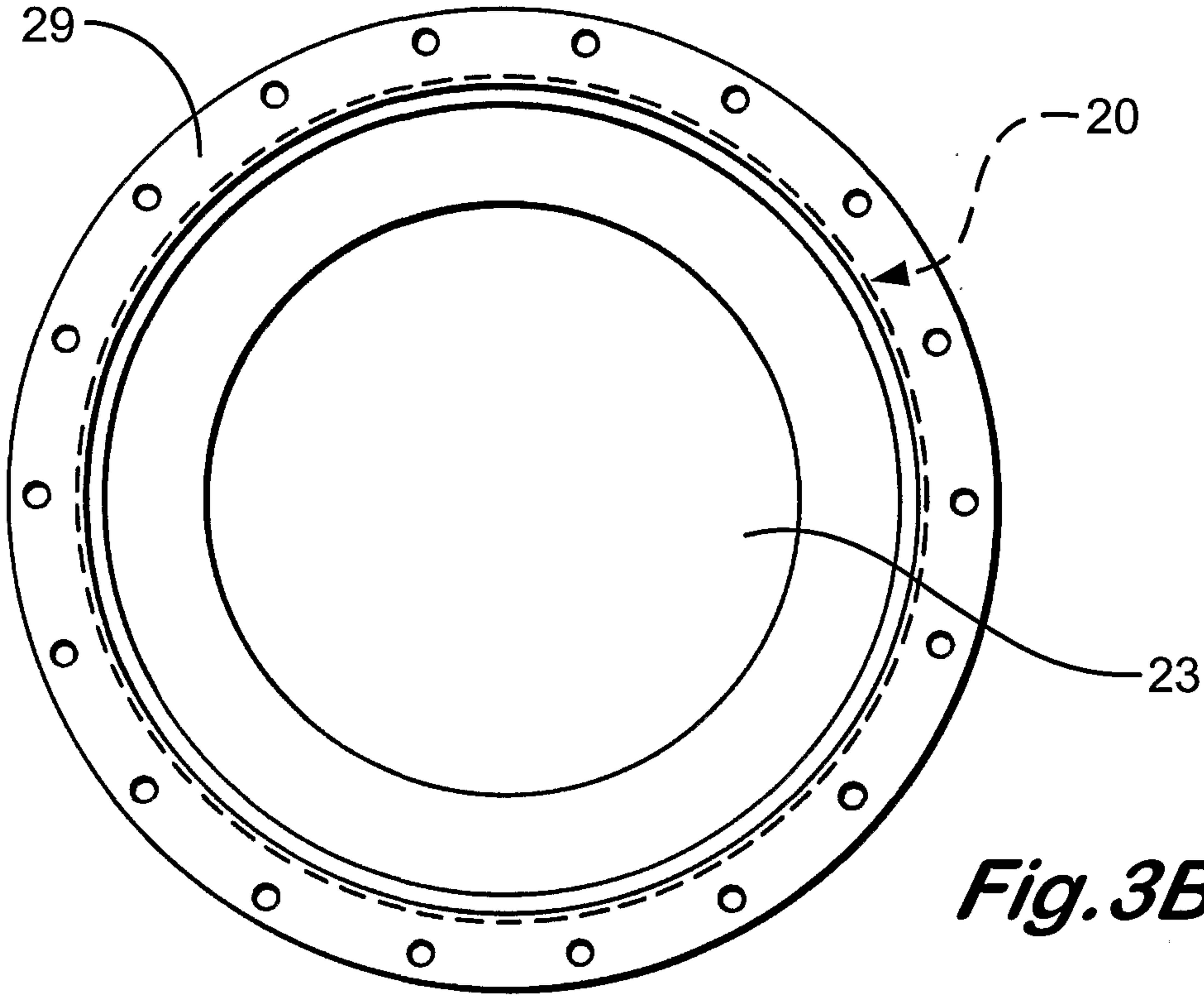


Fig.3B

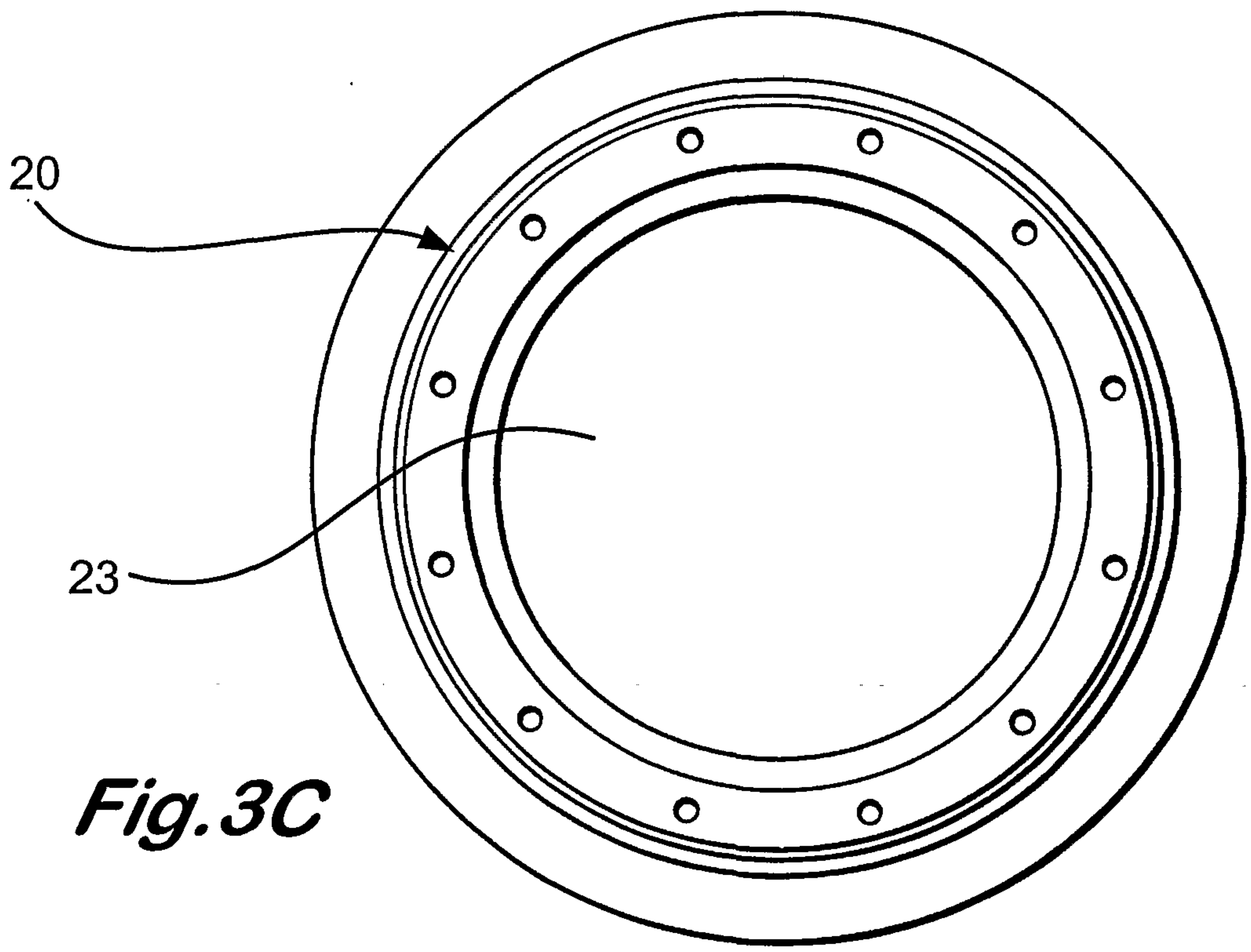
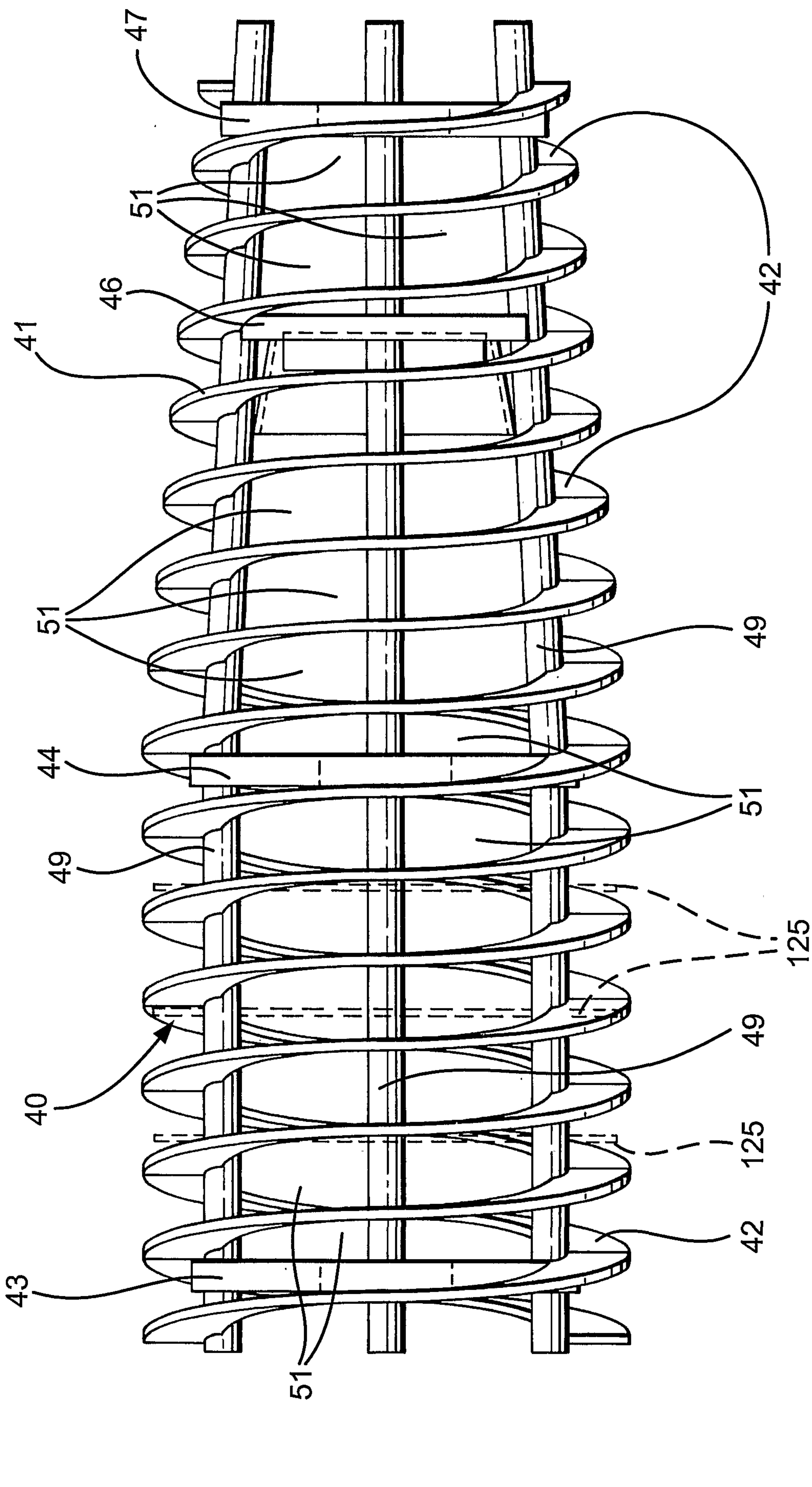


Fig.3C

Fig.4A



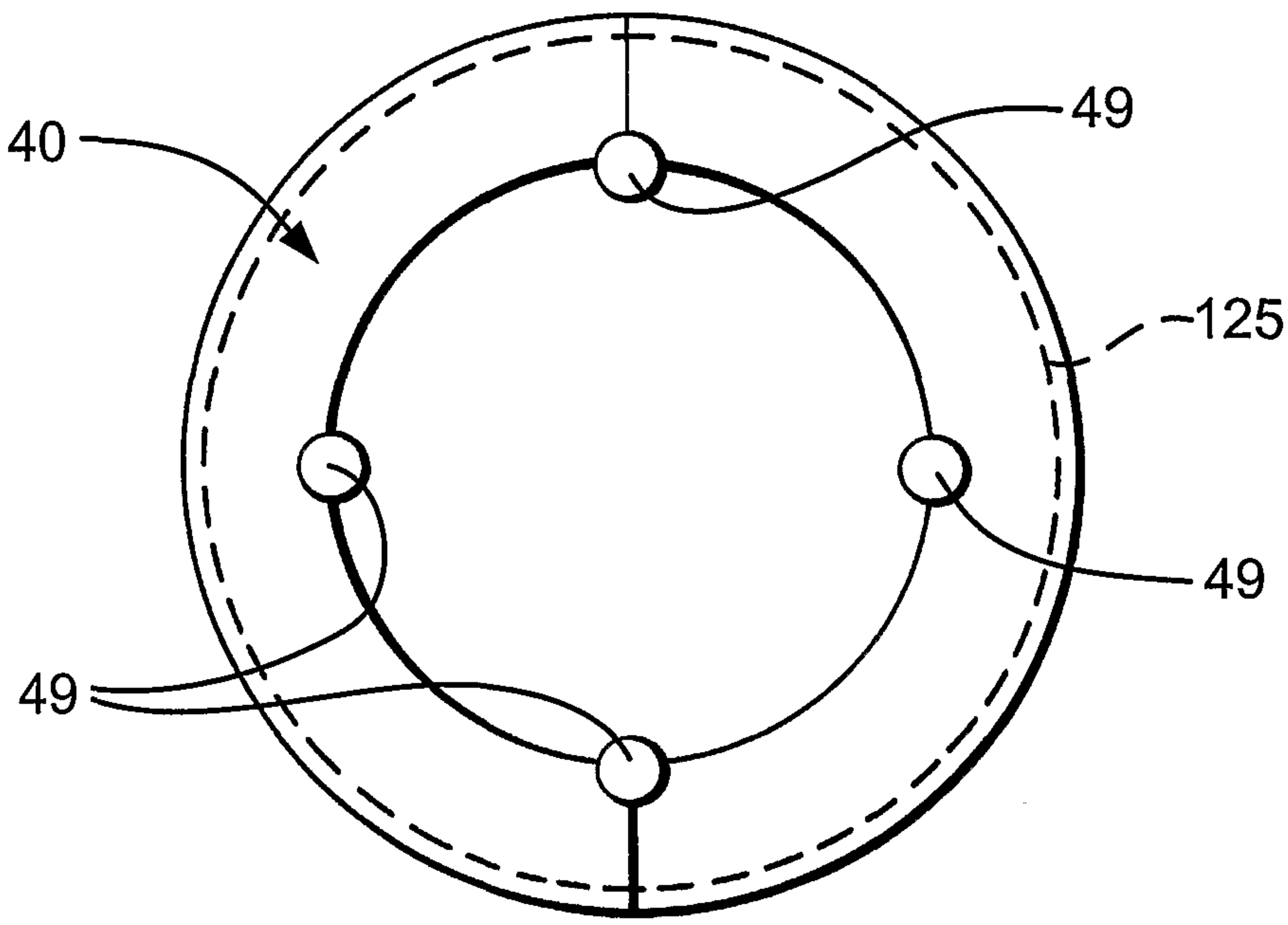


Fig.4B

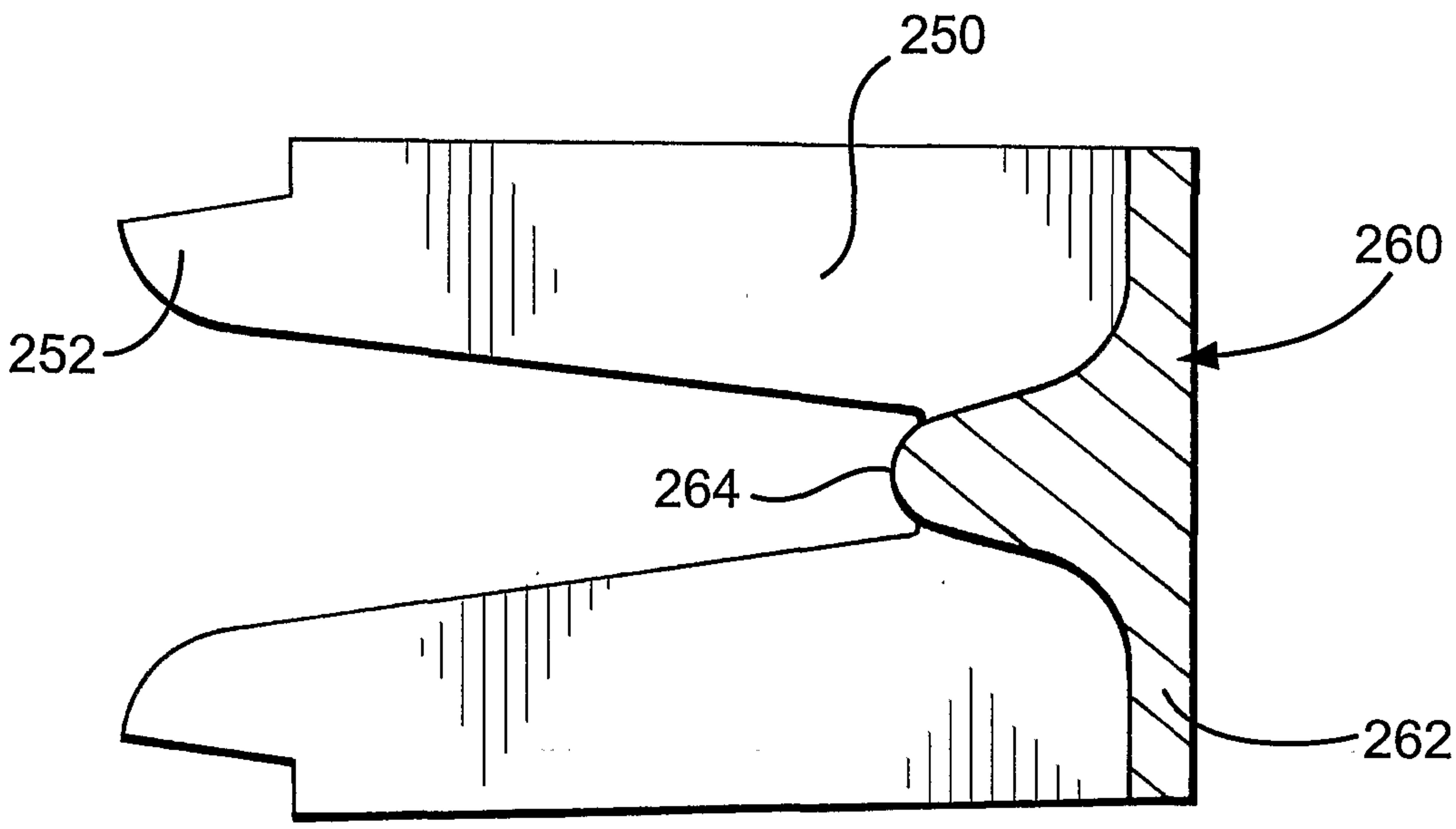


Fig.5C

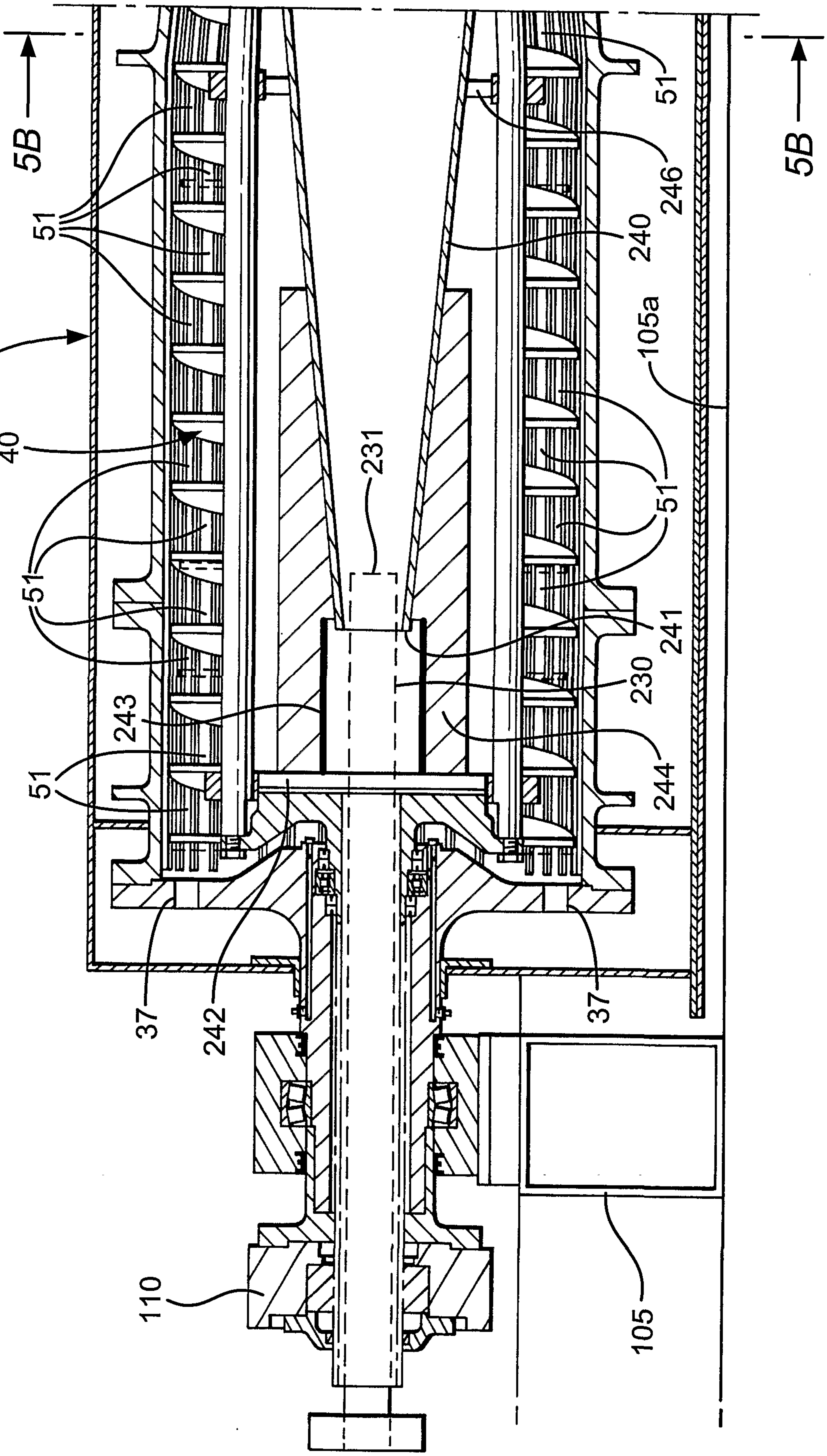

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Fig.5A

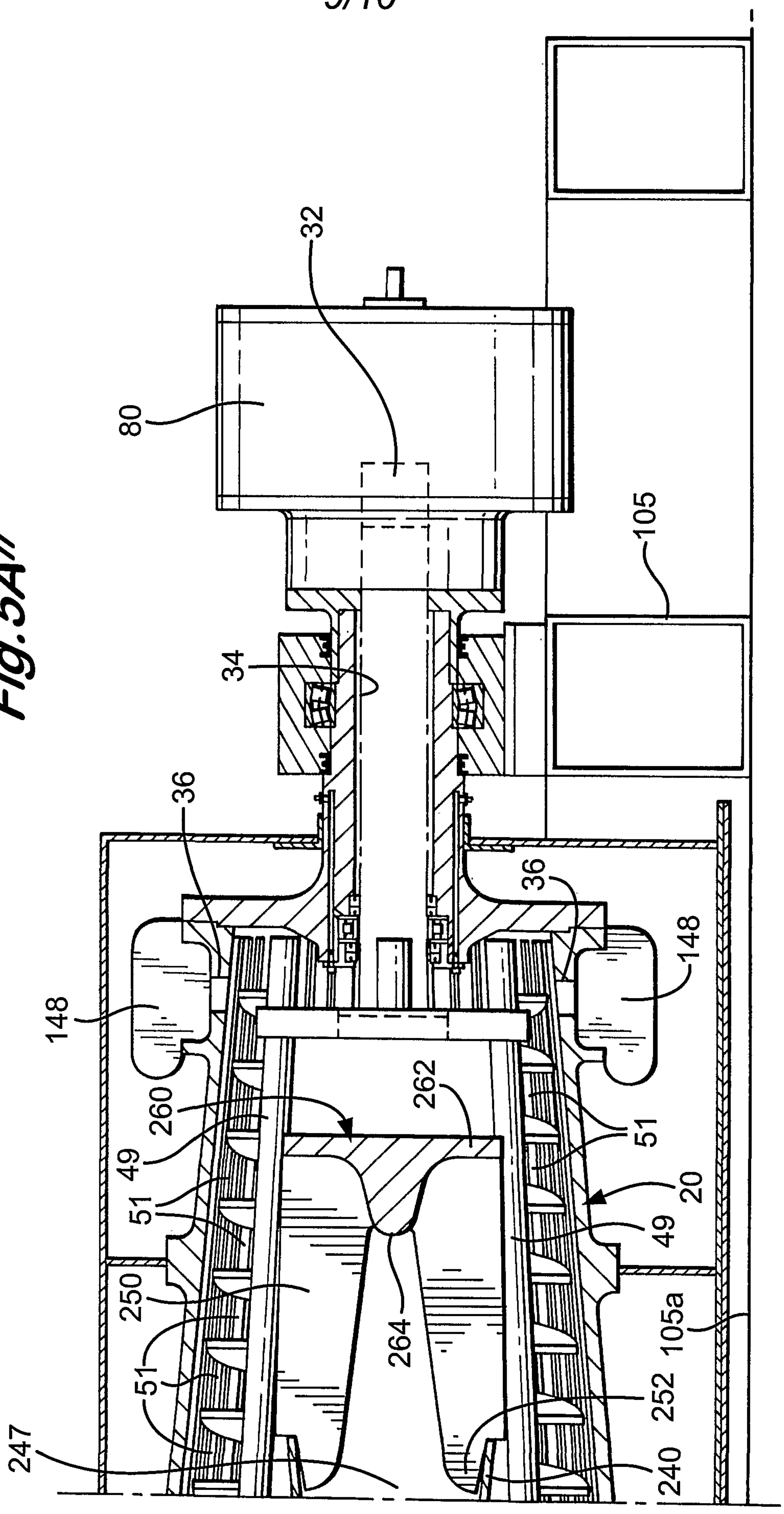
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Fig.5A//

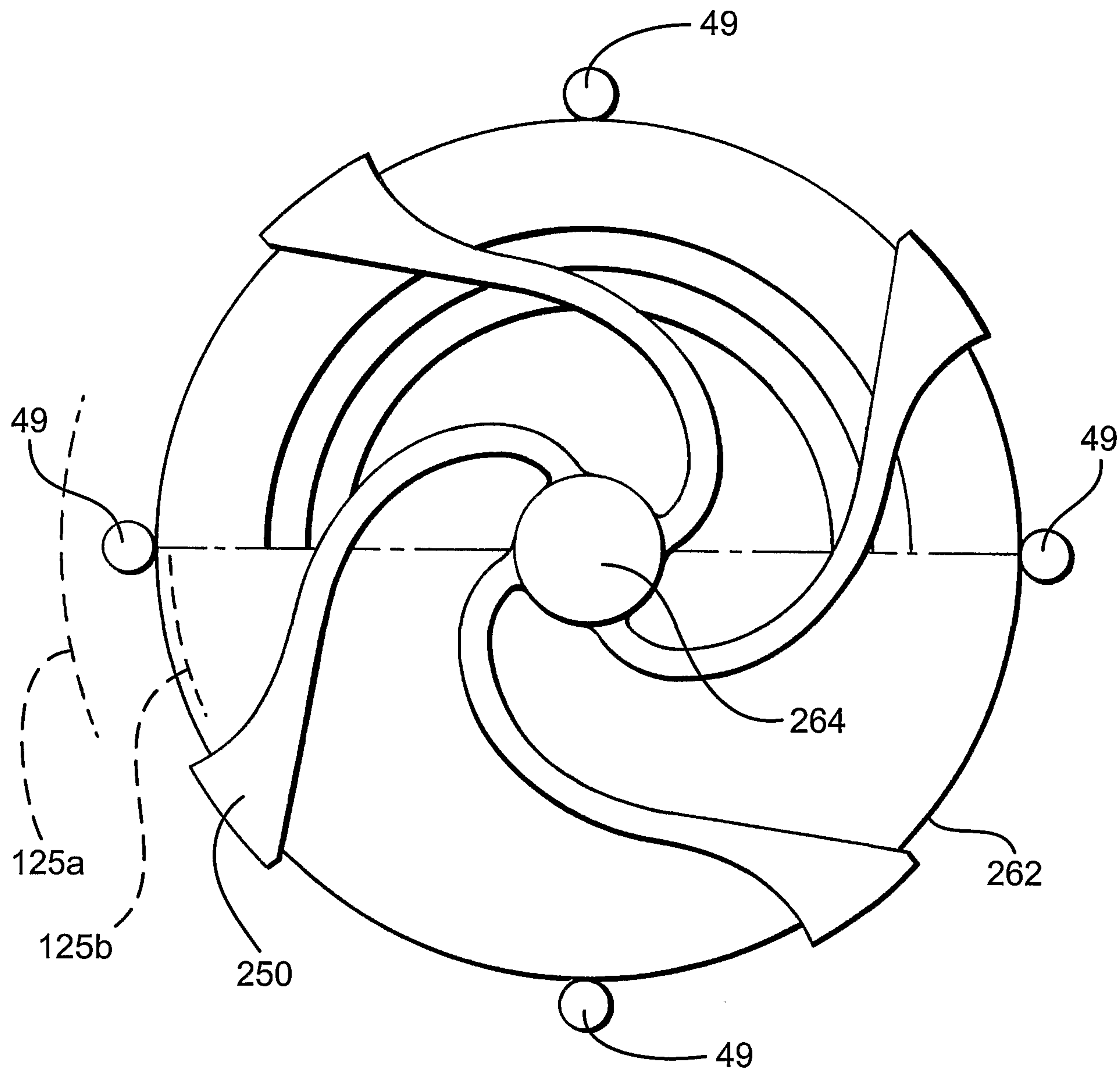
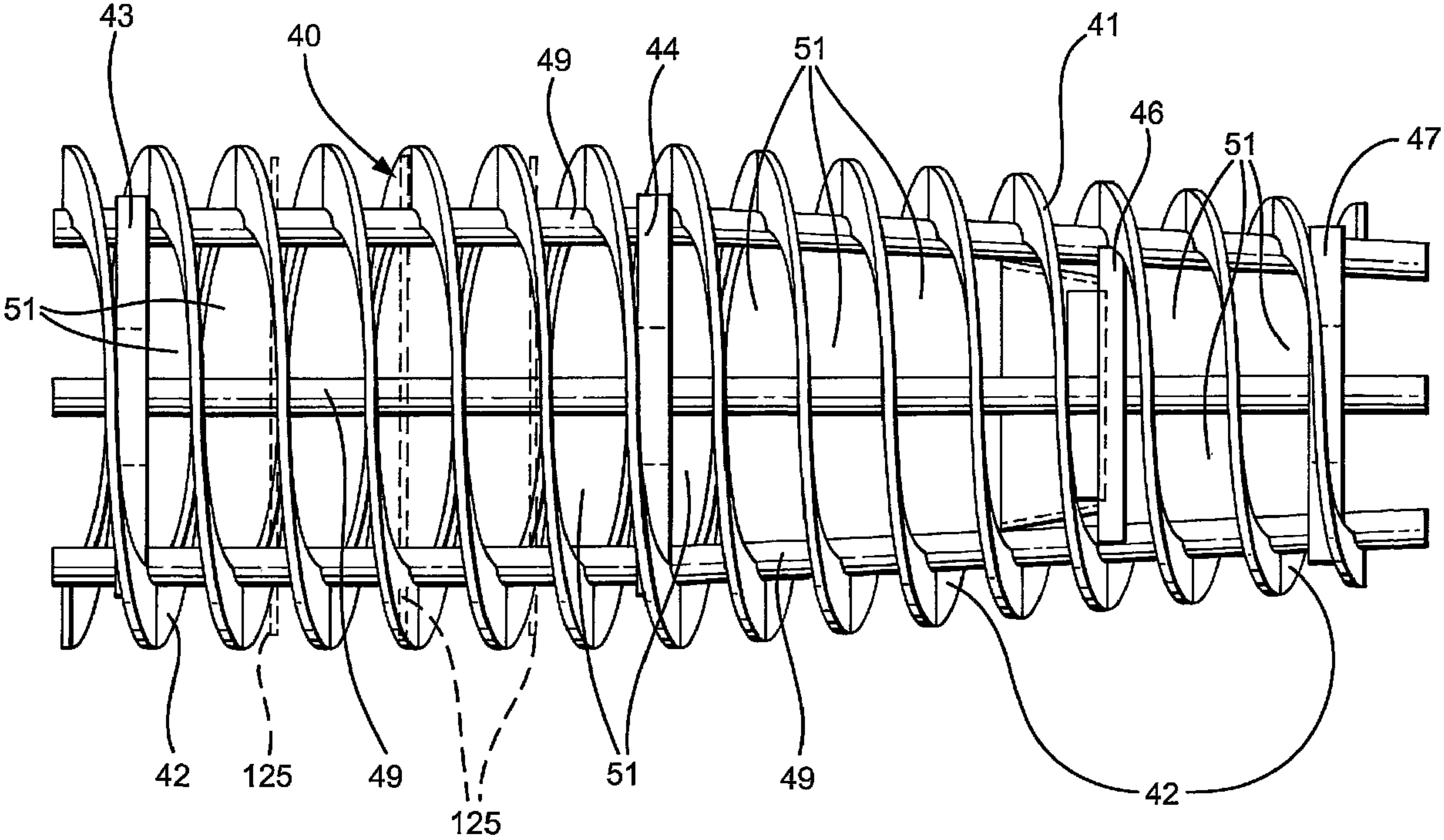


Fig.5B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