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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 defines a cylindrical portion and a conical portion and comprises a central body. The conveyor screw defines a first flight attached to the central body. The first flight defines a first diameter and a pitch angle being less than 20°. The conveyor screw further defines a second flight attached to the central body. The second flight has the same winding direction as the first flight and being at least partially intertwined with the first flight. The second flight defines a pitch angle being greater than 30° and the second diameter being smaller than the first diameter.

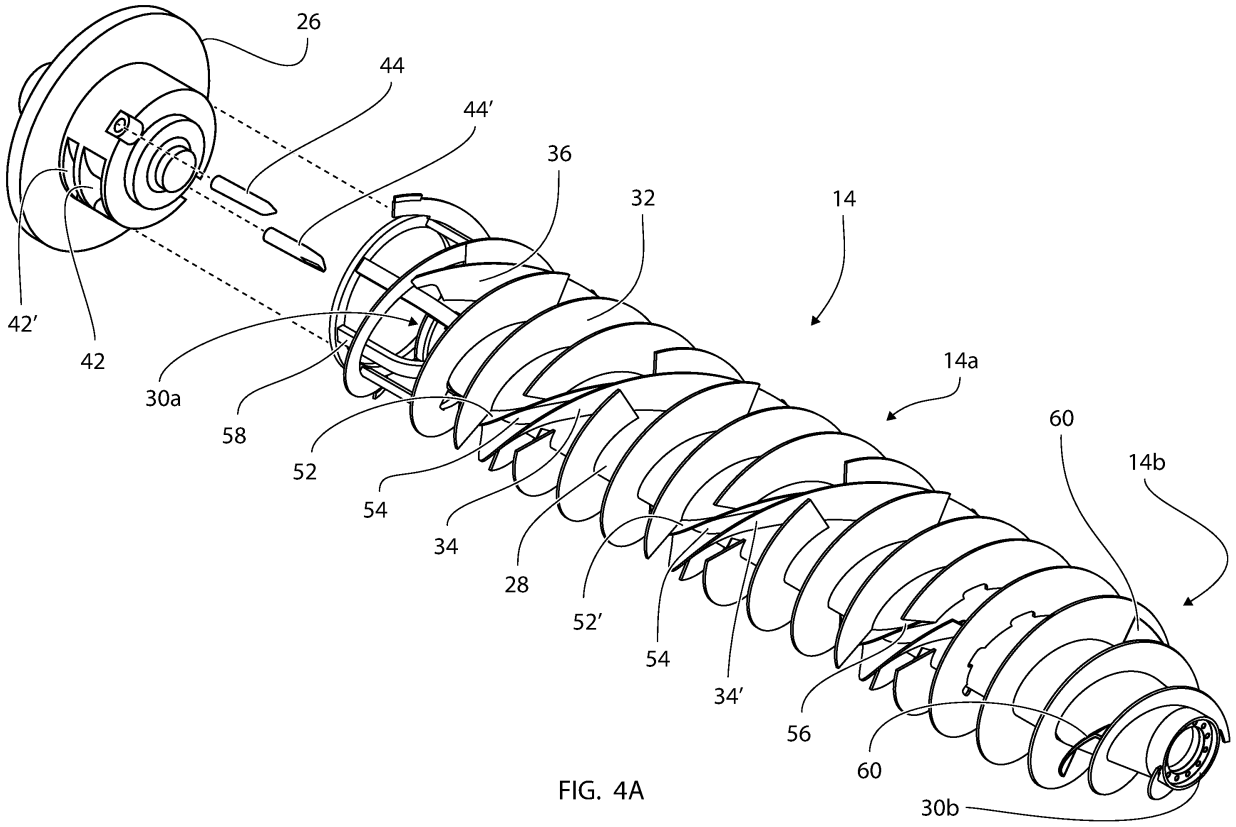

FIG. 4A

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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, and in particular decanter centrifuges, can be used for separating the oil and fat from the residual solids and liquids when extracting oil and/or fat from oil-containing plant- or animal items, such as fish oil extraction, oil from kitchen waste and vegetable oil extraction and in particular corn oil extraction from corn seeds/whole stillage, the solids of the plant- or animal items are removed in a first separation stage, leaving a residue of liquids. The liquids mainly consist of water and oil/fat. The oil/fat is separated from the water in a second separation stage after the solids have been removed.

[0003] By using the above technique, some oil/fat will inevitably be trapped in the compacted solids cake. This oil/fat is considered to be lost as it is not easily recoverable even by resuspension of the solids.

[0004] 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.

[0005] 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.

[0006] 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 ta 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.

[0007] 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.

[0008] 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.

[0009] US 20150209804 describes an apparatus comprising an outer drum, an inner drum, an activation spiral and a heavy-material discharging spiral.

[0010] 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.

[0011] 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.

[0012] DE 2651657 relates to a centrifugal decanter having a clear fluid discharge between the inlet and the solids outlet.

[0013] US 3268159 relates to a centrifugal decanter in which the feed zone is closer to large end hub than both conveyor bearings.

[0014] JP 62106856 relates to a centrifugal decanter in which the solids and liquids discharge are on the same side.

[0015] US 3494472 relates to a centrifugal separator in the form of a sieve drum.

[0016] US 7022061 describes a centrifugal separator with power recovery discharge pipes for the light phase.

[0017] 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

[0018] WO 2012/062337 A2 relates to a centrifugal separator comprising an outlet housing being rotatable around an adjustment axis.

[0019] DE 10 2020 129 478 A1 relates to a conveyor screw body having web elements.

[0020] EP 0506835 B1 relates to a decanter centrifuge having at least one bearing of the conveyor supported at the free end of a trunnion.

[0021] EP 0602766 B1 relates to a decanter centrifuge having a central hub having radially projecting support ribs.

[0022] 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.

[0023] 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.

[0024] EP 3177403 B1 relates to a decanter centrifuge having individual openings in the cylindrical section of the screw hub.

[0025] WO 2021122878A1 relates to a decanter centrifuge having, at least in the inlet area, a screw hub with an open wall structure.

[0026] WO 2021122884A1 relates to a decanter centrifuge having a transverse disk for stabilizing the worm hub construction.

[0027] WO 2022096734A1 relates to a centrifuge screw having rods between at least two winding sections. The rods are formed completely or almost completely spaced.

[0028] 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.

[0029] 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.

[0030] US 8841469 relates to a method of recovering oil from corn by adding a chemical additive.

[0031] It has been noted that the normal flight configuration of the decanter conveyor screw is not optimal for oil release. It is therefore an object of the present invention to provide technologies for increasing the release of oil from the feed and in particular the oil trapped in the solids of the feed.

Summary of the invention

[0032] The object of the present invention is in a first aspect achieved by a conveyor screw for a decanter centrifuge, the conveyor screw defining a cylindrical portion and a conical portion and comprising:

a central body extending in a longitudinal direction,
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.

[0033] The pitch angle is here calculated by the expression: Pitch angle = ATAN(Pitch/(π*(Bowl diameter)))

[0034] The above-described conveyor screw is intended to be used in a decanter centrifuge together with a rotatable bowl having an inner surface. The inner surface of the bowl defines a cylindrical portion and a conical portion and substantially corresponding to the outer shape of conveyor screw. The bowl has a feed inlet and light phase outlet at one end of the bowl adjacent the at the cylindrical portion and a heavy phase outlet at an opposite end of the bowl at the conical portion as seen in the longitudinal direction. The slurry is a mixture of solids and water.

[0035] The feed is introduced into the feed inlet of the bowl as a mixture of solids and liquids, whereby the liquids are mainly water and oil. By rotating the bowl, the centrifugal forces will cause a slurry being a mixture of the solids and the water to move outwards towards the inner surface of the bowl, whereas the oil will move inwards towards the central body. However, the solids contain oils and fats which do not easily release from the slurry.

[0036] The first flight of the conveyor screw has a pitch angle of less than 20° and extend substantially to the inner surface of the bowl. The first flight is intended for scraping and conveying the slurry material in the longitudinal direction from the feed inlet towards the heavy phase outlet. The second flight of the conveyor screw has a pitch angle greater than 30° and has a smaller outer diameter than the first flight. It is intended for spreading out the slurry along the inner surface of the bowl. As the second flight has a smaller diameter than the first flight there is a gap between the second flight and the inner wall of the bowl. The second flight therefore is intended to scrape and spread out the slurry in a layer of limited thickness resulting in a greater exposure of the solids to the liquid.

[0037] 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 that the slurry, the oil will accumulate near the central body and can be collected at the light phase outlet.

[0038] In the present context, a flight is understood to be a plate attached (e.g. by welding) radially to the central body of the conveyor screw to provide the conveying surface of the conveyor screw.

[0039] 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 or third outer perimeter.

[0040] 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 slurry 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.

[0041] 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.

[0042] In this way it is ensured that the oil is collected in the oil channel but not the slurry as the oil is lighter and will flow closer to the central body and the slurry will flow closer to the bowl wall due to the centrifugal forces.

[0043] According to a further embodiment of the first aspect, the second flight passes through gaps in the first flight.

[0044] 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 slurry to be more efficient.

[0045] According to a further embodiment of the first aspect, 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°.

[0046] In this way the spread-out effect is enhanced as the slurry 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 between the fourth flight and fifth flight.

[0047] According to a further embodiment of the first aspect, the second pitch angle being at least twice the first pitch angle, preferably at least thrice the first pitch angle, more preferably at least four times the first pitch angle, such as the first pitch angle is between 1° and 20°, preferably between 8° and 15° and/or the second pitch angle is between 30° and 60°, preferably between 35° and 45°.

[0048] The first pitch angle can be smaller so that the slurry move more slowly through the bowl to allow more time for the solids to release oil. The second pitch angle can be larger so as to scrape and spread out the slurry properly.

[0049] According to a further embodiment of the first aspect, the first flight extends about the cylindrical portion and the conical portion of the flight, whereas the second flight extends about the cylindrical portion only.

[0050] As the first flight is conveying the slurry, the first flight should preferably extend into the conical portion of the bowl, whereas the second flight is only intended to enhance the release of oil from the slurry, it must not necessarily extend into the conical portion of the bowl.

[0051] According to a further embodiment of the first aspect, the pitch angle of the first flight differs between the cylindrical portion and the conical portion.

[0052] In this way the conveying speed may differ between the cylindrical portion and the conical portion.

[0053] According to a further embodiment of the first aspect, the conveyor screw further comprising a baffle plate extending between the cylindrical portion and the conical portion.

[0054] The baffle plate, also known as baffle disc, is used for preventing oil flowing out via the conical end of the bowl.

[0055] According to a further embodiment of the first aspect, the first flight defines a length in the longitudinal direction, the ratio between the first diameter and the length exceeding 3.9, preferably exceeding 4.2, more preferably exceeding 4.5, most preferably exceeding 4.9.

[0056] A longer first flight will allow for a longer retention time of the slurry in the bowl, which in turn will allow the solids more time to release the oil.

[0057] According to a further embodiment of the first aspect, the first diameter is exceeding 640mm, preferably exceeding 670mm, more preferably exceeding 700mm, most preferably exceeding 715mm.

[0058] According to a further embodiment of the first aspect, the central body is hollow, and fibre reinforced along the complete cylindrical portion.

[0059] 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.

[0060] According to a further embodiment of the first aspect, the central body defines a first bearing surface and a second bearing surface, the central body being free from any openings, such as fluid openings, between the first bearing surface and the second bearing surface.

[0061] State of the art conveyor screws typically have a feed inlet opening in the central body. Having no opening in the central body will allow the conveyor screw to be lighter and longer while maintaining the stiffness and structural stability of the conveyor screw.

[0062] According to a further embodiment of the first aspect, the conveyor screw preferably comprises a cage structure extending from the central body at the first bearing surface in a direction away from the second bearing surfaces, the first screw being at least partially attached to the cage structure.

[0063] In this way the conveyor screw bearing can be moved inside the bowl while allowing the first flight to extend behind the bearing.

[0064] The object of the present invention is in a second aspect achieved by a 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 first outer perimeter.

[0065] The conveyor screw according to the first aspect is preferably mounted in a bowl of a decanter centrifuge.

[0066] The object of the present invention is in a third aspect achieved by a 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^3/h while rotating the bowl to apply a g-force of at least 3000 G at the bowl wall.

[0067] 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.

Brief description of the drawings

[0068]

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

[0069] 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 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.

[0070] 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 = ATAN(Pitch/(π*(Bowl diameter))) 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 outlet housings 44 extending into the bowl 12 for transporting the light phase from the bowl 12 to the light phase outlet 24.

[0071] 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 form 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.

[0072] 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.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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.

[0078] 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'.

[0079] 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.

[0080] 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.

[0081] 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 solid 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.

[0082] 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.

[0083] 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.

[0084] 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.

[0085] 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.

[0086] 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.

[0087] 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 defining a cylindrical portion and a conical portion and comprising:

   a central body extending in a longitudinal direction,
   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.

2. The conveyor screw according to claim 1, 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.

3. The conveyor screw according to claim 2, wherein the third outer perimeter defining a third diameter, the third diameter being smaller than the second diameter.

4. The conveyor screw according any of the preceding claims, wherein the second flight passes through gaps in the first flight.

5. The conveyor screw according to any of the preceding claims, 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◦.

6. The conveyor screw according to claim 1, wherein the second pitch angle being at least twice the first pitch angle, preferably at least thrice the first pitch angle, more preferably at least four times the first pitch angle, such as the first pitch angle is between 1◦ and 20◦, preferably between 8◦ and 15◦ and/or the second pitch angle is between 30◦ and 60◦, preferably between 35◦ and 45◦.

7. The conveyor screw according to any of the preceding claims, wherein the first flight extends about the cylindrical portion and the conical portion of the flight, whereas the second flight extends about the cylindrical portion only.

8. The conveyor screw according to any of the preceding claims, wherein the pitch angle of the first flight differs between the cylindrical portion and the conical portion.

9. The conveyor screw according to any of the preceding claims, further comprising a baffle plate extending between the cylindrical portion and the conical portion.

10. The conveyor screw according to any of the preceding claims, wherein the first flight defines a length in the longitudinal direction, the ratio between the first diameter and the length exceeding 3.9, preferably exceeding 4.2, more preferably exceeding 4.5, most preferably exceeding 4.9, and/or, the first diameter is exceeding 640mm, preferably exceeding 670mm, more preferably exceeding 700mm, most preferably exceeding 715mm.

11. The conveyor screw according to any of the preceding claims, wherein the central body is hollow and fibre reinforced along the complete cylindrical portion.

12. The conveyor screw according to any of the preceding claims, wherein the central body defines a first bearing surface and a second bearing surface, the central body being free from any openings, such as fluid openings, between the first bearing surface and

the second bearing surface,

13. The conveyor screw according to claim 12, wherein the conveyor screw preferably comprises a cage structure extending from the central body at the first bearing surface in a direction away from the second bearing surfaces, the first screw being at least partially attached to the cage structure.

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 first outer perimeter.

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 $75m^3/h$ while rotating the bowl to apply a g-force of at least 3000 G at the bowl wall.

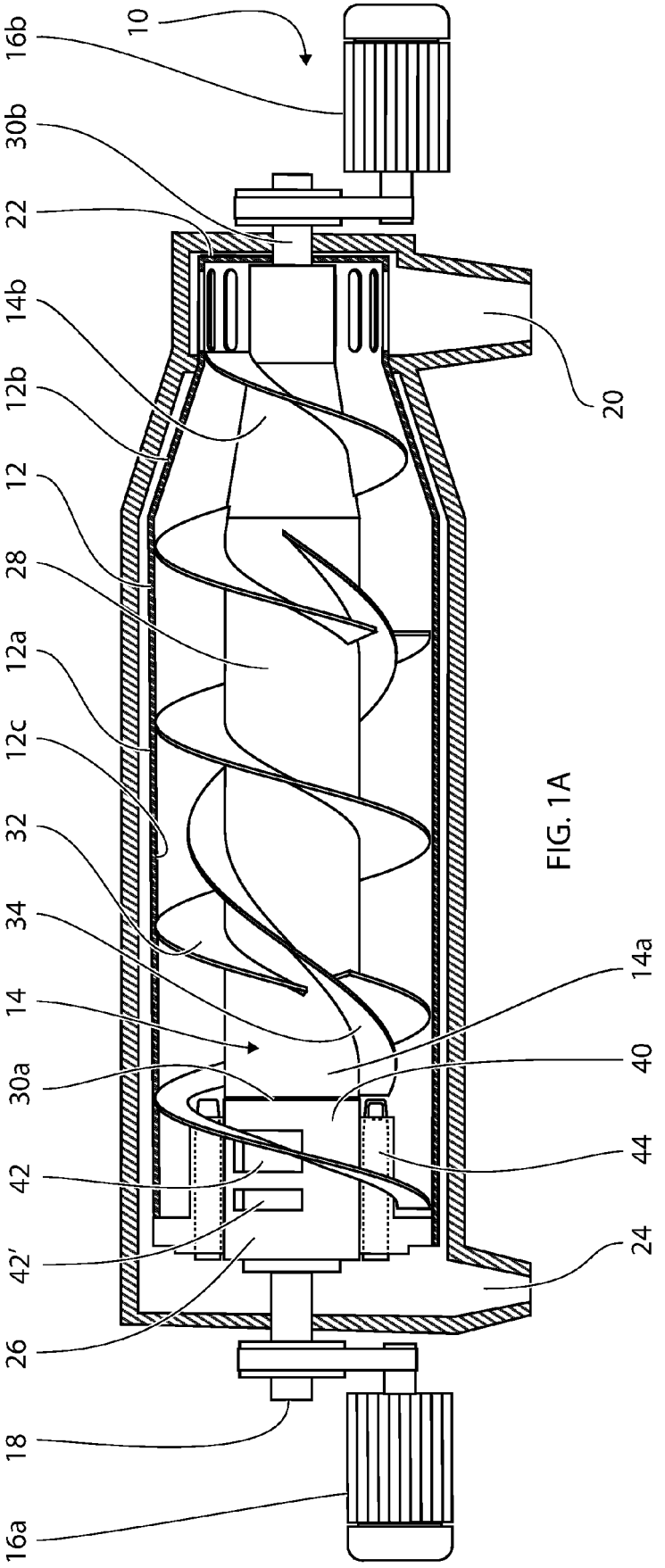

10
16b
30b
22
14b
12b
12
28
12a
12c
32
34
14
30a
42
42'
26
18
16a
14a
40
44
24
20

FIG. 1A

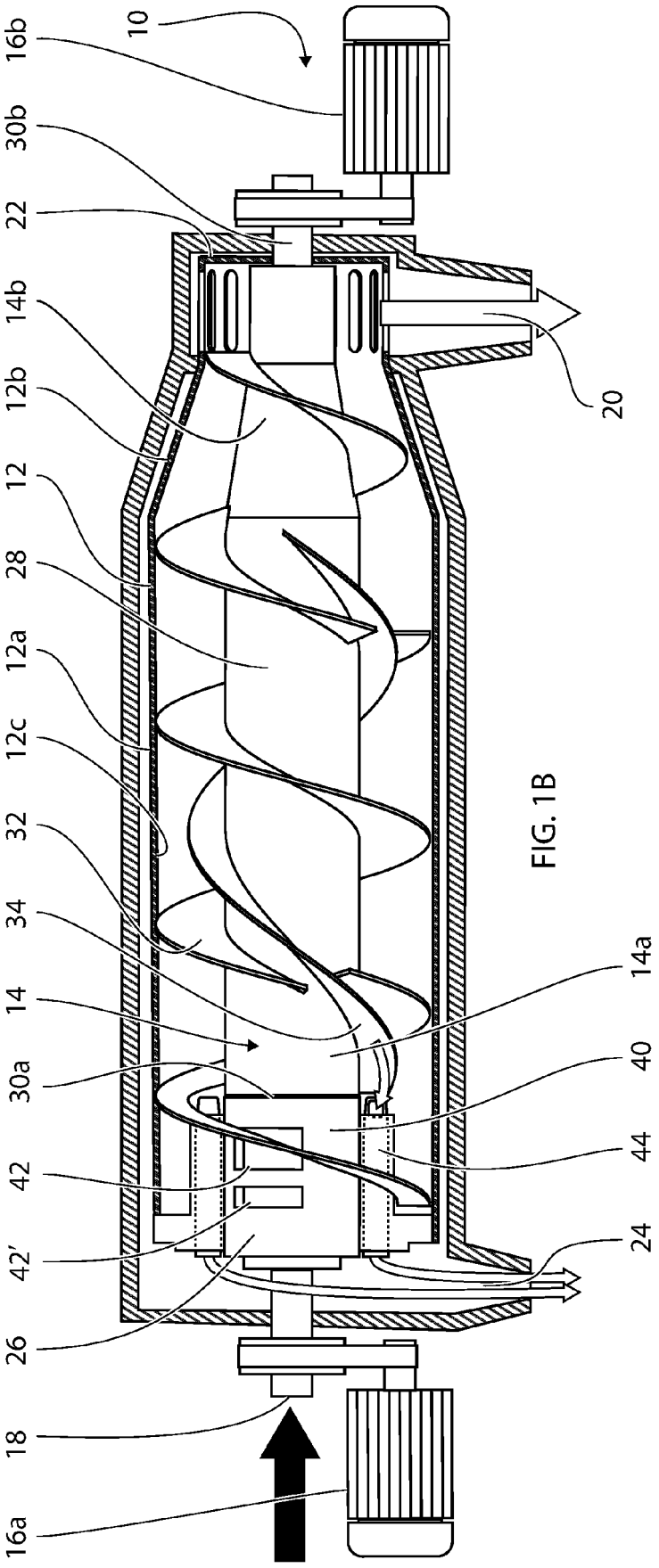
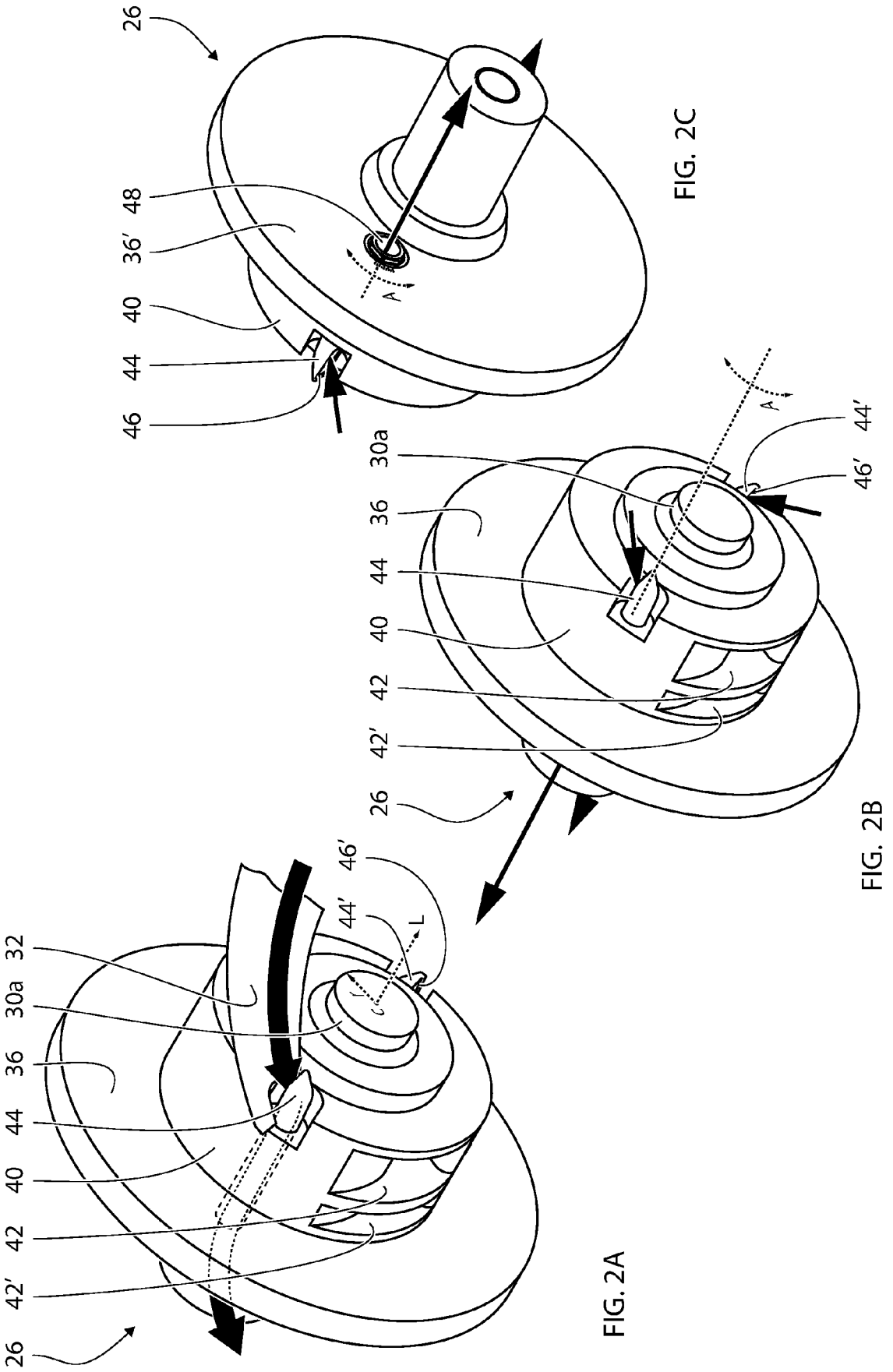

10
16b
30b
22
14b
12b
12
28
12a
12c
32
34
14
30a
42
42'
26
18
16a
20
14a
40
44
24

FIG. 1B


26
48
36'
40
44
46
A
FIG. 2C
30a
36
44
40
42
42'
26
A
44'
46'
FIG. 2B
46'
44'
L
32
30a
36
44
40
42
42'
26
FIG. 2A

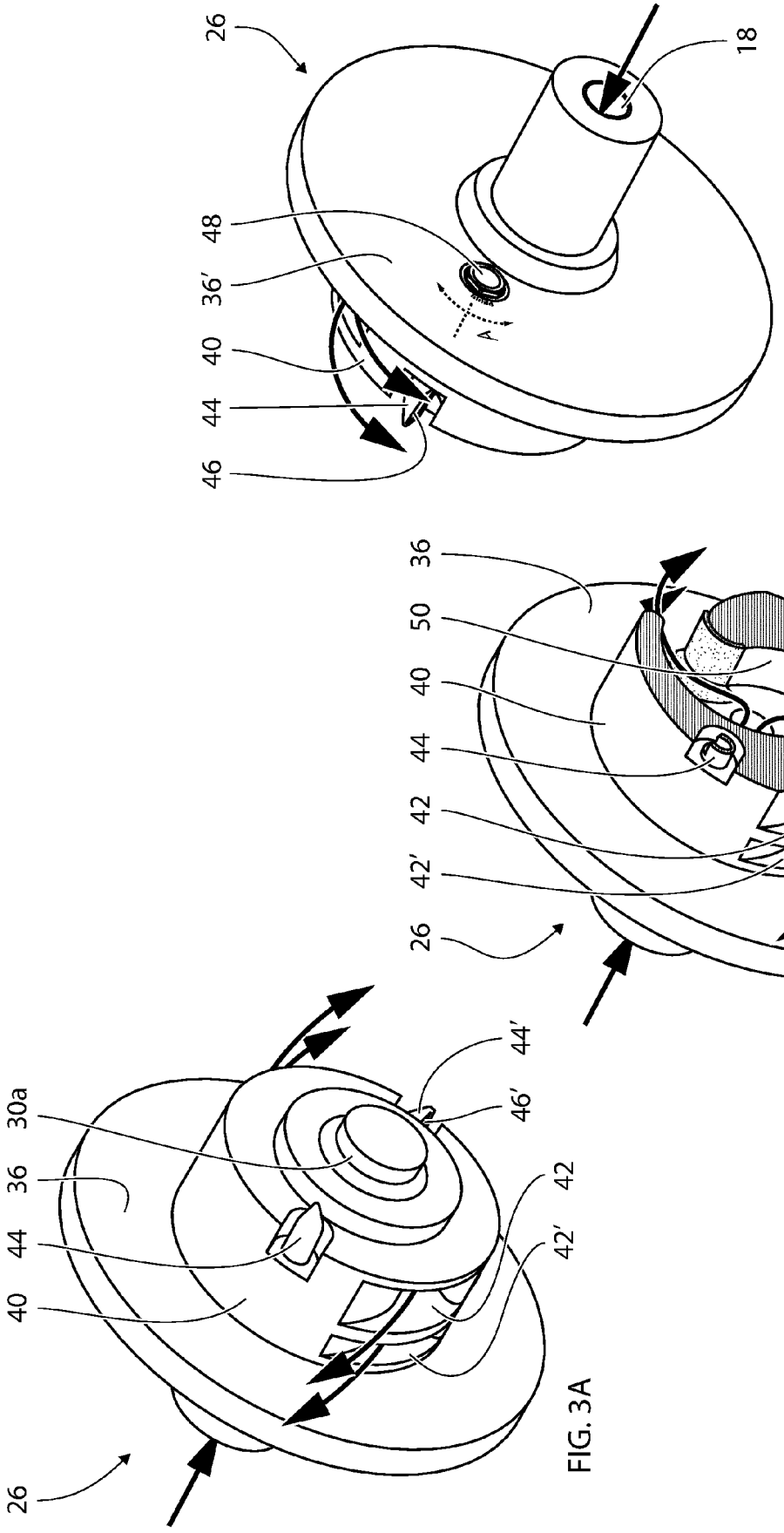


FIG. 3A

FIG. 3B

FIG. 3C

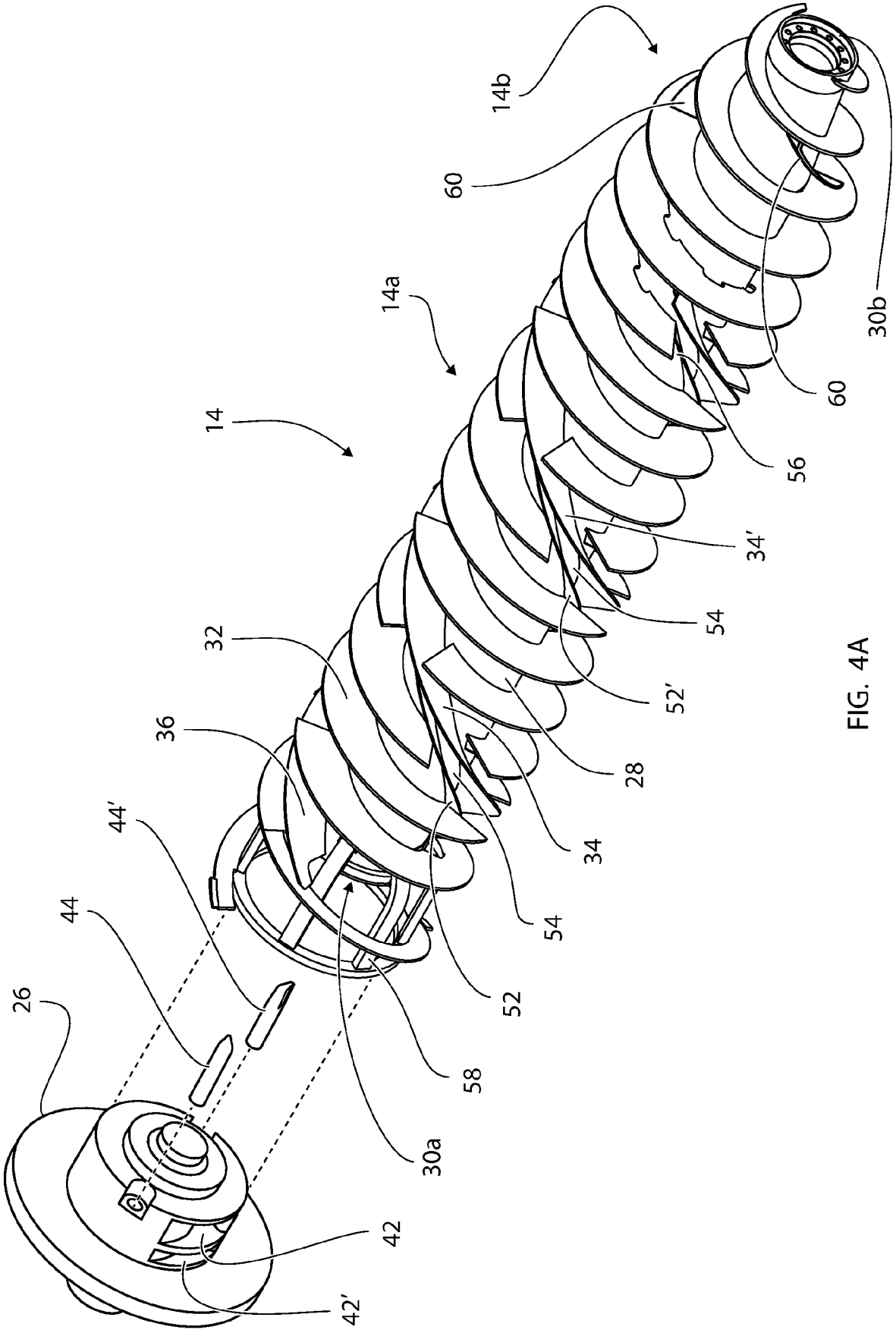

14b
60
14a
30b
14
60
56
34'
54
32
52'
36
28
34
54
44'
52
44
58
26
30a
42
42'

FIG. 4A

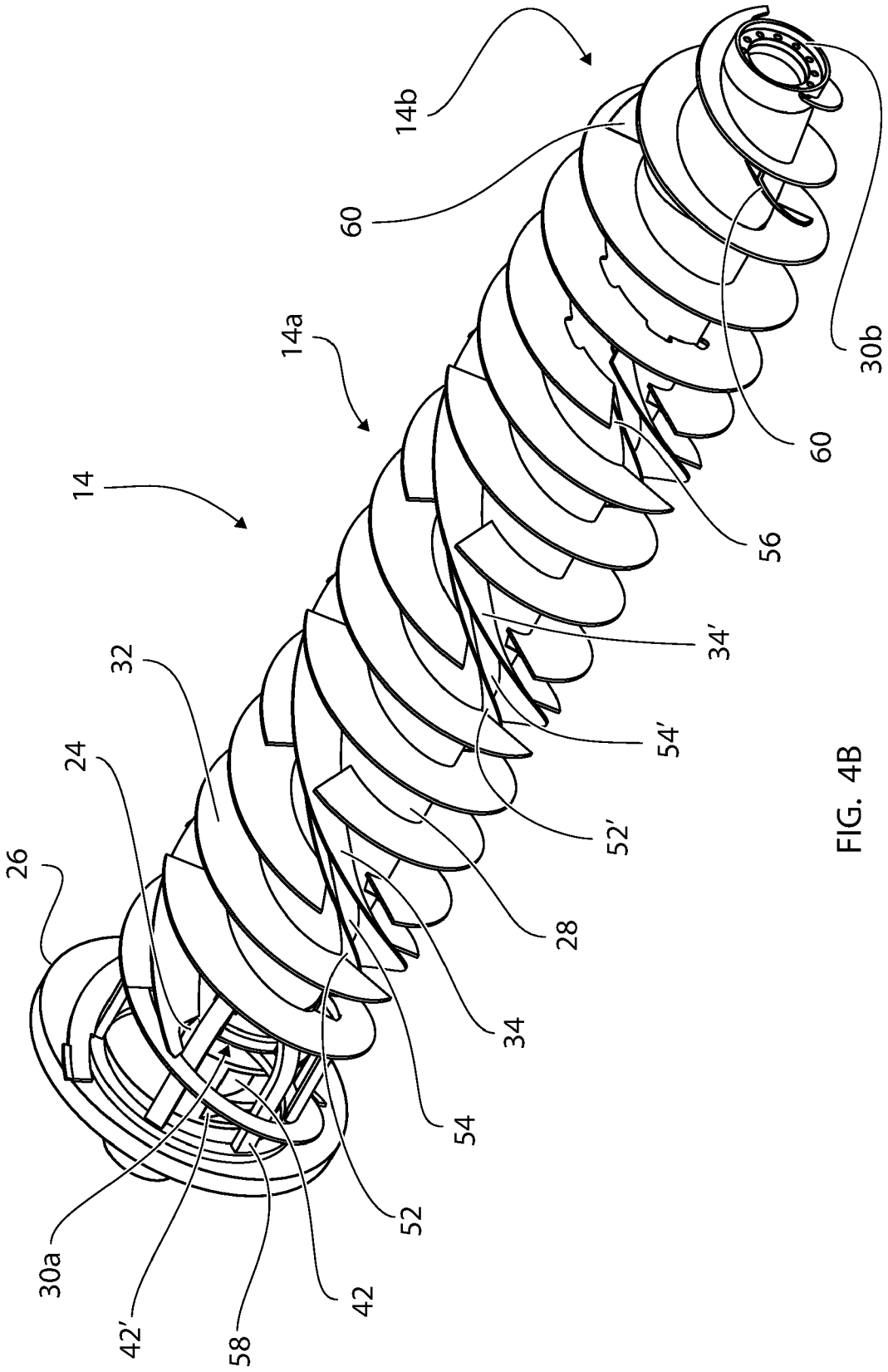


FIG. 4B

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Application Number
EP 23 21 3454

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Place of search	Date of completion of the search	Examiner
Munich	3 April 2024	Pössinger, Tobias

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