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### (54) A DECANTER CENTRIFUGE FOR SEPARATING FEED MATERIAL

(57) The present invention relates to a conveyor screw for a decanter centrifuge. The conveyor screw comprises a central body extending in a longitudinal direction. The central body comprises a first bearing surface at a first end of the central body and a second bearing surface at a second end of the central body. The second end being opposite the first end. The central body further defines a cylindrical portion adjacent the first

bearing surface and a conical portion adjacent the second bearing surface. The conveyor screw further comprises a screw thread being attached to the central body. The screw thread extends in the longitudinal direction and defines an outer perimeter extending circumferentially about the cylindrical portion. The central body being free from any fluid openings between the first bearing surface and the second bearing surface.

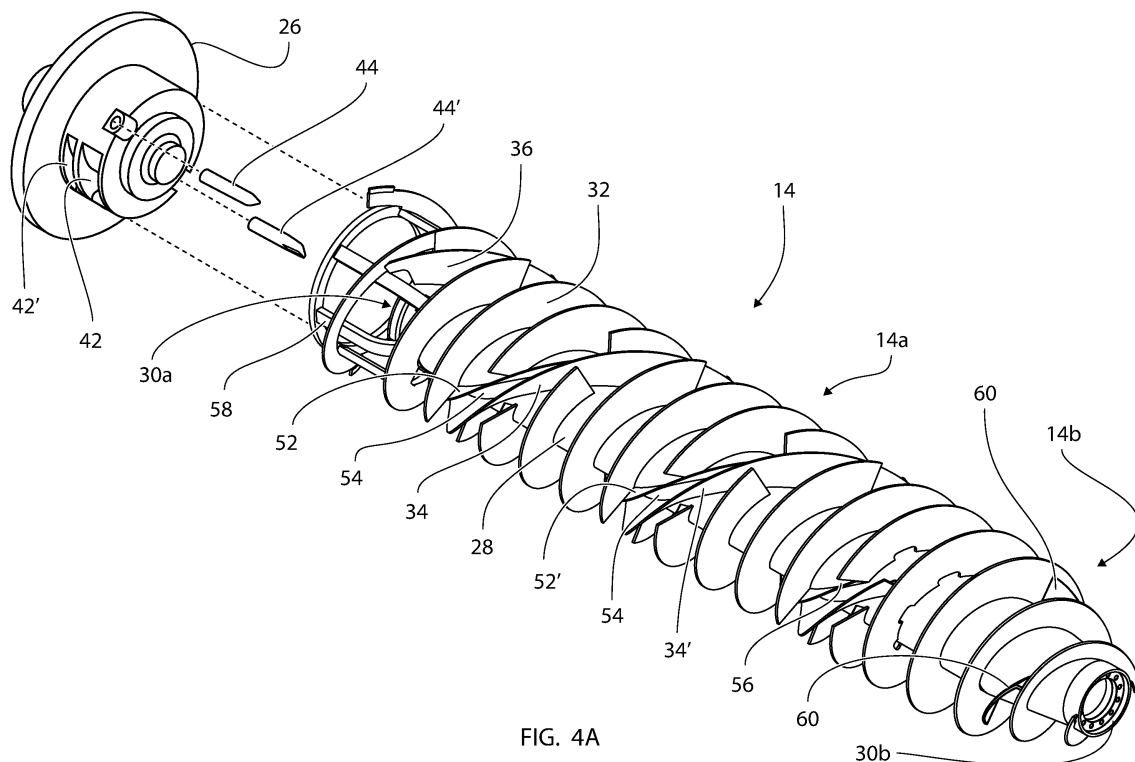


FIG. 4A

## Description

**[0001]** The present invention relates to a conveyor screw for a decanter centrifuge, a decanter centrifuge and a method of operating a decanter centrifuge.

### Introduction

**[0002]** Centrifugal based methods are often preferred when extracting oil from oil containing plant- or animal items. Thereby, the oil is separated from the residual solids and liquids, preferably by using a decanter centrifuge. In most conventional applications of oil extraction, such as vegetable oil extraction, the solids are removed in a first separation stage and the oil is removed in a second separation stage after the solids have been removed. By doing so, some oil or fat will inevitably be trapped in the compacted solids cake. This oil is considered to be lost as it is not easily recoverable even by resuspension of the solids.

**[0003]** In particular, in relation to the fermentation of ethanol from corn, the byproduct from the fermentation It has therefore been suggested to remove the oil already in the first separation stage using a two-phase decanter and leaving a residue of solids and liquids. In this way a higher oil yield and a cleaner oil can be obtained.

**[0004]** WO 2010/142299 A1 relates to a decanter centrifuge having a conveyor hub with a tubular steel body with an inner core made of a material such as carbon fibre reinforced epoxy.

**[0005]** WO 2020/109135 A1 relates to a method of producing a low-fat product from a starting material made of a fat and/or oil containing plant- or animal item. The method comprises extracting a greater part of the extractable oil and/or fat originally contained in the plant- or animal item using a first decanter and leaving a residue of solids and liquids.

**[0006]** US 7156801 relates to a decanter centrifuge comprising a conveyor screw with one or more flights and having a nominal transport speed varying along the longitudinal axis. The nominal transport speed depends in a non-linear way on the screw pitch.

**[0007]** DE 102019102623 describes a centrifugal decanter for products that are difficult to de-oil, such as olive pulp, must be mixed particularly intensively so that all or even a residual liquid/residual moisture that is still contained in the solid can be separated more easily. The screw used having two radially offset helices extending over the cylindrical region of the drum and the worm with the same or different winding directions and/or different pitches, so that a radially outer first screw thread and a radially inner second screw thread are formed, so that a part of the suspension to be processed when the drum and screw rotates through the second radially - in relation to the axis of rotation - further inward helix or in conveyed in the radially inner screw flight in a different direction and/or in the same direction and/or at a different speed than at the same time another part of the suspension that

is located in the area of the radially further outer helix or the radially outer screw flight.

**[0008]** US 20150209804 describes an apparatus comprising an outer drum, an inner drum, an activation spiral and a heavy-material discharging spiral.

**[0009]** EP 0868217 discloses a decanter centrifuge having several blades arranged to convey axially in the outer drum sludge having settled on the inside of this drum.

**[0010]** EP 2130607 B1 relates to a decanter centrifuge having the inlet arranged at an end of the casing opposite the end in which the opening for expelling the solid phase is arranged.

**[0011]** DE 2651657 relates to a centrifugal decanter having a clear fluid discharge between the inlet and the solids outlet.

**[0012]** US 3268159 relates to a centrifugal decanter in which the feed zone is closer to large end hub than both conveyor bearings.

**[0013]** JP 62106856 relates to a centrifugal decanter in which the solids and liquids discharge are on the same side.

**[0014]** US 3494472 relates to a centrifugal separator in the form of a sieve drum.

**[0015]** US 7022061 describes a centrifugal separator with power recovery discharge pipes for the light phase.

**[0016]** US 9089852 describes a centrifugal decanter mentioning that the solid discharge port may be oriented at an angle to the radial to achieve an energy-saving repulse effect

WO 2012/062337 A2 relates to a centrifugal separator comprising an outlet housing being rotatable around an adjustment axis.

**[0017]** DE 10 2020 129 478 A1 relates to a conveyor screw body having web elements.

**[0018]** EP 0506835 B1 relates to a decanter centrifuge having at least one bearing of the conveyor supported at the free end of a trunnion.

**[0019]** EP 0602766 B1 relates to a decanter centrifuge having a central hub having radially projecting support ribs.

**[0020]** EP 2440335 A1 relates to a decanter centrifuge having conveyor screw comprising a hub with a cylindrical part and a generally conical part, the two parts being interconnected by broad mutually spaced ribs extending in the longitudinal direction.

**[0021]** EP 2926911 B1 relates to a decanter centrifuge having a centrifuge worm which is mounted at one of its axial end areas by means of a connecting flange.

**[0022]** EP 3177403 B1 relates to a decanter centrifuge having individual openings in the cylindrical section of the screw hub.

**[0023]** WO 2021122878A1 relates to a decanter centrifuge having, at least in the inlet area, a screw hub with an open wall structure.

**[0024]** WO 2021122884A1 relates to a decanter centrifuge having a transverse disk for stabilizing the worm hub construction.

**[0025]** WO 2022096734A1 relates to a centrifuge screw having rods between at least two winding sections. The rods are formed completely or almost completely spaced.

**[0026]** WO 2022096739A1 relates to a screw hub for a centrifuge screw having in the longitudinal direction having at least sections of an open wall structure.

**[0027]** WO 2022096745A1 relates to a centrifuge screw having an open wall structure. The open wall structure extending at most over a length of 50% of the total length of the cylindrical longitudinal section.

**[0028]** US 8841469 relates to a method of recovering oil from corn by adding a chemical additive.

**[0029]** When separating the oil and fat already in the first separation stage, it is necessary to allow the solids sufficient time to release the oil/fat. To be able to efficiently release the oil, a long retention time of the feed material inside the decanter centrifuge is required. To allow a long retention time while maintaining the flow speed through the decanter, it may be necessary to make the bowl of the decanter centrifuge longer. When making the bowl longer, the conveyor screw must be longer as well.

**[0030]** There is a tendency for the conveyor screw to deflect and bend during use. This is due to vibrations induced into the conveyor screw by the rotation of the conveyor screw and the bowl. The vibrations induced by the rotation of the conveyor screw has a frequency corresponding to the rotation of the conveyor, i.e. a higher rotational speed of the conveyor screw will induce a higher frequency vibration into the conveyor screw. To avoid resonance effects in the conveyor screw, it must be ensured that the frequency of the vibrations due to the rotation of the conveyor screw will not be at or near the eigenfrequency of the conveyor screw. Resonance effects in the conveyor screw may cause excessive bending stress on the conveyor screw. This problem increases for longer conveyor screws, where the distance between the conveyor bearings is longer, since the bending rigidity decreases when the length of the conveyor screw increases. As the bending rigidity decreases, the eigenfrequency of the conveyor screw decreases, thus the eigenfrequency decreases with increasing length of the conveyor screw. Thus, when the conveyor screw is made longer, it must be made more rigid to maintain the same rotational speed.

**[0031]** It is therefore an object of the present invention to provide technologies for allowing a longer conveyor screw to maintain the eigenfrequency when the conveyor screw increases in length.

#### Summary of the invention

**[0032]** The object of the present invention is according to a first aspect achieved by a conveyor screw for a decanter centrifuge, the conveyor screw comprising a central body extending in a longitudinal direction, the central body comprising a first bearing surface at a first

end of the central body and a second bearing surface at a second end of the central body, the second end being opposite the first end, the central body further defining a cylindrical portion adjacent the first bearing surface and a conical portion adjacent the second bearing surface, the conveyor screw further comprising a screw thread being attached to the central body, the screw thread extending in the longitudinal direction and defining an outer perimeter extending circumferentially about the cylindrical portion, the central body being free from any fluid openings between the first bearing surface and the second bearing surface.

**[0033]** The conveyor screw is used in a bowl of a decanter centrifuge to convey a slurry being a mixture of the solids and the water towards the heavy phase outlet. It rotates at a differential speed relative to the bowl for the thread to impose a conveying action on the slurry. The heavy phase outlet is located at a conical portion of the bowl. The bearing surfaces of the conveyor screw are located at opposite ends of the central body. There is typically a drive and a gearbox at one of the bearings for rotating the conveyor screw. During operation, the drive applies a torque onto the central body causing the conveyor screw to rotate.

**[0034]** It has been noted that the typical conveyor screws used in standard decanter centrifuges accommodates a feed passage along the axis of the central body and at least one fluid opening along the axial direction for introducing the flowable feed material to be separated into the decanter centrifuge. However, this imposes structural limitations to the conveyor screw and decreases the rigidity of the conveyor screw as the fluid opening constitutes a void which limits the stiffness of the conveyor screw. The fluid opening is typically located near the middle of the central body along the axial direction which further decreases the bending rigidity of the overall structure. Further, the feed passage inside the conveyor screw limits the use of reinforcing structures inside the conveyor screw for increasing the bending rigidity.

**[0035]** In addition to the length of the conveyor screw, the stiffness of the conveyor screw also depends on the diameter of the central body. An increased diameter of the central body will increase the stiffness of the conveyor screw. Consequently, the length of the central body can be increased if the diameter of the central body increases. However, an increased diameter of the central body will reduce the available process volume between the conveyor hub and the bowl wall and the retention time of the process media will be reduced and the oil extraction will be compromised.

**[0036]** The presence of openings in the central body lowers the stiffness of the conveyor screw which lowers the natural frequency, also known as the eigenfrequency, of the conveyor screw. Further, making the central body longer will lower the natural frequency of the conveyor screw. Operating a long conveyor screw at high rotational speeds near the natural frequency of the conveyor screw

may cause harmful vibrations that may cause the conveyor screw to fail. This also limits the length of the conveyor screw when operating at high speeds.

**[0037]** However, keeping the central body of decanter centrifuge free from openings between the first bearing surface and the second bearing surface will increase the stiffness and structural stability of the conveyor screw compared to having fluid openings in the central body. This allows the conveyor screw to be longer. The fluid inlet is then preferably moved to the large end hub of the decanter centrifuge.

**[0038]** According to a further embodiment of the first aspect, the central body being free from any openings between the first bearing surface and a second bearing surface.

**[0039]** Preferably, there are no openings at all between the first bearing surface and a second bearing surface as any opening will constitute a void which limits the stiffness of the conveyor screw.

**[0040]** According to a further embodiment of the first aspect, the conveyor screw comprises a cage structure extending from the central body at the first bearing surface in a direction away from the second bearing surface, the screw thread being at least partially attached to the cage structure.

**[0041]** In this way the bearing surface can be moved inside the bowl while allowing the first screw to extend behind the bearing.

**[0042]** According to a further embodiment of the first aspect, the cage structure part comprises an inner ring attached to the central body, and outer ring and a plurality of ribs interconnecting the inner ring and the outer ring.

**[0043]** In this embodiment of the cage structure the screw thread can be attached onto the ribs while the inner and outer ring keeps the structural stability of the cage structure.

**[0044]** According to a further embodiment of the first aspect, the central body defines a cylinder at the cylindrical portion and a truncated cone at the conical portion.

**[0045]** The cylinder and the truncated cone extend along the longitudinal direction. The screw thread follows the outline of the central body.

**[0046]** According to a further embodiment of the first aspect, the outer perimeter of the screw thread defines a diameter and the screw thread defines a length in the longitudinal direction, the ratio between the diameter and the length exceeding 3.9, preferably exceeding 4.2, more preferably exceeding 4.5, most preferably exceeding 4.9.

**[0047]** As the stiffness of the conveyor screw increases with the diameter of the central body while decreasing with the length of the central body, a ratio between the diameter and the length of the central part can be established. For simplicity, the ratio is established between the outer perimeter of the screw thread instead of the diameter of the central body. Typical limits for maintaining sufficient stiffness for decanter centrifuges having a fluid opening in the central body is about 4. However, a higher ratio exceeding 4.2 is possible provided no fluid opening

is provided in the central body. Such as a ratio exceeding 4.5 or 4.9.

**[0048]** According to a further embodiment of the first aspect, the diameter is exceeding 640mm, preferably exceeding 670mm, more preferably exceeding 700mm, most preferably exceeding 715mm.

**[0049]** According to a further embodiment of the first aspect, the central body defines a hollow interior which is at least partially reinforced by a reinforcing material extending at least half the distance between the first bearing surface and the second bearing surface, the reinforcing material preferably being fibre reinforced epoxy.

**[0050]** A hollow and fibre reinforced central body will allow the conveyor screw to be lighter and longer while maintaining the stiffness and structural stability of the conveyor screw.

**[0051]** According to a further embodiment of the first aspect, the screw thread comprising:

a first flight being attached to the central body and extending in the longitudinal direction, the first flight defining a first outer perimeter extending circumferentially about the cylindrical portion of the conveyor screw, the first outer perimeter defining a first diameter, the first flight defining a first pitch angle at the cylindrical portion of the conveyor screw, the first pitch angle being less than 20°, and,

a second flight being attached to the central body, extending in the longitudinal direction, having the same winding direction as the first flight and being at least partially intertwined with the first flight, the second flight defining a second outer perimeter extending circumferentially about the cylindrical portion of the conveyor screw, the second outer perimeter defining a second diameter, the second flight defining a second pitch angle at the cylindrical portion of the conveyor screw, the second pitch angle being greater than 30°, and the second diameter being smaller than the first diameter. The pitch angle is here calculated by the expression:  $\text{Pitch angle} = \text{ATAN}(\text{Pitch}/(\pi \cdot (\text{Bowl diameter})))$

**[0052]** It has been surprisingly found out that the combination of the longitudinal conveying of the slurry by the first flight and the spreading-out effect on the slurry achieved by the second flight increases the amount of oil released from the solids. As the oil has a lower density than the slurry, the oil will accumulate near the central body and can be collected at the light phase outlet.

**[0053]** In the present context, a flight is understood to be a plate welded radially to the central body of the conveyor screw to provide the conveying surface of the conveyor screw.

**[0054]** According to a further embodiment of the first aspect, the conveyor screw further defining a third flight extending parallel with the second flight, the second flight extending to the second outer perimeter whereas the third flight extending to a third outer perimeter, the second

flight and the third flight defining an oil channel between themselves, the oil channel defining a width between the second flight and the third flight being less than the distance between the central body and the second outer perimeter.

**[0055]** To collect the oil more easily, the second flight and the third flight are formed as two parallel flights as described above. The second flight will spread out the solids and the third flight will collect the oil. The oil will flow towards the light phase outlet in the channel between the second flight and the third flights.

**[0056]** According to a further embodiment of the first aspect, the third outer perimeter defining a third diameter, the third diameter being smaller than the second diameter.

**[0057]** In this way it is ensured that the oil is collected in the oil channel but not the water as the oil is lighter and will flow closer to the central body and the water will flow between the oil and the slurry due to the centrifugal forces.

**[0058]** According to a further embodiment of the first aspect, the second flight passes through gaps in the first flight.

**[0059]** In this way the first flight and the second flight can be intertwined with minimal interruption of the first flight. This will allow the conveying of the solids to be more efficient.

**[0060]** According to a further embodiment of the first aspect, the conveyor screw comprises a fourth flight being substantially identical to the second flight and extending in parallel with the second flight, and a fifth flight corresponding to the third flight and running parallel with the fourth flight establishing a further oil channel together with the fourth flight, the fourth flight and the fifth flight being phase shifted relative to the second flight and the third flight, respectively, preferably by 180°

In this way the spread-out effect is enhanced as the solids will be spread out twice for every turn of the conveyor screw. A fifth flight corresponding to the third flight and running parallel with the fourth flight establishing a further oil channel.

**[0061]** The object of the present invention is according to a second aspect achieved by decanter centrifuge comprising a rotatable bowl and a conveyor screw according to any of the preceding embodiments accommodated inside the rotatable bowl, the rotatable bowl defining an inner surface substantially matching the outer perimeter of the screw thread.

**[0062]** The conveyor screw according to the first aspect is preferably mounted in a bowl of a decanter centrifuge.

**[0063]** The object of the present invention is according to a first aspect achieved by method of operating a decanter centrifuge according to the second aspect, wherein the method comprising: continuously introducing a flowable material to be separated into the bowl at a rate higher than 75m<sup>3</sup>/h while rotating the bowl to apply a g-force of at least 3000 G at the bowl wall.

**[0064]** The decanter centrifuge according to the second aspect is preferably operated at a high g-force and flow rate to allow an efficient oil release from the feed.

## 5 Brief description of the drawings

### **[0065]**

FIG. 1A is a side view of a decanter centrifuge according to the present invention.

FIG. 1B is a side view of a decanter centrifuge according to the present invention.

FIG. 2A is a perspective view of a circular base according to the present invention.

FIG. 2B is a perspective view of the base showing the discharge of the light phase.

FIG. 2C is a perspective view of the base from the rear side showing the discharge.

FIG. 3A is a perspective view of the base showing the inflow of the flowable material.

FIG. 3B is a perspective cutaway view of the base showing the trunnion interior.

FIG. 3C is a perspective view of the base from the rear side showing the inflow.

FIG. 4A is a perspective view of the conveyor screw.

FIG. 4B is a perspective view of the conveyor screw.

## Detailed description of the drawings

**[0066]** Fig. 1A is a side view of a decanter centrifuge 10 according to the present invention. The decanter centrifuge 10 comprises a rotatable bowl 12 and a conveyor screw 14. The bowl 12 has a cylindrical part 12a and a conical part 12b. The conveyor screw 14 has a corresponding cylindrical part 14a and conical part 14b. The bowl 12 is rotated by a drive motor 16a and the conveyor screw 14 is rotated by a back drive motor 16b. The back drive motor 16b is typically connected via a gearbox (not shown). An inlet 18 is provided for introducing the feed into the decanter centrifuge 10. The bowl 12 comprises a heavy phase outlet 20 at a small end hub 22 at the conical part 12b of the bowl 12 and a light phase outlet 24 at a base 26 forming a large end hub at the cylindrical part 12a of the bowl 12.

**[0067]** The conveyor screw 14 comprises a central body 28 extending in a longitudinal direction between a first bearing surface 30a at the cylindrical part 14a and a second bearing surface 30b at the conical part 14b. The conveyor screw 14 comprises a first flight 32 being attached to the central body 28. The first flight 32 extends over both the cylindrical part 14a and the conical part 14b of the conveyor screw 14. The first flight 32 extending to an inner wall 12c of the bowl 12 and defines a pitch angle being less than 20°. The present embodiment further comprises a second flight 34 not extending to the inner wall 12c of the bowl 12 and defining a pitch angle being greater than 30°. The pitch angle is here calculated by the expression: Pitch angle =  $\text{ATAN}(\text{Pitch}/(\pi \cdot (\text{Bowl dia} -$

meter))) The second flight 34 does not extend to the inner wall 12c and extends over only the cylindrical part 14a of the conveyor screw 14. The base 26 comprising a trunnion 40 which encompasses feed inlets 42 42' for the feed and the bearing surface 30a for the conveyor screw 14. The feed inlets 42 42' communicating with the inlet 18. The trunnion 40 also comprises at outlet housings 44 extending into the bowl 12 for transporting the light phase from the bowl 12 to the light phase outlet 24.

**[0068]** Fig. 1B is a side view of a decanter centrifuge 10 according to the present invention showing the inlet and outlet flows. The feed is introduced via the inlet 18 as shown by the arrow. The feed can be a crushed oil-containing plant- or animal item such as crushed corn seeds. The feed enters the bowl 12 via feed inlets 42 42'. The feed is separated into a slurry fraction and an oil fraction by centrifugal forces from the rotation of the bowl 12. The slurry fraction is a mixture of solids and water. The slurry fraction forms a heavy phase and are conveyed by the conveyor screw 14 and is discharged at the heavy phase outlet 20 as shown by the arrow. The oil fraction forms a light phase which is discharged via the outlet housings 44 and light phase outlet 24 as shown by the arrow. The slurry fraction being heavier than the oil fraction and will thus flow outwards and accumulate at the inner wall 12c of the bowl 12, the oil fraction being lighter than the slurry fraction and will thus flow inwards and accumulates near the central body 28. The first flight 32 collects the slurry fraction and conveys it towards the heavy phase outlet 20 of the bowl 12, whereas the second flight 34 being able to scrape and spread out the slurry fraction.

**[0069]** FIG. 2A is a perspective view of a circular base 26 according to the present invention. The base 26 comprises an inner surface 36 facing the interior of the bowl (not shown here) and an outer surface (not visible here) being opposite the inner surface 36 and facing the outside of the bowl. The base 26 comprising the trunnion 40 which constitutes a cylindrical element positioned about a centre point C of the base 26 protruding in a longitudinal direction L from the inner surface 36 of the base 26 into the bowl.

**[0070]** The trunnion 40 comprising a bearing surface 30a for the conveyor screw and feed inlets 42 42' for introducing feed (not shown) into the bowl. The bearing surface 30a being located further away in the longitudinal direction L from the inner surface 36 than the feed inlets 42 42' and encircles the centre point C. The bearing surface 30a being spaced apart from the centre point C in a radial direction r. The radial direction r being perpendicular to the longitudinal direction L. The feed inlets 42 42' is located more spaced apart in radial direction r from the centre point C than the bearing surface 40. In the present embodiment, two feed inlets 42 and 42' are provided, whereby the feed inlet 42 is the main feed inlet and the feed inlet 42' is an overflow inlet used during temporary high inflows.

**[0071]** The trunnion 40 further comprising the outlet

housing 44. The outlet housing 44 being at least partially cylindrical and extending from the base 26 through the trunnion 40 in the longitudinal direction L into the bowl. The outlet housing 44 is located spaced apart in radial direction r from the centre point C, typically further spaced apart from the centre point C than the bearing surface 30a. In the present embodiment, the screw flight 34 ends at the outlet housing 44. Further, in the present embodiment two outlet housings 44 and 44' are provided spaced apart by 180 degrees about the centre point C.

**[0072]** The light phase being oil/fat. During use, the light phase flows inwardly due to centrifugal forces and enters one of the outlet housings 44 44' as shown by the arrows. The light phase enters the outlet housing 44 44' via a light phase opening 46. (Only the light phase opening 46' of the outlet housing 44' is visible in the present view, however, the outlet housing 44 has an identically configured light phase opening). The light phase opening 46 defines a weir edge extending in parallel with the first adjustment axis of the outlet housing 44 44' and defining in normal use a level of the light phase within the bowl. In the present embodiment, the outlet housing 44 44' has a cylindroconical shape having the light phase opening 46' in a conically shaped part of the outlet housing 44 for a smoother flow.

**[0073]** FIG. 2B is a perspective view of the base showing the discharge of the light phase. The light phase enters the outlet housings 44 44' at a radial distance from the centre point C. The radial distance of the opening 46 (and thereby the weir) from the centre point C can be adjusted by rotating the outlet housing 44 44' about an adjustment axis A. In this way the level of the light phase within the bowl can be adjusted. In use the bowl (not shown) rotates causing the feed (not shown) inside the bowl to separate in a heavy phase (not shown) and light liquid phase having a surface at a level, which is slightly above the level of the weir edge thereby providing a pressure head driving the light phase out of the bowl through the opening 46 and the outlet housing 44.

**[0074]** FIG. 2C is a perspective view of the base from the rear side showing the outer surface 36' and the discharge of the light phase as shown by the arrows. The outlet housing 44 extends to the outer surface 36' of the base 26 and defines an outlet 48 at the outer surface 36' of the base 26 for ejecting the light phase. The outlet housing 44 can be adjusted about the adjustment axis A from the outside.

**[0075]** FIG. 3A is a perspective view of the base showing the inflow of the flowable material. The flowable material is introduced centrally in the longitudinal direction and flows out in the radial direction into the bowl (not shown) via the feed inlets 42 42'.

**[0076]** FIG. 3B is a perspective cutaway view of the base 26 showing the interior of the trunnion 40. As can be seen the flowable material is deflected by deflectors 50 from flowing in the longitudinal direction to a direction substantially corresponding to the tangential direction of the rotation of the bowl (not shown). In this way, less time

within the bowl is needed to accelerate the flowable material to the bowl rotation speed, and the separation can therefore be more efficient.

**[0077]** FIG. 3C is a perspective view of the base from the rear side showing the inlet 18. The inlet is centrally in the longitudinal direction.

**[0078]** Fig. 4A is a perspective view of the conveyor screw 14 according to the present invention. The conveyor screw 14 comprises the first flight 32 and the second flight 34 being attached to the central body 28. The first flight 32 extends over both the cylindrical part 14a and the conical part 14b of the conveyor screw 14 and defines a pitch angle being less than 20° for being able to collect the slurry fraction and convey it towards the heavy phase outlet of the bowl. The second flight 34 extends in the longitudinal direction along the cylindrical portion of the conveyor screw 14 only. The first flight 32 and the second flight 34 being at least partially intertwined.

**[0079]** Both the first flight 32 and the second flight 34 has the same winding direction, however, the second flight 34 defining a pitch angle being more than 30° for scraping and spreading out the slurry at the inner surface of the bowl. The second flight 34 extends to a smaller outer perimeter than the first flight 32 for the slurry to be spread out on the inner surface of the bowl. This will allow more oil to be released from the slurry.

**[0080]** The conveyor screw 14 is further provided with a baffle plate 60 between the cylindrical part 14a and the conical part 14b for preventing oil from flowing towards the heavy phase outlet of the bowl. The conveyor screw 14 is further provided with a third flight 52 extending to a smaller outer perimeter than the second flight 34. The purpose of the third flight 52 is to define an oil channel 54 between the second flight 34 and the third flight 52 to allow the oil to flow towards the light phase outlet of the bowl.

**[0081]** The first flight 32 comprises gaps 56 for allowing the second flight 34 and the third flight 52 to pass through. The first flight 32 is slightly offset at the gaps 56 to scrape any slurry which would otherwise be missed due to the gaps 56. The conveyor screw 14 further comprises a cage structure 58 extending from the first bearing surface 30a away from the second bearing surface 30b for carrying the first screw 32 beyond the first bearing surface 32a.

**[0082]** The present conveyor screw 14 also includes an additional fourth flight 34' and fifth flight 52' which essentially correspond to the second flight 34 and third flight 52, respectively, albeit being 180° phase shifted. In this way there will be an additional oil channel 54' and two spread-out effects on the slurry for each turn of the conveyor screw 14.

**[0083]** The present view also shows the base 26 being attached to the first bearing surface 30a during use. The base 28 comprises the feed inlet 42 42' and the outlet housing 44.

**[0084]** Fig. 4B is a perspective view of the conveyor screw 14 according to the present invention when the

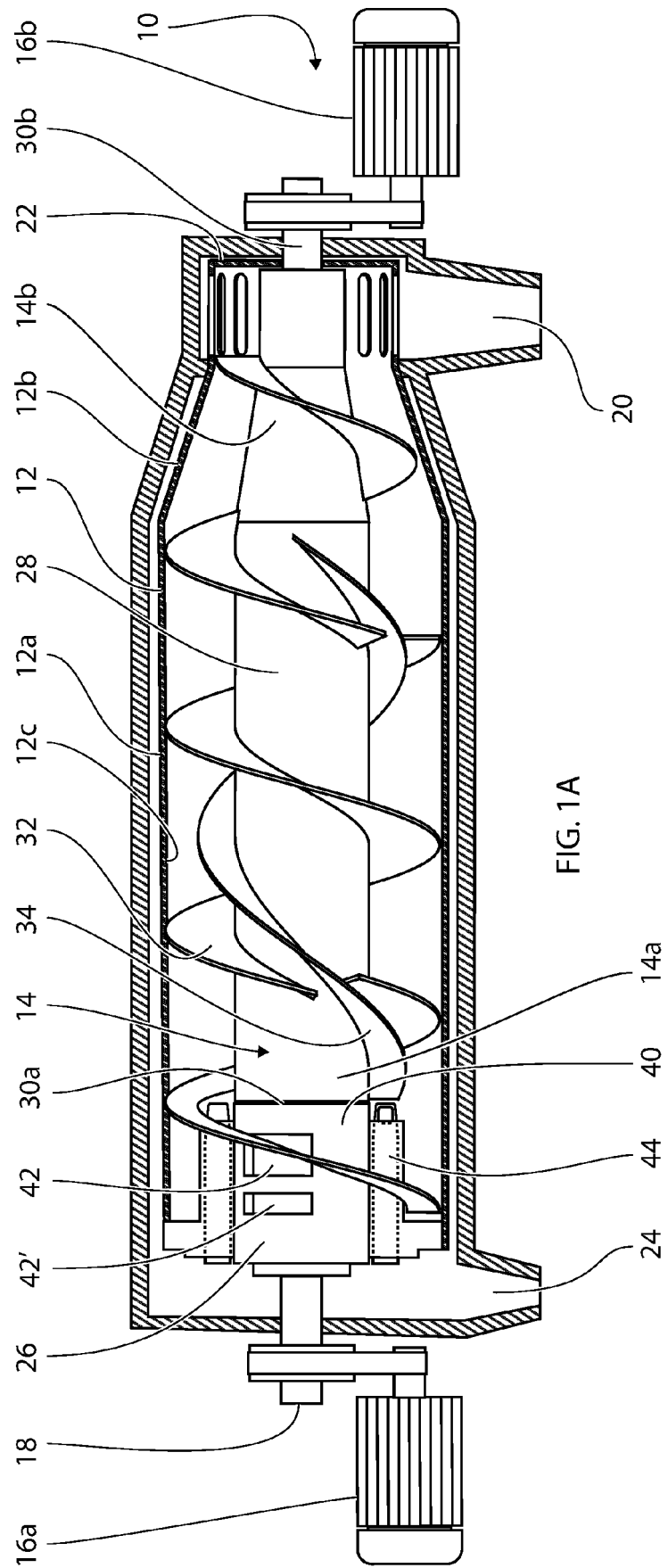
base 26 is connected to the first bearing surface 30a. The central body 28 being free from any fluid openings between the first bearing surface 30a and the second bearing surface 30b for increasing the structural stability and stiffness of the conveyor screw 14.

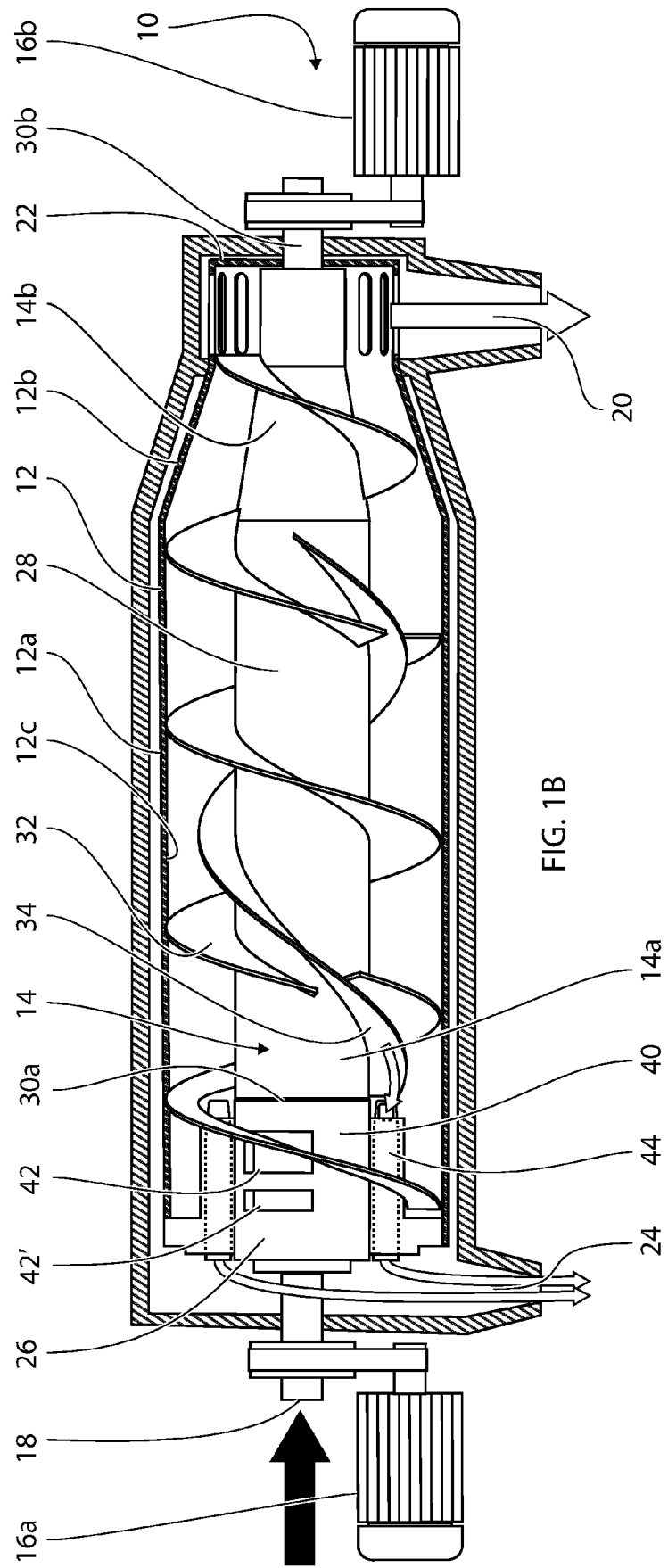
## Claims

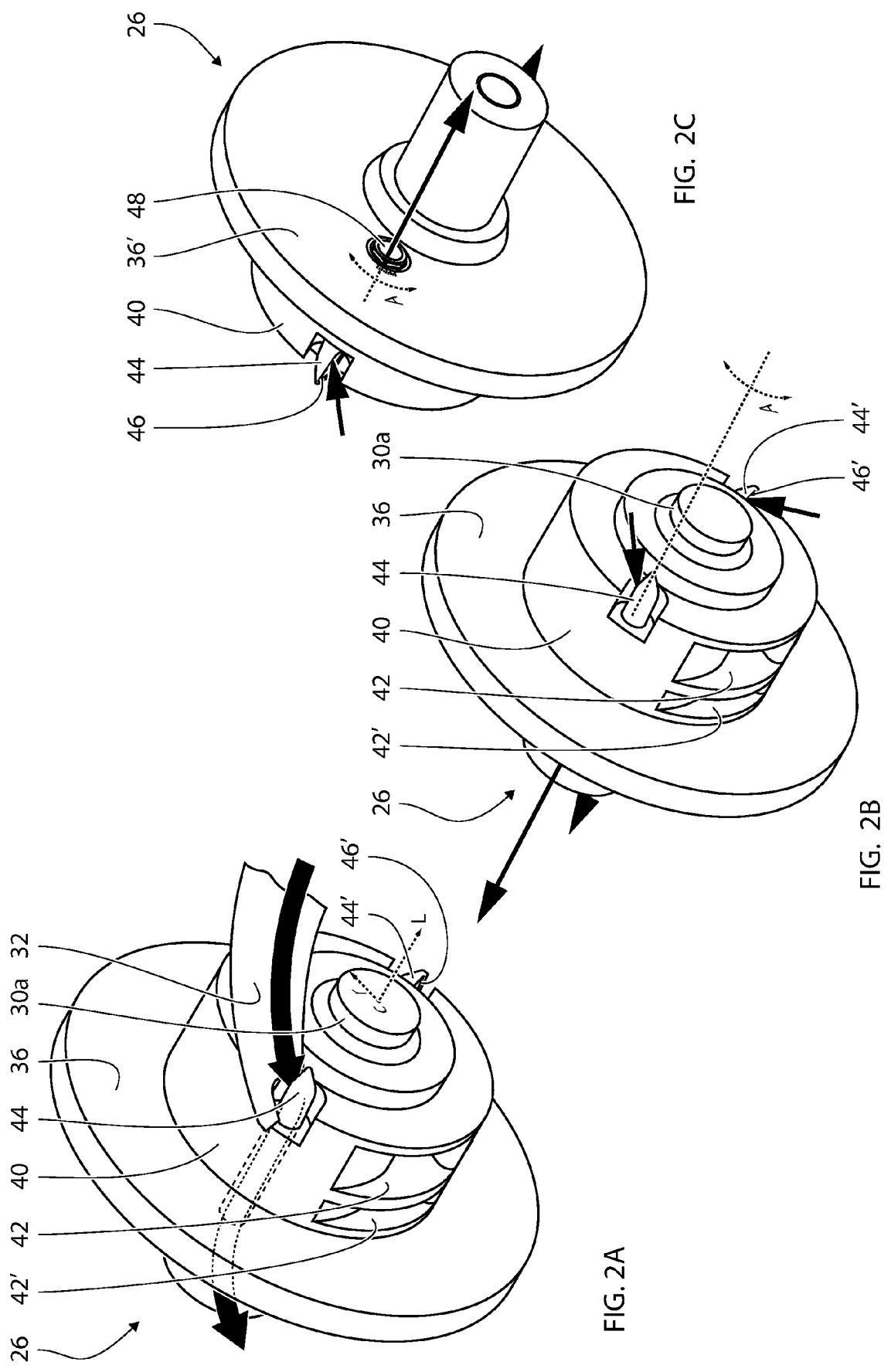
1. A conveyor screw for a decanter centrifuge, the conveyor screw comprising a central body extending in a longitudinal direction, the central body comprising a first bearing surface at a first end of the central body and a second bearing surface at a second end of the central body, the second end being opposite the first end, the central body further defining a cylindrical portion adjacent the first bearing surface and a conical portion adjacent the second bearing surface, the conveyor screw further comprising a screw thread being attached to the central body, the screw thread extending in the longitudinal direction and defining an outer perimeter extending circumferentially about the cylindrical portion, the central body being free from any fluid openings between the first bearing surface and the second bearing surface.
2. The conveyor screw according to claim 1, wherein the central body being free from any openings between the first bearing surface and a second bearing surface
3. The conveyor screw according to any of the preceding claims, wherein the conveyor screw comprises a cage structure extending from the central body at the first bearing surface in a direction away from the second bearing surface, the screw thread being at least partially attached to the cage structure.
4. The conveyor screw according to claim 3, wherein the cage structure part comprises an inner ring attached to the central body, and outer ring and a plurality of ribs interconnecting the inner ring and the outer ring.
5. The conveyor screw according to any of the preceding claims, wherein the central body defines a cylinder at the cylindrical portion and a truncated cone at the conical portion.
6. The conveyor screw according to any of the preceding claims, wherein the outer perimeter of the screw thread defines a diameter and the screw thread defines a length in the longitudinal direction, the ratio between the diameter and the length exceeding 3.9, preferably exceeding 4.2, more preferably exceeding 4.5, most preferably exceeding 4.9.

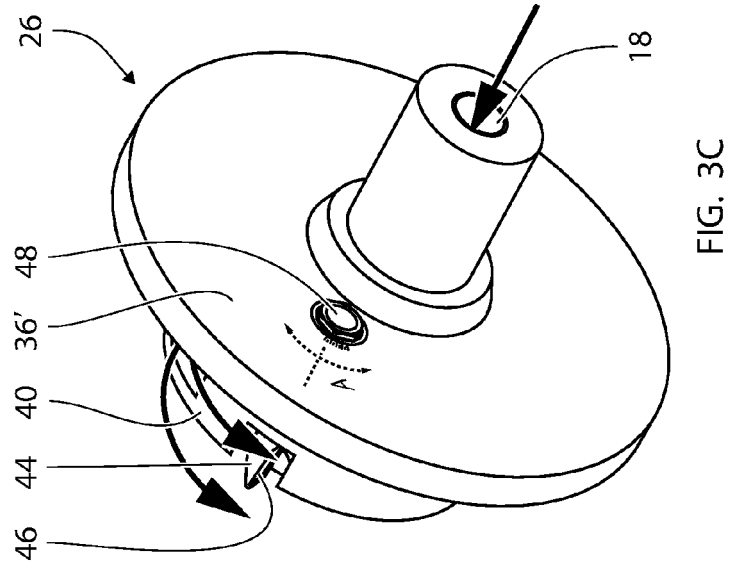
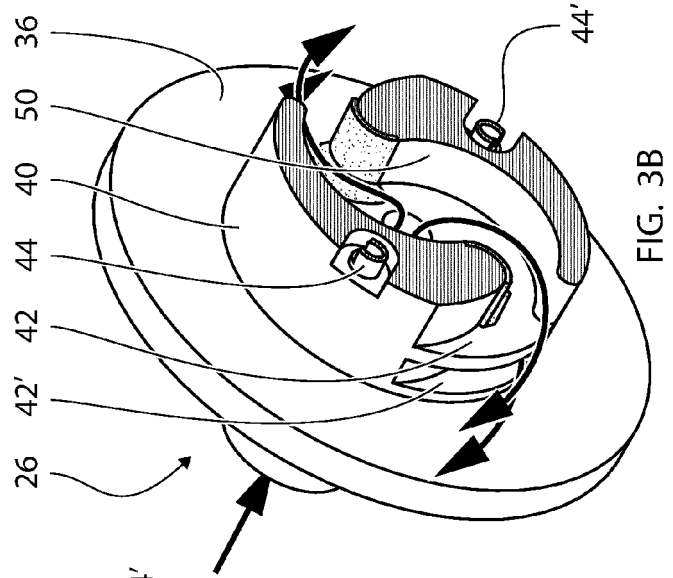
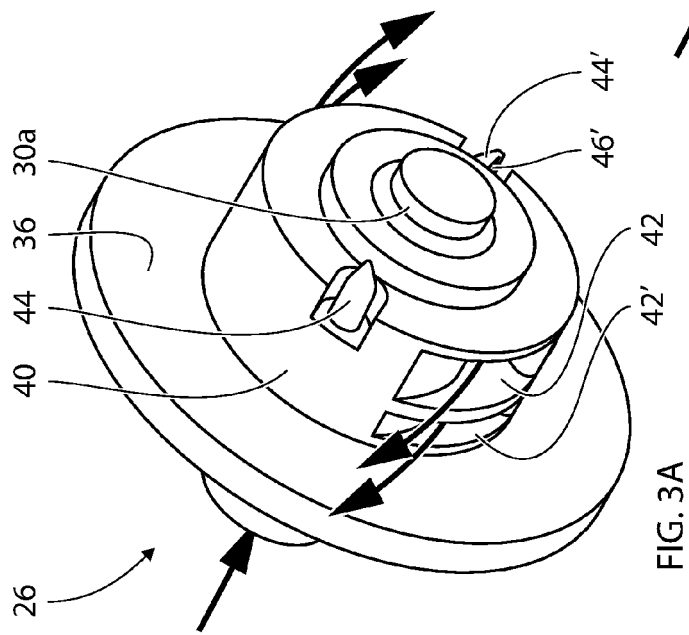
7. The conveyor screw according to claim 6, wherein the diameter is exceeding 640mm, preferably exceeding 670mm, more preferably exceeding 700mm, most preferably exceeding 715mm. 5
8. The conveyor screw according to any of the preceding claims, wherein the central body defines a hollow interior which is at least partially reinforced by a reinforcing material extending at least half the distance between the first bearing surface and the second bearing surface, the reinforcing material preferably being fibre reinforced epoxy. 10
9. The conveyor screw according to any of the preceding claims, wherein a first flight being attached to the central body and extending in the longitudinal direction, the first flight defining a first outer perimeter extending circumferentially about the cylindrical portion of the conveyor screw, the first outer perimeter defining a first diameter, the first flight defining a first pitch angle at the cylindrical portion of the conveyor screw, the first pitch angle being less than 20°, and, a second flight being attached to the central body, extending in the longitudinal direction, having the same winding direction as the first flight and being at least partially intertwined with the first flight, the second flight defining a second outer perimeter extending circumferentially about the cylindrical portion of the conveyor screw, the second outer perimeter defining a second diameter, the second flight defining a second pitch angle at the cylindrical portion of the conveyor screw, the second pitch angle being greater than 30°, and the second diameter being smaller than the first diameter. 15  
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10. The conveyor screw according to claim 9, wherein the conveyor screw further defining a third flight extending parallel with the second flight, the second flight extending to the second outer perimeter whereas the third flight extending to a third outer perimeter, the second flight and the third flight defining an oil channel between themselves, the oil channel defining a width between the second flight and the third flight being less than the distance between the central body and the second outer perimeter. 40  
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11. The conveyor screw according to claim 10, wherein the third outer perimeter defining a third diameter, the third diameter being smaller than the second diameter. 50
12. The conveyor screw according to any of the claims 9-11, wherein the second screw thread passes through gaps in the first screw thread. 55
13. The conveyor screw according to any of claims 9-12, wherein the conveyor screw comprises a fourth flight being substantially identical to the second flight and extending in parallel with the second flight, and a fifth flight corresponding to the third flight and running parallel with the fourth flight establishing a further oil channel together with the fourth flight, the fourth flight and the fifth flight being phase shifted relative to the second flight and the third flight, respectively, preferably by 180°. 5
14. A decanter centrifuge comprising a rotatable bowl and a conveyor screw according to any of the preceding claims accommodated inside the rotatable bowl, the rotatable bowl defining an inner surface substantially matching the outer perimeter of the screw thread. 10
15. A method of operating a decanter centrifuge according to claim 14, wherein the method comprising: continuously introducing a flowable material to be separated into the bowl at a rate higher than 75m<sup>3</sup>/h while rotating the bowl to apply a g-force of at least 3000 G at the bowl wall. 15  
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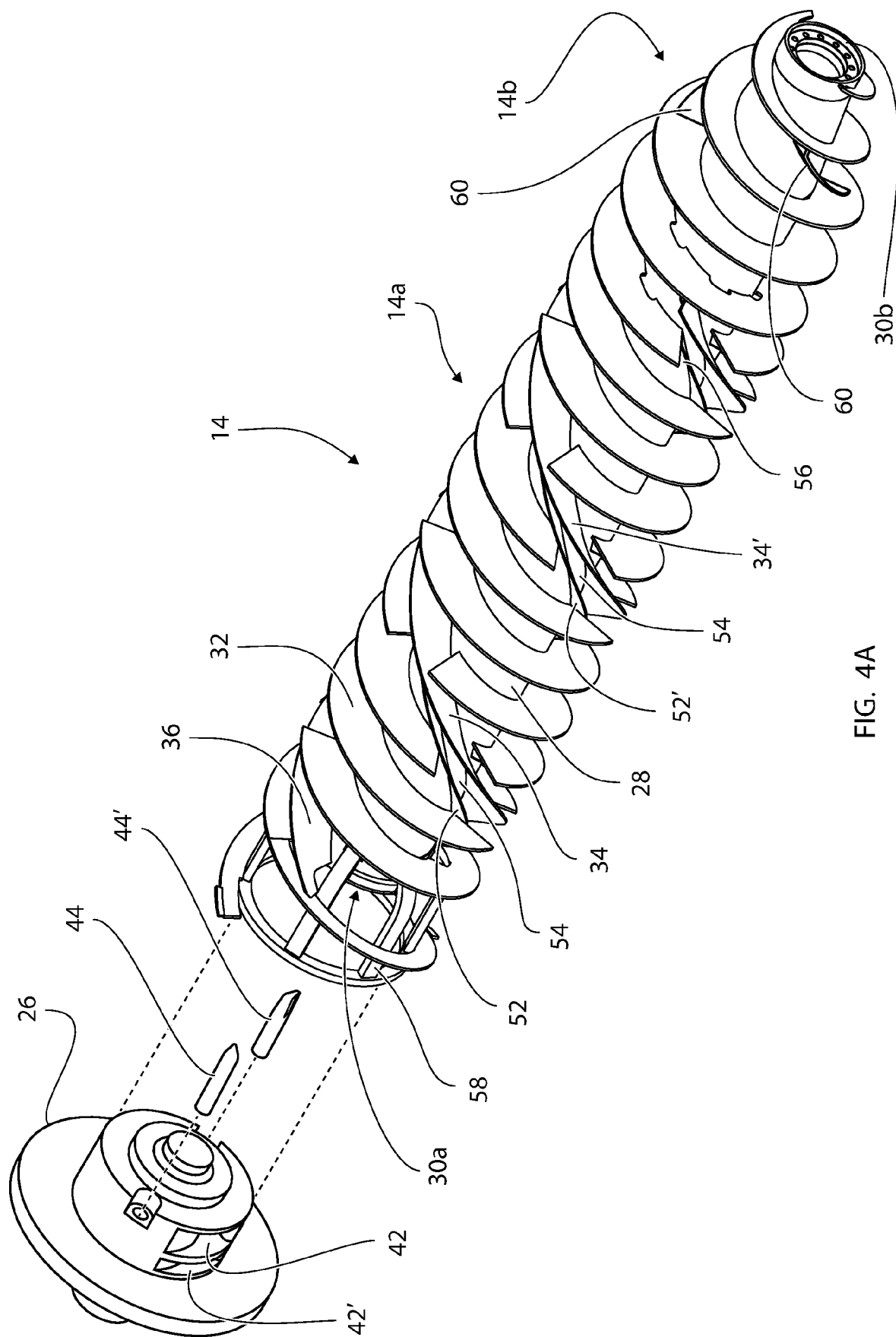


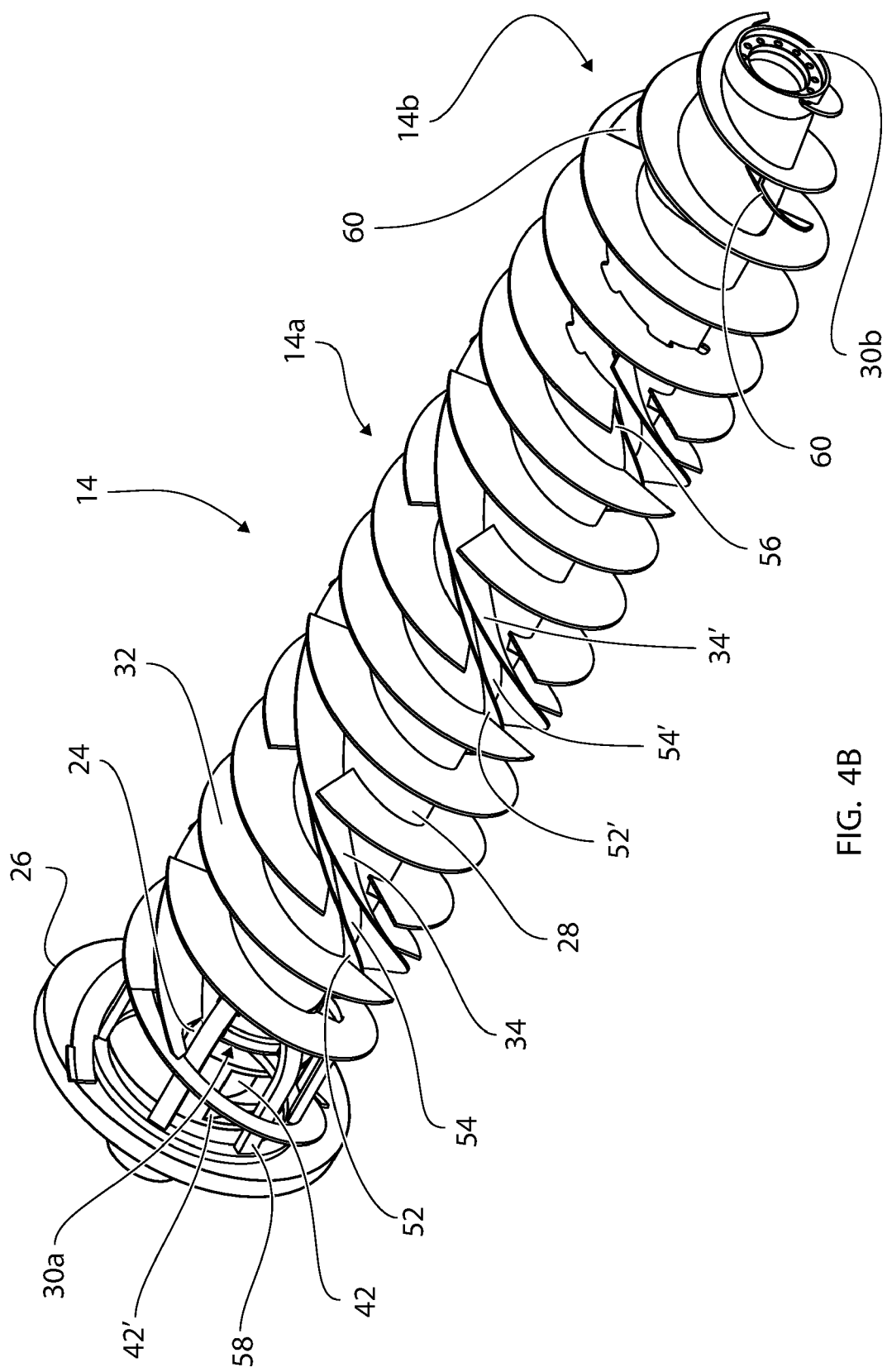














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The present search report has been drawn up for all claims			
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