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(71) Applicant: **Xylem Europe GmbH**
8200 Schaffhausen (CH)

(72) Inventors:
- **RAMSTRÖM, Stefan**
186 35 Vallentuna (SE)
- **ANDERSEN, Tobias**
147 31 Tumba (SE)

(74) Representative: **Brann AB**
P.O. Box 3690
Sveavägen 63
103 59 Stockholm (SE)

(54) PUMP FOR PUMPING LIQUID AS WELL AS HYDRAULIC UNIT FOR SUCH A PUMP

(57) The invention relates to a pump and to an hydraulic unit (1) of a pump, said hydraulic unit comprising an open impeller (8) and a housing (6) that comprises an impeller seat (5), wherein the impeller (8) comprises a cover plate (14), a hub (15) and at least one spirally swept blade (16), wherein each blade (16) of the impeller (8) comprises a leading edge (17), a trailing edge (18) and a lower edge (19), wherein the lower edge (19) extends from the leading edge (17) to the trailing edge (18) and separates a suction side (20) of the blade (16) from a pressure side (21), wherein the lower edge (19) of the blade (16) is located opposite an upper surface (11) of the impeller seat (5), wherein the impeller (8) is suspended at a lower end of an axially extending drive shaft assembly (23), and wherein the impeller (8) is displaceable back and forth in the axial direction in relation to the impeller seat (5) between a lower position and an upper position, during operation of the pump. The hydraulic unit is characterized in that the impeller (8) comprises an engagement unit (33) that is in engagement with the drive shaft assembly (23), wherein the engagement unit (33) of the impeller (8) and the drive shaft assembly (23) in cooperation bias the impeller (8) towards said lower position during forward rotation of the drive shaft assembly (23) and are configured to displace the impeller (8) towards said upper position during reverse rotation of the drive shaft assembly (23).

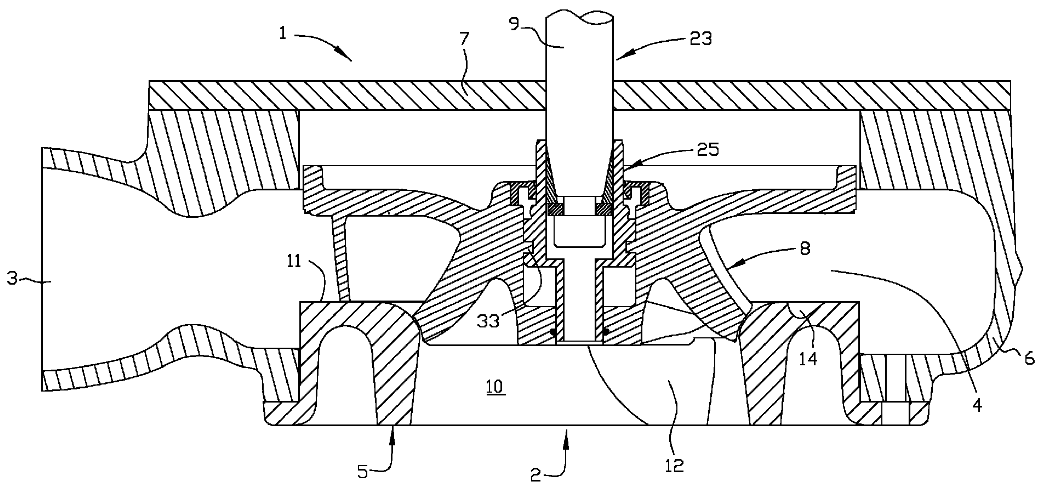

Fig. 1

EP 4 571 117 A1

Description

Technical field of the Invention

[0001] The present invention relates generally to the field of pumps configured for pumping liquid, and in particular to pumps configured for pumping liquid comprising solid matter. Further, the present invention relates to the field of submergible pumps, such as sewage/wastewater pumps, especially configured to pump liquid such as sewage/wastewater that may comprise plastic objects, hygiene articles, fabrics, rags, disposable gloves, face masks, wet wipes, etc. The present invention relates specifically to a hydraulic unit for said pumps and applications, and to a pump comprising such a hydraulic unit comprising an open impeller. The hydraulic unit of the pump further comprises an impeller seat, which is also known under the terms suction cover and inlet insert/-plate.

[0002] Thus, in accordance with a first aspect, the present invention relates to a hydraulic unit comprising an open impeller and a housing that defines a pump chamber having an axial inlet opening and an outlet opening and that comprises an impeller seat located in said pump chamber, wherein the impeller comprises a cover plate, a centrally located hub and at least one spirally swept blade connected to the cover plate and to the hub, wherein each blade of the impeller comprises a leading edge adjacent the hub and a trailing edge at the periphery of the impeller and a lower edge, wherein the lower edge extends from the leading edge to the trailing edge and separates a suction side of the blade from a pressure side of the blade, wherein the lower edge of the blade is located opposite an upper surface of the impeller seat, wherein the impeller is suspended at a lower end of an axially extending drive shaft assembly, and wherein the impeller is displaceable back and forth in the axial direction in relation to the impeller seat between a lower position and an upper position, during operation of the pump.

[0003] Further, in accordance with a second aspect, the present invention relates to a pump for pumping liquid comprising solid matter, said pump comprising a drive unit and an hydraulic unit as described hereinabove.

Background of the invention and State of the art

[0004] In sewage/wastewater treatment plants, septic tanks, wells, pump stations, etc., it occurs that solid matter/contaminations such as socks, sanitary towels, papers, disposable diapers, disposable gloves, face masks, rags, wet wipes, etc. obstruct the pump that is submerged in the basin/tank from pumping the liquid, i.e. socalled hard clog of the pump. This means that solid matter has entered the pump inlet and prevents the impeller from rotating, and thereby prevents the pump to transport water. Thus, the pump is jammed by a piece of solid matter being wedged between the impeller and the pump housing/impeller seat.

[0005] When the open impeller and the impeller seat are positioned at a fixed distance from each other, the pollutants are sometimes too large to simply pass through the pump. Large pieces of solid matter may in worst case cause the impeller to become suddenly wedged, thus entailing a risk of seriously damaging the pump, such as bearings and drive unit. Such an unintentional shutdown is costly since it entails expensive, tedious and unplanned maintenance work.

[0006] European patent EP 1357294 discloses such a pump that comprises an impeller that is arranged to rotate in the pump housing of the pump, said impeller being suspended by a drive shaft, and the pump comprises an impeller seat. The impeller seat of the '294 thereto comprises a guide pin and a feeding groove. The impeller is located at a fixed distance in the axial direction in relation to the impeller seat. The guide pin is connected to the inlet wall of the impeller seat and extends inwards from the inlet wall. The guide pin is configured together with the leading edge of the blades of the impeller to guide the solid matter outwards to the feeding groove, and the feeding groove is configured together with the lower edge of the blades of the impeller to transport the solid matter to the volute and out via the outlet. However, the guide pin and feeding groove together with fixed distance to the impeller will every now and then jam solid matter firmly between the impeller and impeller seat, and there is a risk that the impeller cannot rotate in either direction.

[0007] European patent EP 1899609 discloses a pump that partly solves the problem of fixed distance between the impeller seat and the impeller. The pump comprises an open impeller that is arranged to rotate in the pump housing of the pump, said impeller being suspended by a drive shaft, and the pump comprises an impeller seat having a guide pin and a feeding groove. The impeller is displaceable in the axial direction in relation to the impeller seat during operation of the pump in order to allow larger pieces of solid matter to pass through, contaminations that otherwise would risk blocking the pump and/or wedge the impeller. During forward rotation of the impeller, the impeller is displaced in the axial direction away from the impeller seat by the solid matter when the solid matter enters the gap between the leading edge of the blade and the guide pin and/or the gap between the lower edge of the blade and the upper surface of the impeller seat.

[0008] Thereto, such pumps and applications are often protected by suitable monitoring and control units that monitors the operation of the pump and controls the operation of the pump based thereon. For instance, when the rotational speed of the impeller decreases and/or the power consumption is increased the impeller and/or the pump housing is partly clogged and the monitoring and control unit enters a cleaning sequence that comprises the step of rotating the impeller in the reverse/backwards direction, i.e. opposite the direction of rotation of the impeller during forward/normal operation of the pump.

Large pieces of solid matter may sometimes be too large and cause hard clog of the pump despite the impeller is displaceable in the axial direction, and the above cleaning sequence is capable to remove also such solid matter from the hydraulic unit and transport it back into the tank/reservoir of the pump station. One drawback of having an axially fixed impeller is that the torque available for reverse rotation has to be larger than the torque allowable in the forward direction, for the pump to theoretically be able to remove the clogging solid matter by itself by means of cleaning sequence. Thus, the potential torque in the forward direction cannot be utilized.

[0009] However, one disadvantage of having an axially displaceable impeller is that it is difficult to secure a correct and optimal axial distance between the lower edge of the impeller and the impeller seat, since the axial displaceability unfortunately entails an instability/tiltability of the impeller in relation to the impeller seat and if the axial distance is too small there is an immediate risk that the lower edge of the blade of the impeller strikes the impeller seat. A greater axial distance entails decreased efficiency of the pump. Thereto, each time the impeller is displaced away from the impeller seat during operation, the duty of the pump is decreased. Thereto, in many situations the impeller and impeller seat would have been able to cut or shred the solid matter into smaller pieces if the impeller would have been locked at a fixed distance from the impeller seat, but the axial displaceability entails that solid matter is kept in one piece whereby the cleaning sequence is initiated and during the cleaning sequence the duty of the pump is non-existing at the same time as the pump consumes power.

[0010] Thus, there is a specific need to provide a pump and hydraulic unit that operates in an accurate, reliable and cost-efficient manner, also when the liquid comprises solid matter.

[0011] It should also be mentioned that submersible pumps of the above kind are used to pump liquid from basins that are difficult to maintain and that pumps often operate for 12 or more hours daily. It is therefore utterly desirable to provide a pump with long working life, efficient operation and a pump that is self-cleaning.

Object of the Invention

[0012] The present invention aims at obviating abovementioned disadvantages and failings of previously known pumps, and at providing an improved hydraulic unit and an improved pump.

[0013] A primary object of the present invention is to provide an improved hydraulic unit and pump of the initially defined type, wherein the risk of clogging is decreased at the same time as the ability of self-cleaning of the pump is increased. It is also an object of the present invention to provide an improved hydraulic unit and pump of the type defined in the introduction, wherein the efficiency over time is increased. It is another object of the present invention to provide an improved hydraulic unit and pump of the type defined in the introduction, wherein the torque required during reverse operation during cleaning sequence is decreased, and being much lower than the torque allowable during forward operation. It is also an object of the present invention to provide an improved hydraulic unit and pump of the initially defined type, wherein said pump is able to disintegrate the solid matter in order to decrease the risk of clogging the cut water of the pump, and the downstream piping of the pump station. A further object of the present invention is to provide a pump and an hydraulic unit wherein the impeller does not run the risk of becoming tilted as a consequence of asymmetrically applied force acting in the axial direction against the impeller.

Brief Description of the Inventive Features

[0014] According to the invention at least the primary object is attained by means of the initially defined hydraulic unit and pump having the inventive features defined in the independent claims. Preferred embodiments of the present invention are further defined in the dependent claims.

[0015] According to a first aspect of the present invention, there is provided a hydraulic unit of the initially defined type, which is characterized in that the impeller comprises an engagement unit that is in engagement with the drive shaft assembly, wherein the engagement unit of the impeller and the drive shaft assembly in cooperation bias the impeller towards said lower position during forward rotation of the drive shaft assembly and are configured to displace the impeller towards said upper position during reverse rotation of the drive shaft assembly.

[0016] According to a second aspect of the present invention, there is provided a pump of the initially defined type, which is characterized in that the pump comprises an inventive hydraulic unit.

[0017] Thus, the present invention is based on the insight of the inventors that it is advantageous to have a fixed impeller during forward/normal rotation of the drive shaft assembly/impeller and an axially displaceable impeller during reverse/backwards rotation of the drive shaft assembly. During forward rotation the impeller is biased/forced to a fixed and stable position located at an optimal and correct axial distance in relation to the impeller seat, and during reverse rotation the impeller is mechanically lifted from the impeller seat which immediately and distinctly disengage/unclog the solid matter. Since less torque is needed to unwedge/unclog solid matter than the torque and momentum used to wedge the solid matter, a higher torque can be used during forward operation and thereby the ability/likelihood to disintegrate solid matter between the impeller and impeller seat is increased. Should the impeller not be able to disintegrate the solid matter and the solid matter wedges the pump, then the pump will guaranteed be able to unwedge/unclog the solid matter due to the forced displacement of the impeller in the axial direction during the reverse rotation of the drive shaft assembly. Thus, shorter cleaning sequences and decreased losses, increased efficiency during forward operation, decreased risk for inadequate self-cleaning. Thereto, the rotational speed needed during reverse rotation is decreased, and the number of turns needed during reverse rotation is decreased, i.e. the power consumed for cleaning is decreased.

[0018] According to various embodiments of the present invention, the drive shaft assembly comprises an external thread, and wherein the engagement unit of the impeller comprises an internal thread engaging said external thread of the drive shaft assembly. Thereby, upon reverse rotation of the drive shaft assembly, the impeller will become displaced in a complete axial direction if the solid matter prevents the impeller to rotate in the reverse direction.

[0019] According to various embodiments of the present invention, the external thread of the drive shaft assembly is constituted by a multiple start thread, preferably having equal to or more than two thread starts, and equal to or less than ten thread starts. Thereby, the helix angle of the threads may be increased without the risk of increased stability against tilting of the impeller. A plurality of thread starts entails that the play in the thread engagement decreases.

[0020] According to various embodiments of the present invention, the pitch of an individual thread of the external thread of the drive shaft assembly is equal to or more than 10 millimetre per turn, and equal to or less than 30 millimetre per turn. Thereby, the unwedging of the solid matter is immediate and distinct, and thereby the length of the reverse rotation during the cleaning sequence may be decreased.

[0021] According to various embodiments of the present invention, the hub of the impeller comprises a cylinder-shaped recess and an axially extending hole that connects the cylinder-shaped recess and the pump chamber, the drive shaft assembly comprising an axially extending pin that projects from said lower end of the drive shaft assembly, wherein said pin is arranged in said hole of the impeller and is arranged to prevent the pumped liquid to enter the cylinder-shaped recess of the impeller.

[0022] Further advantages with and features of the invention will be apparent from the other dependent claims as well as from the following detailed description of preferred embodiments.

Brief Description of the Drawings

[0023] A more complete understanding of the abovementioned and other features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments in conjunction with the appended drawings, wherein:

- Fig. 1 is a schematic cross-sectional side view of a hydraulic unit belonging to a pump according to the present invention, the figure showing the impeller in a lower position, wherein the impeller comprises a first embodiment of the engagement unit,
- Fig. 2 is a schematic cross-sectional view from above of the inventive hydraulic unit, i.e. disclosing the housing of the pump and the impeller seat,
- Fig. 2 is a schematic perspective view from above of an impeller seat,
- Fig. 4 is a schematic perspective view from below of an open impeller,
- Fig. 5 is a schematic cross-sectional side view of the impeller according to figure 4,
- Fig. 6 is a schematic cross-sectional side view of the lower part of the drive shaft assembly and an impeller comprising a second embodiment of the engagement unit, wherein the impeller is in the lower position,
- Fig. 7 is a schematic cross-sectional side view of the lower part of the drive shaft assembly and the impeller, wherein the impeller is in the upper position,
- Fig. 8 is a schematic perspective view from above of the lower part of the drive shaft assembly, and
- Fig. 9 is a schematic perspective view from above of the engagement unit of the impeller.

Detailed description of preferred embodiments of the Invention

[0024] The present invention relates specifically to the field of submergible pumps especially configured for pumping liquid comprising solid matter, such as sewage/wastewater pumps. Such pumps are configured to pump liquid such as sewage/wastewater that may comprise plastic objects, hygiene articles, fabrics, rags, disposable gloves, face masks, wet wipes, etc., i.e. solid matter comprising elastic and durable components.

[0025] Reference is initially made to figures 1 and 2, wherein a part of an inventive pump is disclosed, more specifically the hydraulic unit, generally designated 1, of an inventive pump. In the figures the remaining parts of the pump are removed for the sake of clarity. These parts are inter alia a drive unit and a sealing unit, the latter being positioned between the hydraulic unit and the drive unit in order to prevent water to enter the motor of the drive unit. The present invention relates in general to pumps, but in the preferred embodiment the pump is a submersible, centrifugal pump. The present invention will be described in conjunction with such a pump, without in any way being limited thereto.

[0026] The hydraulic unit 1 of the pump comprises an axial inlet 2, an outlet 3 and a pump chamber 4 located intermediate said inlet 2 and said outlet 3, i.e. the pump chamber 4 is located downstream the inlet 2 and upstream the outlet 3. The pump chamber is also known as volute. The pump chamber 4 is partly delimited by an impeller seat, generally designated 5, that encloses the inlet 2, and by a housing 6. The pump chamber 4 is also delimited by an intermediate wall 7 separating the pump chamber 4 from the rest of the pump. Said impeller seat 5 is also known as suction cover or wear plate or inlet insert/plate. In some applications, the outlet 3 of the hydraulic unit also constitutes the outlet of the pump 1, and in other applications the outlet 3 of the hydraulic unit is connected to a separate outlet of the pump 1. The outlet of the pump 1 is configured to be connected to an outlet conduit (not shown). The outlet 3 is radially directed in the disclosed embodiments, but according to alternative embodiments the outlet may be directed in the tangential direction.

[0027] The drive unit of the pump 1 comprises an electric motor arranged in a liquid tight pump housing, and a drive shaft 9 extending from the electric motor through the intermediate wall 7 and into the pump chamber 4. The hydraulic unit 1 furthermore comprises an open impeller 8 arranged to rotate in said pump chamber 4, wherein the impeller 8 is connected to and driven in rotation by the drive shaft 9 during operation of the pump, whereby liquid is sucked into said inlet 2 and pumped out of said outlet 3 by means of the rotating impeller 8 when the pump is active. The pump housing 6, the impeller seat 5, the impeller 8, and other essential components, are preferably made of metal, such as aluminum and steel. The electric motor is powered via an electric power cable extending from a power supply, and the pump comprises a liquid tight lead-through receiving the electric power cable. The impeller seat 5 is preferably releasably connected to the housing 6, e.g. by means of a plurality of bolts, in such a way that the impeller seat 5 cannot rotate relative the housing 6. According to alternative embodiments, the impeller seat 5 is in press fit engagement with the housing 6. According to other alternative embodiments, the impeller seat 5 and the housing 6 are constituted by a single component.

[0028] According to preferred embodiments, the pump, more precisely the electric motor, is operatively connected to a control unit, such as an Intelligent Drive comprising a Variable Frequency Drive (VFD). Thus, said pump is configured to be operated at a variable operational speed [rpm], by means of said control unit. According to preferred embodiments, the control unit is located inside the liquid tight pump housing, i.e. it is preferred that the control unit is integrated into the pump. The control unit is configured to control the operational speed of the pump. According to alternative embodiments the control unit is an external control unit, or the control unit is separated into an external sub-unit and an internal sub-unit. The operational speed of the pump is more precisely the rpm of the electric motor and of the impeller 8 and correspond/relate to a control unit output frequency. The control unit is configured and capable of operating the pump and impeller 8 in a normal direction of rotation, i.e. forward, in order to pump liquid, and in an opposite direction of rotation, i.e. reverse/backwards, in order to clean or unblock the pump chamber 4 and the impeller 8.

[0029] The components of the pump are usually cooled down by means of the liquid/water surrounding the pump. The pump is designed and configured to be able to operate in a submerged configuration/position, i.e. during operation be located entirely under the liquid surface. However, it shall be realized that the submersible pump during operation must not be entirely located under the liquid surface but may continuously or occasionally be fully or partly located above the liquid surface. In dry installed applications the submergible pump comprises dedicated cooling systems.

[0030] The axial inlet of the impeller seat 5 is defined by an inlet wall 10. The inlet wall 10 is more or less cylindrical or slightly conical having a decreasing flow area in the downstream direction, i.e. upwards in figure 1. The impeller seat 5 comprises an upper surface 11, which upper surface 11 is the surface that is seen from above, i.e. figure 2. The upper surface 11 may comprise a flat section and an arc-shaped section, wherein the flat section may be located in a horizontal plane or be tilted inwards/downwards and the arc-shaped section interconnects the flat section and the inlet wall 10. According to various embodiments the upper surface 11 only comprises an arc-shaped section extending all the way from the inlet wall 10 to the periphery of the impeller seat 5. According to other various embodiments the upper surface 11 only comprises a flat section extending all the way from the inlet wall 10 to the periphery of the impeller seat 5.

[0031] Reference is now also made to figure 3. According to various embodiments the impeller seat 5 comprises a guide pin 12 connected to and extending radially inwards from said inlet wall 10. The main function of the guide pin 12 is to scrape off solid matter from the impeller 8 and feed the solid matter outwards, during normal operation of the pump 1.

[0032] According to various embodiments, said impeller seat 5 also comprises a feeding groove 13 arranged in the upper surface 11 of the impeller seat 5 and extending from the inlet wall 10 to the periphery of the impeller seat 5. An inlet of the feeding groove 13 is preferably located adjacent the guide pin 12. The feeding groove 13 is preferably swept/curved in the direction of rotation of the pump, more precisely the direction of rotation of the impeller 8, seen from the inlet wall 10 towards the periphery. Part of the inlet of the feeding groove 13 may be arranged in the inlet wall 10 of the impeller seat 5. The function of the feeding groove 13 is to feed the solid matter outwards towards the wall of the housing 6, during normal operation of the pump, in cooperation with the impeller 8. The feeding groove 13 and the guide pin 12 preferably used together, however it shall be realized that they are perfectly usable one without the other.

[0033] Reference is now made to figures 4 and 5 disclosing the open impeller 8. The impeller 8 comprises a cover plate 14, a centrally located hub 15 and at least two spirally swept blades 16 connected to the cover plate 14 and to the hub 15. The blades 16 are equidistant located around the hub 15. The blades 16 are also known as vanes, and the cover plate 14 is also known as upper shroud.

[0034] The blades 16 are swept/curved, seen from the hub 15 towards the periphery of the impeller 8, in a direction opposite the direction of rotation of the impeller 8 during normal (liquid pumping) operation of the pump. Thus, seen from below, i.e. figure 3, the direction of rotation of the impellers 8 during normal operation is counterclockwise.

[0035] Each blade 16 comprises a leading edge 17 adjacent the hub 15 and a trailing edge 18 at the periphery of the impeller 8. The leading edge 17 of the impeller 8 is located upstream the trailing edge 18, wherein two adjacent blades 16 together defines a channel extending from the leading edges 17 to the trailing edges 18. The leading edge 17 is located at the inlet of the impeller seat 5, and the leading edge 17 is spirally swept from the hub outwards, in the same direction as the sweep of the blade 16. During operation, the leading edges 17 grabs hold of the liquid, the channels accelerate and/or add pressure to the liquid, and the liquid leaves the impeller 8 at the trailing edges 18. Thereafter the liquid is guided by the pump housing 4 of the hydraulic unit towards the outlet 3. Thus, the liquid is sucked into the impeller 8 and pressed out from the impeller 8. Said channels are also delimited by the cover plate 14 of the impeller 8 and by the impeller seat 5. The diameter of the impeller 8 and the shape and configuration of the channels/blades determines the pressure build up in the liquid and the pumped flow.

[0036] Each blade 16 also comprises a lower edge 19, wherein the lower edge 19 extends from the leading edge 17 to the trailing edge 18 and separates a suction side/-surface 20 of the blade 16 from a pressure side/surface 21 of the blade 16. The lower edge 19 is configured to be facing and located opposite the upper surface 11 of the impeller seat 5. Thus, the suction side 20 of one blade 16 is located opposite the pressure side 21 of an adjacent blade 16. The leading edge 17 and the trailing edge 18 also separates the suction side 20 from the pressure side 21. The leading edge 17 is preferably rounded. The lower edge 19 of the blade 16 is connected to the leading edge 17 at a location corresponding to the interface between the inlet wall 10 and the upper wall 11 of the impeller seat 5.

[0037] The axial distance, i.e. the gap height, between the leading edge 17 of the blade 16 and the upper surface 22 of the guide pin 12 is equal to or more than 0,05 mm and equal to or less than 1 mm, preferably equal to or more than 0,1 mm and equal to or less than 0,5 mm. The same applies to the distance between the upper surface 11 of the impeller seat 5 and the lower edge 19 of the blade 16.

[0038] Thereby the solid matter located between the leading edge of the guide pin 12 and the leading edge of the blade 16 will be scraped off outwards upon normal operation of the pump, i.e. forward rotation of the impeller 8. Thus, said range will promote scraping off solid matter at the interface between the leading edge of the blade 16 and the leading edge of the guide pin 12, and between the lower edge 19 of the blade 16 and the feeding groove 13.

[0039] According to various embodiments, the radially innermost part of the guide pin 12 is located radially outside a lower surface of the hub 15 of the impeller 8. Thereby, solid matter may not be trapped between the hub 15 of the impeller 8 and the upper surface 22 of the guide pin 12, and solid matter raked off inwards during reverse operation of the pump 1 will more easily leave the guide pin 12.

[0040] Reference is now primarily made to figures 6 and 7, wherein the impeller 8 is suspended at a lower end of an axially extending drive shaft assembly, generally designated 23. In figure 6 the drive shaft 9 of the drive shaft assembly 23 is removed. According to the invention, the impeller 8 is displaceable back and forth in the axial direction in relation to the impeller seat 5, and in relation to the drive shaft assembly 23, between a lower position (disclosed in figures 1 and 6) and an upper position (disclosed in figure 7). The impeller 8 comprises a cylinder-shaped recess 24, the lower end of the drive shaft assembly 23 being received in said cylinder-shaped recess 24.

[0041] The drive shaft assembly 23 comprises the drive shaft 9 and a sleeve 25, wherein the sleeve 25 surrounds and is releasably connected to the drive shaft 9. Hence, the sleeve 25 makes up the lower end of the drive shaft assembly 23. The sleeve 25 is connected to the drive shaft 9 in any suitable way in order to co-rotate with the drive shaft 9, and in the disclosed embodiment the sleeve 25 is connected to the drive shaft 9 by means of a conventional tool cone arrangement 26. The drive shaft 9 is cone-shaped and the tool cone 26 is pressed onto the drive shaft 9 using a bolt 27 that is in engagement with the drive shaft 9 and is tightened, whereupon the tool cone 26 is forced radially outwards such that the sleeve 25 is braced or clamped on the drive shaft 9. The advantage of this embodiment is that the axial position between the sleeve 25 and the drive shaft 9 may be readily adjusted by loosening the bolt 27, axially displacing the sleeve 25 and subsequently retightening of the bolt 27. According to an alternative embodiment the drive shaft assembly 23 is a homogenous detail, i.e. the sleeve 25 and the drive shaft 9 are constituted by a single element. According to another embodiment, the sleeve 25 screwed onto the end of a cylinder-shaped, non-conical, drive shaft 9 and such embodiment entails adjustment of the axial position between the sleeve 25 and the drive shaft 9 by arranging a desired number of spacing shims between the sleeve 25 and the drive shaft 9.

[0042] The impeller 8 comprises a hole 28 in the hub 15, said hole 28 connecting the cylinder-shaped recess 24 with the pump chamber 4. One purpose of said hole 28 is to allow for introduction of a suitable tool to manipulate the screw 27 in order to connect the sleeve 25 to the drive shaft 9.

[0043] According to various embodiments, the drive shaft assembly 23 comprises an axially extending pin 29 that projects downwards at the lower end of the drive shaft assembly 23. Said pin 29 is arranged in said hole 28 of the impeller 8 in order to prevent the pumped liquid from entering the cylinder-shaped recess 24 of the impeller 8. The axial displaceability of the impeller 8 in relation to the drive shaft assembly 23 entails that also the hole 28 of the impeller 8 is axially displaceable in relation to the pin 29. A liquid sealing 30 is preferably arranged between said hole 28 and said pin 29 in order to prevent that the pumped liquid and solid matter from entering the cylinder-shaped recess 24 from below. Hence, the pin 29 is always arranged in said hole 28, regardless of the mutual position of the impeller 8 and the drive shaft assembly 23. The hole 28 may comprise and/or be constituted by a liner element 31, wherein the pin 29 is guided by the liner element 31 and thereby the cooperation of the pin 29 and the liner element 31 support to decrease/eliminate the risk of tilting the impeller 8 when an asymmetric force is axially applied on the latter. The pin 29 is preferably tube-shaped and has a through-hole 32, the purpose of which is to allow introduction of a suitable tool to manipulate the screw 27 in order to connect the sleeve 25 to the drive shaft 9. Furthermore, a plug or cover, not shown, may be inserted in the through-hole 32 of the pin 29 in order to prevent solid matter from entering and clogging the head of the bolt 27.

[0044] The present invention is based on a new configuration of the hydraulic unit 1. The impeller 8 comprises an engagement unit 33 that is in engagement with the drive shaft assembly 23. The engagement unit 33 of the impeller 8 and the drive shaft assembly 23 in cooperation bias the impeller 8 towards said lower position (figure 6) during forward rotation of the drive shaft assembly 23 and are configured to displace/bias the impeller 8 towards said upper position (figure 7) during reverse rotation of the drive shaft assembly 23.

[0045] According to various embodiments, the minimum axial distance between the lower edge 19 of the blade 16 of the impeller 8 and the upper surface 11 of the impeller seat 5, when the impeller 8 is in the upper position, is equal to or more than 5 mm and equal to or less than 30 mm, preferably equal to or less than 40.

[0046] Reference is now also made to figures 8 and 9. According to various preferred embodiments, the drive shaft assembly 23, i.e. the sleeve 25, comprises an external thread 34, and wherein the engagement unit 33 of the impeller 8 comprises an internal thread 35 engaging said external thread 34 of the drive shaft assembly 23.

[0047] When the drive shaft 9 is driven in the forward direction, the water resistance, the inertia of the impeller 8 and the weight of the impeller 8 entails that the impeller 8 is biased downwards towards the lower position and the sleeve 25 of the drive shaft assembly 23 abut a stop element 36 in the axial direction, which stop element 36 prevents further axial displacement of the impeller 8. The stop element 36 is arranged in the cylinder-shaped recess 24 of the impeller 8, and the stop element 36 cooperates with the sleeve 25 in the radial direction in order to support to decrease/eliminate the risk of tilting the impeller 8 when an asymmetric force is axially applied on the latter.

[0048] Thus, when the drive shaft 9 and the impeller are driven/rotated in the forward direction, the impeller 8 will be positioned in the lower position and there is a fixed and locked distance between the lower edge 19 of the impeller 8 and the upper surface 12 of the impeller seat 5. Should a piece of solid matter become jammed/wedged between the impeller 8 and the impeller seat 5, the rotation of the drive shaft 9 and of the impeller 8 is stopped. Thereafter the drive shaft 9, and the sleeve 25 are rotated in the reverse direction at the same time as the impeller 8, due to inertia and due to the wedging solid matter, is prevented from rotating or rotates less then the drive shaft assembly 23. The thread engagement is thereby configured to displace the impeller in the upwards direction towards the upper position whereby the wedging force against the solid matter is removed. When the impeller 8 reaches the upper position the impeller 8 co-rotates with the drive shaft assembly 23 and the solid matter is transported out through the inlet 2 or through the outlet 3. Thereafter the drive shaft 9 is once more driven in the forward direction and the impeller 8 is once more biased towards the lower position.

[0049] The engagement unit 33 is preferably in press fit engagement with the cylinder-shaped recess 24 of the impeller 8, thereby as a safety measure the engagement unit 33 may slip in relation to the impeller 8 in order to protect the drive shaft 9 and drive unit of the pump when a sudden jamming of the impeller 8 happens at high rotational speed.

[0050] With reference to figure 1, disclosing an alternative embodiment of the means for displaceing/biasing the impeller 8 upwards and downwards, the engagement unit 33 is constituted by one or more projection(s), preferably three, that are in engagement with angled recesses/grooves in the envelope surface of the sleeve 25. The grooves may have a constant inclination, i.e. follow a helix, or may have different/varying inclination. When the impeller 8 is in the lower position and in the upper position the projections abut the respective ends of the grooves.

[0051] According to various embodiments, with reference to figures 6-9, the helix angle of the external thread 34 of the drive shaft assembly 23 is equal to or more than 3 degrees, and equal to or less than 45 degrees, preferably equal to or more than 5 degrees and equal to or less than 20 degrees. Thereby the external thread 34 of the sleeve 25 and the internal thread 35 of the engagement unit 33 will not suffer from self-locking when the impeller 8 is in the upper and lower positions.

[0052] According to various embodiments, the external thread 34 of the drive shaft assembly 23 is preferably constituted by a trapezoidal thread. According to alternative embodiments, the external thread 34 may be constituted by a knuckle thread or a square thread. The same of course applies mutatis mutandis also to the internal thread 35.

[0053] According to various embodiments, the external thread 34 of the drive shaft assembly 23 is constituted by one start thread or a multiple start thread, preferably having equal to or more than two thread starts, and equal to or less than ten thread starts (preferably 5 thread starts). A plurality of thread starts, i.e. parallel threads, provides less play and greater stability to the thread engagement. Preferably the pitch of an individual thread of the external thread 34 of the drive shaft assembly 23 is equal to or more than 10 millimetre per turn, and equal to or less than 30 millimetre per turn. The same of course applies mutatis mutandis also to the internal thread 35.

Feasible modifications of the Invention

[0054] The invention is not limited only to the embodiments described above and shown in the drawings, which primarily have an illustrative and exemplifying purpose. This patent application is intended to cover all adjustments and variants of the preferred embodiments described herein, thus the present invention is defined by the wording of the appended claims and thus, the equipment may be modified in all kinds of ways within the scope of the appended claims.

[0055] It should also be noted that all information regarding terms such as above, under, upper, lower, etc. shall be interpreted/read having the equipment being oriented according to the figures, with drawings oriented in such a way that the reference numerals can be properly read. Thus, such and similar terms only indicate mutual relations in the shown embodiments, wherein these embodiments may be changed if the equipment of the present invention is provided with another structure/design.

[0056] It shall also be pointed out that even thus it is not explicitly stated that features from a specific embodiment may be combined with features from another embodiment, the combination shall be considered obvious, if the combination is possible.

Claims

1. Hydraulic unit (1) of a pump configured for pumping liquid comprising solid matter, said hydraulic unit comprising an open impeller (8) and a housing (6) that defines a pump chamber (4) having an axial inlet opening (2) and an outlet opening (3) and that comprises an impeller seat (5) located in said pump chamber (4),

   - wherein the impeller (8) comprises a cover plate (14), a centrally located hub (15) and at least one spirally swept blade (16) connected to the cover plate (14) and to the hub (15), wherein each blade (16) of the impeller (8) comprises a leading edge (17) adjacent the hub (15) and a trailing edge (18) at the periphery of the impeller (8) and a lower edge (19), wherein the lower edge (19) extends from the leading edge (17) to the trailing edge (18) and separates a suction side (20) of the blade (16) from a pressure side (21) of the blade (16),
   - wherein the lower edge (19) of the blade (16) is located opposite an upper surface (11) of the impeller seat (5),
   - wherein the impeller (8) is suspended at a lower end of an axially extending drive shaft assembly (23), and
   - wherein the impeller (8) is displaceable back and forth in the axial direction in relation to the impeller seat (5) between a lower position and an upper position, during operation of the pump,

   characterized in that the impeller (8) comprises an engagement unit (33) that is in engagement with the drive shaft assembly (23), wherein the engagement unit (33) of the impeller (8) and the drive shaft assembly (23) in cooperation bias the impeller (8) towards said lower position during forward rotation of the drive shaft assembly (23) and are configured to displace the impeller (8) towards said upper position during reverse rotation of the drive shaft assembly (23).

2. The hydraulic unit (1) according to claim 1, wherein the minimum axial distance between the lower edge (19) of the blade (16) of the impeller (8) and the upper surface (11) of the impeller seat (5), when the impeller (8) is in the lower position, is equal to or more than 0,05 mm and equal to or less than 1 mm.

3. The hydraulic unit (1) according to claim 1 or 2, wherein the minimum axial distance between the lower edge (19) of the blade (16) of the impeller (8) and the upper surface (11) of the impeller seat (5), when the impeller (8) is in the upper position, is equal to or more than 5 mm and equal to or less than 30 mm.

4. The hydraulic unit (1) according to any of claims 1-3, wherein the drive shaft assembly (23) comprises an external thread (34), and wherein the engagement unit (33) of the impeller (8) comprises an internal thread (35) engaging said external thread (34) of the drive shaft assembly (23).

5. The hydraulic unit (1) according to claim 4, wherein the hub (15) of the impeller (8) comprises a cylinder-shaped recess (24), and wherein the engagement unit (33) of the impeller (8) is constituted by a sleeve/insert having the internal thread (35) on the inside

thereof.

6. The hydraulic unit (1) according to claim 4 or 5, wherein the helix angle of the external thread (34) of the drive shaft assembly (23) is equal to or more than 5 degrees, and equal to or less than 45 degrees, preferably equal to or less than 20 degrees.

7. The hydraulic unit (1) according to any of claims 4-6, wherein the external thread (34) of the drive shaft assembly (23) is constituted by a trapezoidal thread.

8. The hydraulic unit (1) according to any of claims 4-7, wherein the external thread (34) of the drive shaft assembly (23) is constituted by a multiple start thread, preferably having equal to or more than two thread starts, and equal to or less than ten thread starts.

9. The hydraulic unit (1) according to claim 8, wherein the pitch of an individual thread of the external thread (34) of the drive shaft assembly (23) is equal to or more than 10 millimetre per turn, and equal to or less than 30 millimetre per turn.

10. The hydraulic unit (1) according to any preceding claim, wherein the hub (15) of the impeller (8) comprises a cylinder-shaped recess (24) and an axially extending hole (28) that connects the cylinder-shaped recess (24) and the pump chamber (4), the drive shaft assembly (23) comprising an axially extending pin (29) that projects from said lower end of the drive shaft assembly (23), wherein said pin (29) is arranged in said hole (28) of the impeller (8) and is arranged to prevent the pumped liquid to enter the cylinder-shaped recess (24) of the impeller (8).

11. The hydraulic unit (1) according to any preceding claim, wherein the impeller seat (5) comprises a feeding groove (13) arranged in the upper surface (11) of the impeller seat (5) and extending from an inlet wall (10) of the impeller seat (5) to the periphery of the impeller seat (5).

12. The hydraulic unit (1) according to any preceding claim, wherein said impeller seat (5) comprises a guide pin (12) connected to and extending radially inwards from an inlet wall (10) of the impeller seat (5), wherein the leading edge (17) of the blade (16) is located opposite an upper surface (22) of the guide pin (12).

13. The hydraulic unit (1) according to claim 12, wherein the radially innermost part of the guide pin (12) is located radially outside a lower surface of the hub (15) of the impeller (8).

14. Pump for pumping liquid comprising solid matter, said pump comprising a drive unit and an hydraulic unit (1) that comprises an open impeller (8) and a housing (6) that defines a pump chamber (4) having an axial inlet opening (2) and an outlet opening (3) and that comprises an impeller seat (5) located in said pump chamber (4),

- wherein the impeller (8) comprises a cover plate (14), a centrally located hub (15) and at least one spirally swept blade (16) connected to the cover plate (14) and to the hub (15), wherein each blade (16) of the impeller (8) comprises a leading edge (17) adjacent the hub (15) and a trailing edge (18) at the periphery of the impeller (8) and a lower edge (19), wherein the lower edge (19) extends from the leading edge (17) to the trailing edge (18) and separates a suction side (20) of the blade (16) from a pressure side (21) of the blade (16),
- wherein the lower edge (19) of the blade (16) is located opposite an upper surface (11) of the impeller seat (5), and
- wherein the impeller (8) is suspended at a lower end of an axially extending drive shaft assembly (23), and
- wherein the impeller (8) is displaceable back and forth in the axial direction in relation to the impeller seat (5) between a lower position and an upper position, during operation of the pump,

characterized in that the impeller (8) comprises an engagement unit (33) that is in engagement with the drive shaft assembly (23), wherein the engagement unit (33) of the impeller (8) and the drive shaft assembly (23) in cooperation bias the impeller (8) towards said lower position during forward rotation of the drive shaft assembly (23) and are configured to displace the impeller (8) towards said upper position during reverse rotation of the drive shaft assembly (23).

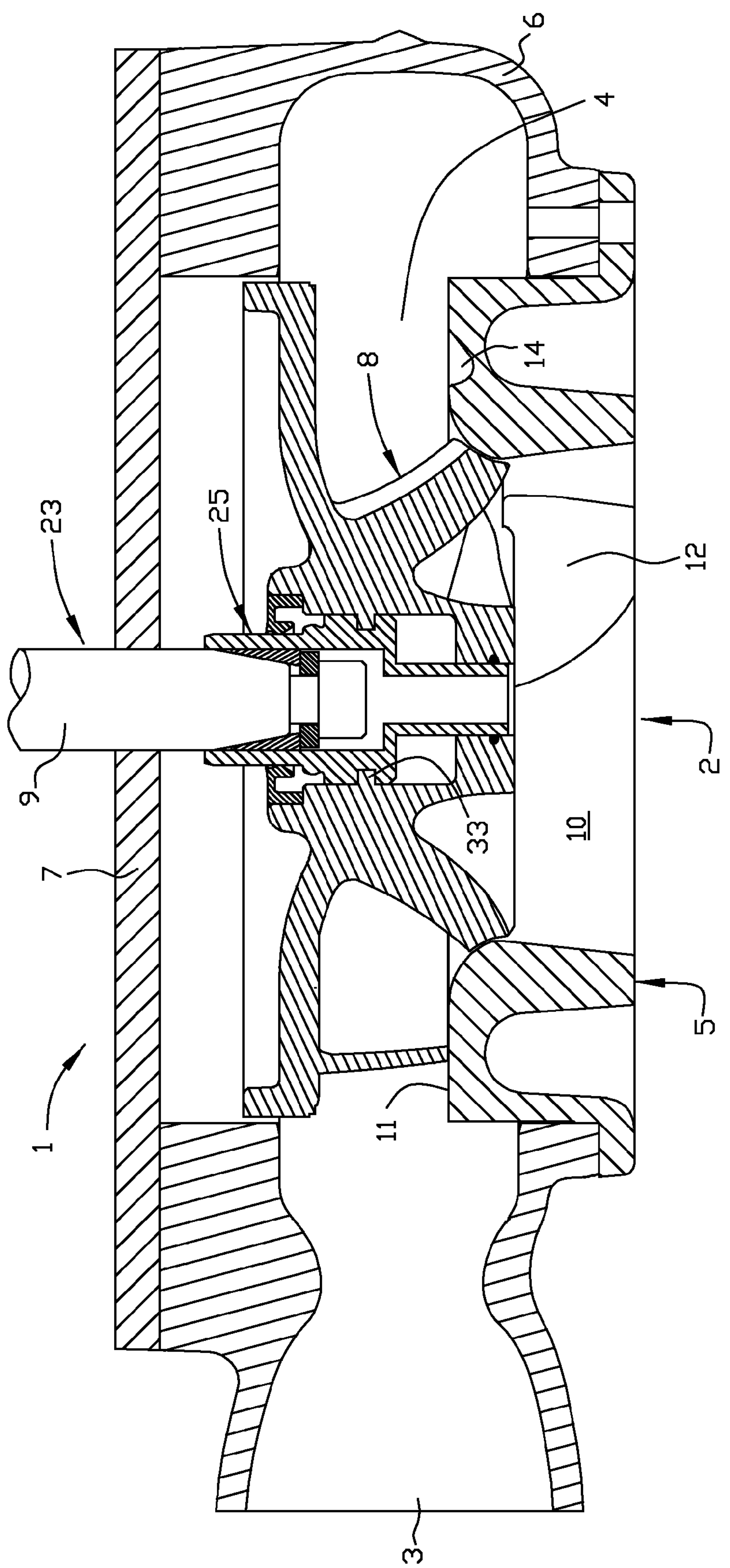

Fig. 1

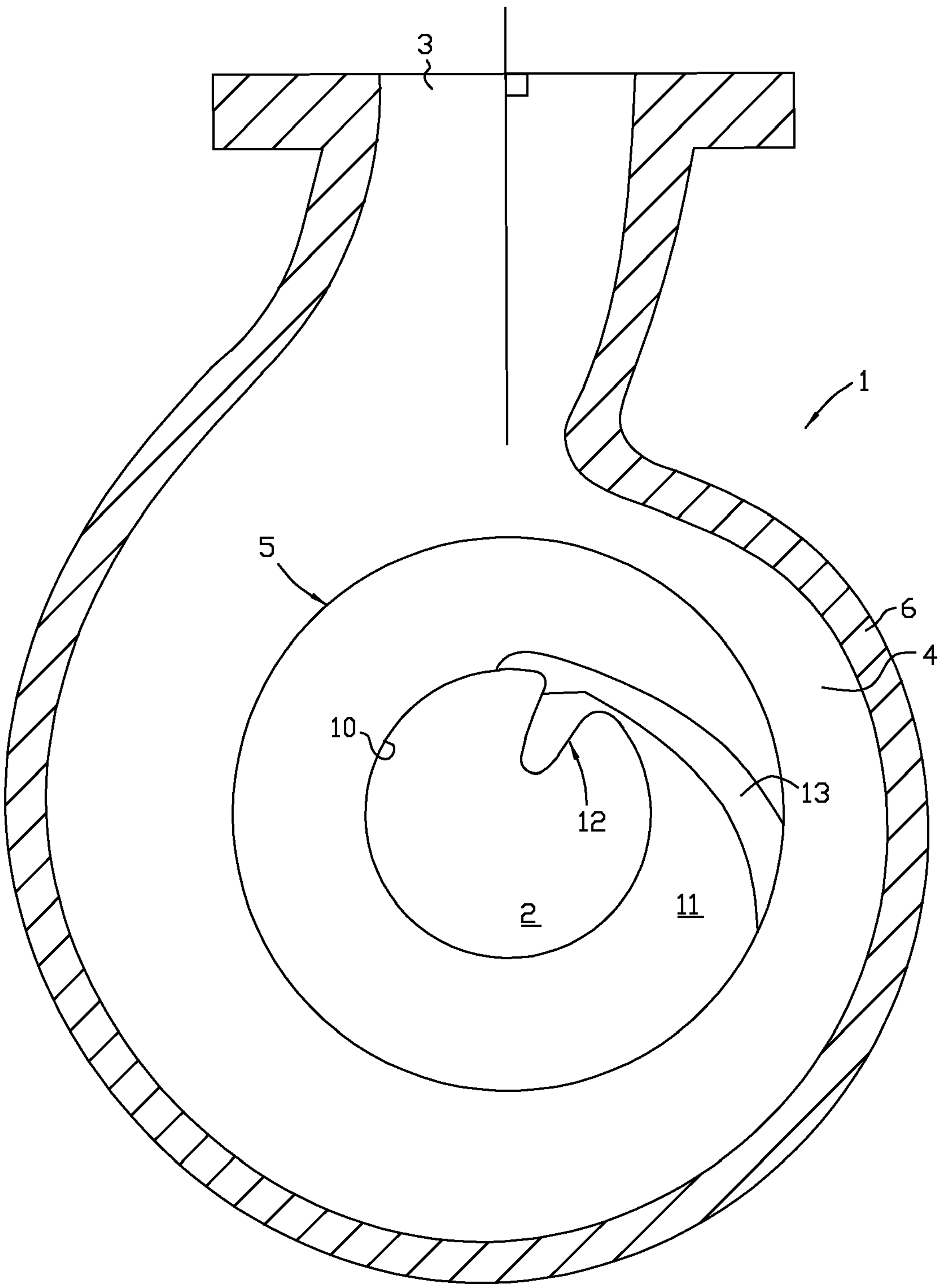

Fig. 2

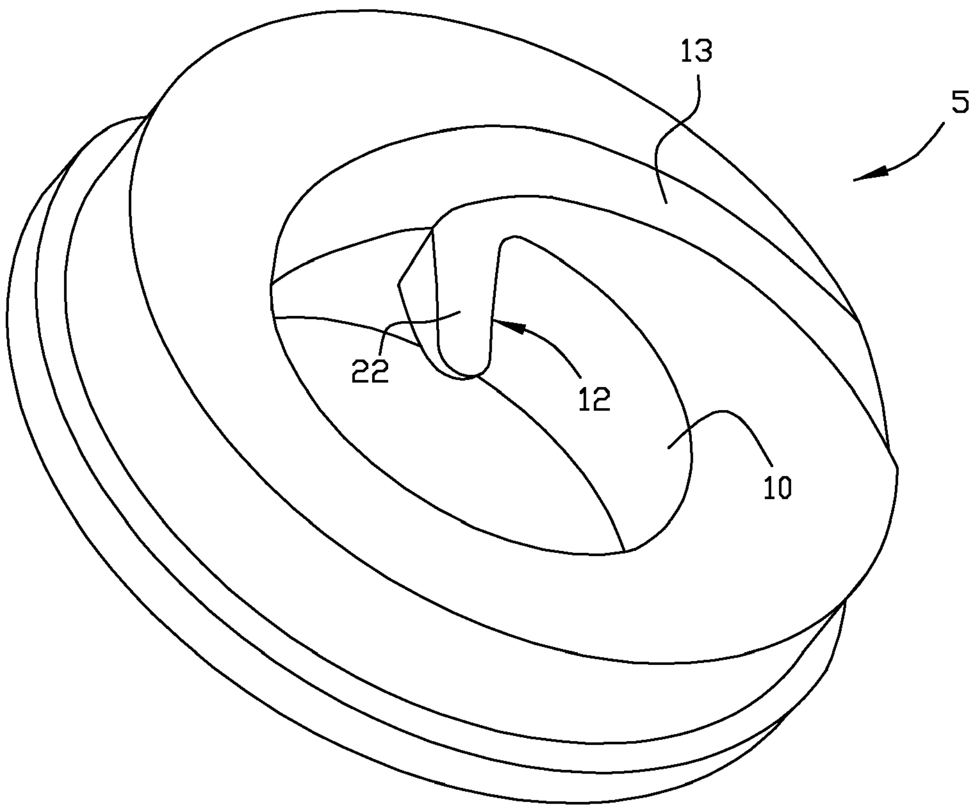

Fig. 3

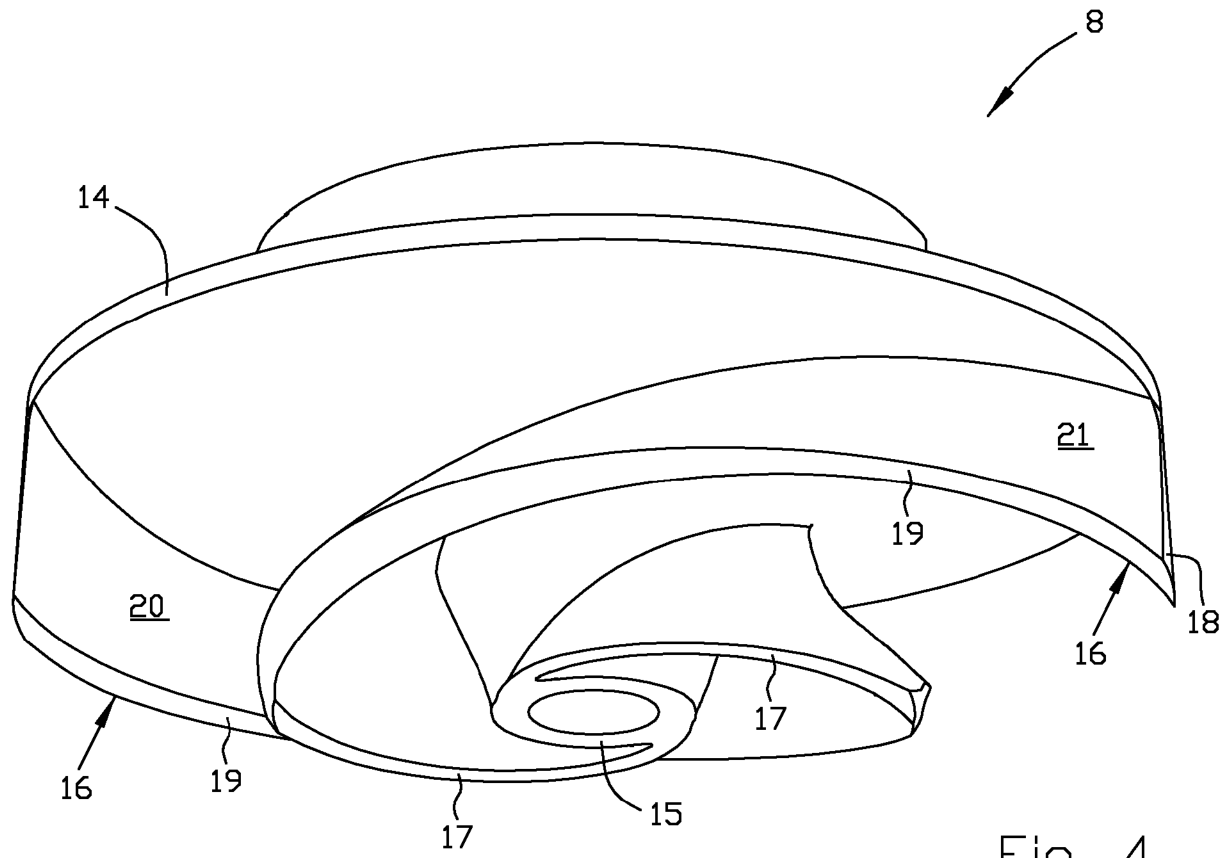

Fig. 4

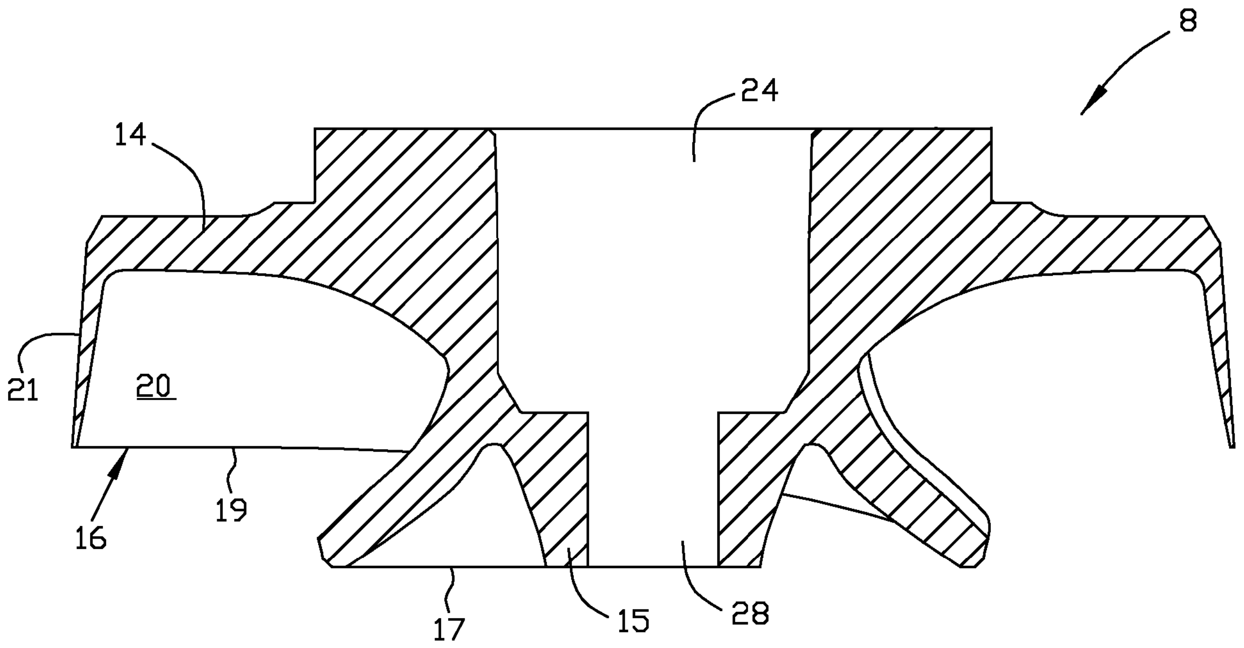

Fig. 5

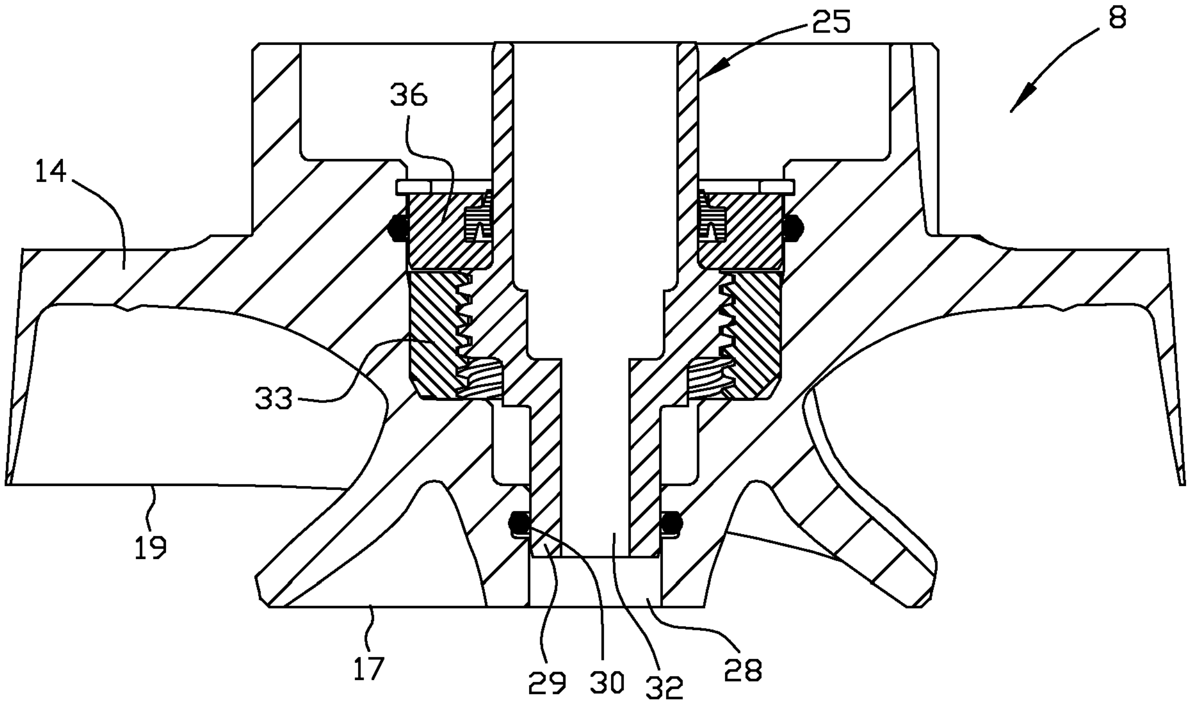

Fig. 6

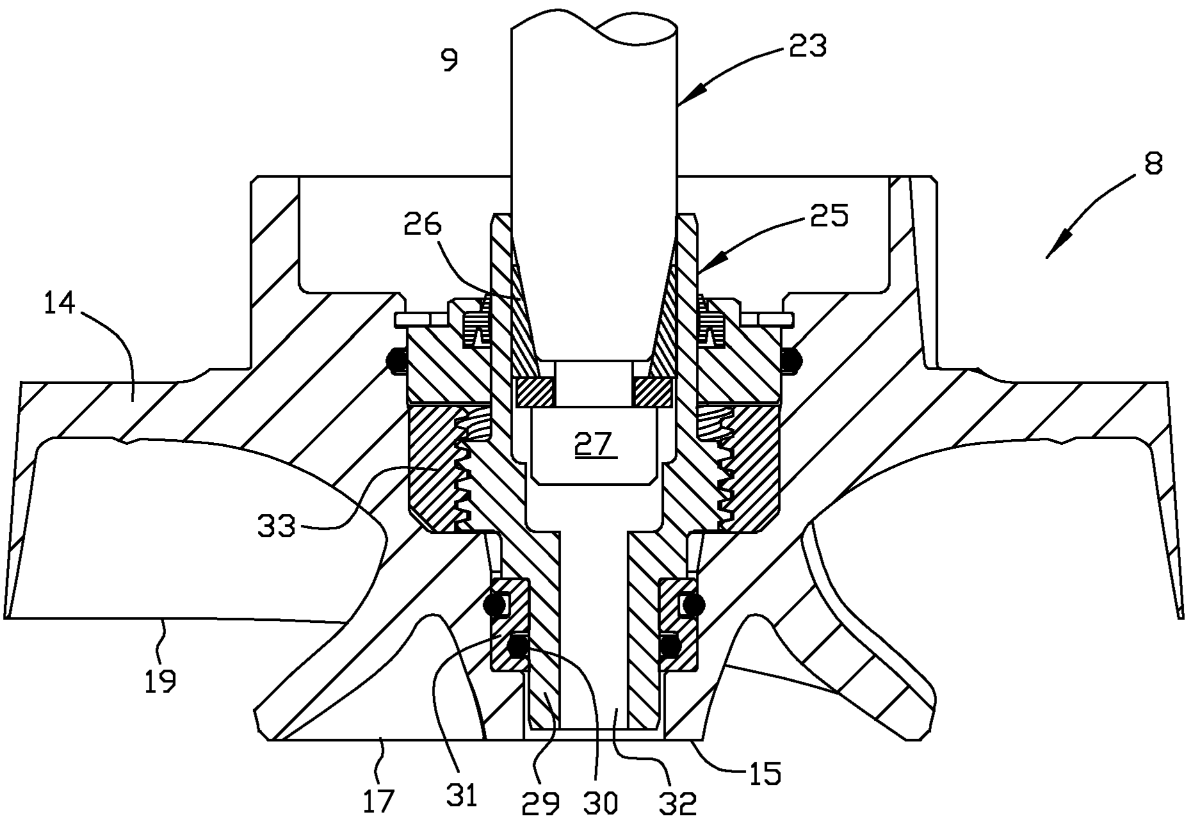

Fig. 7

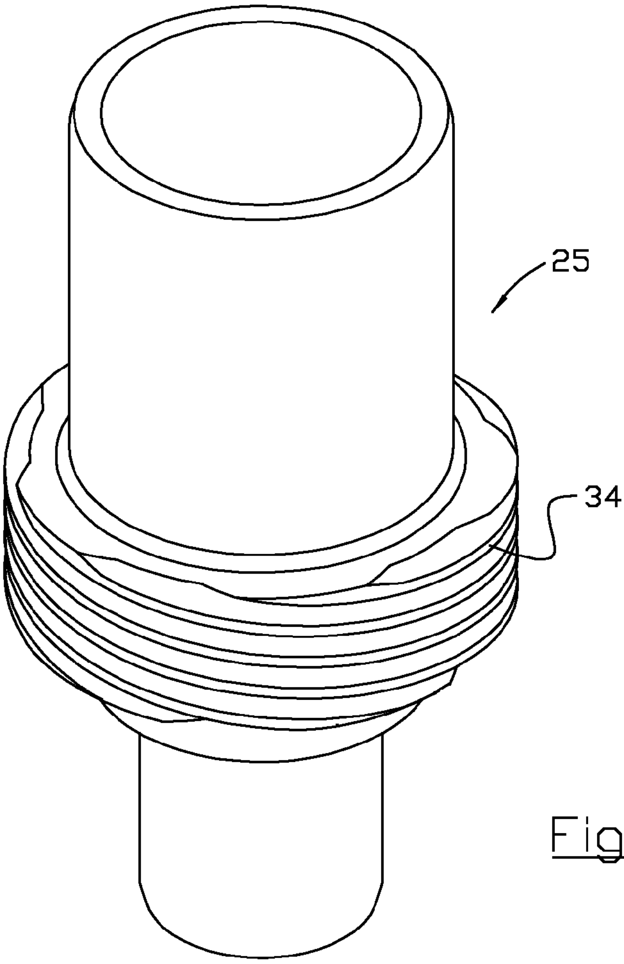

Fig. 8

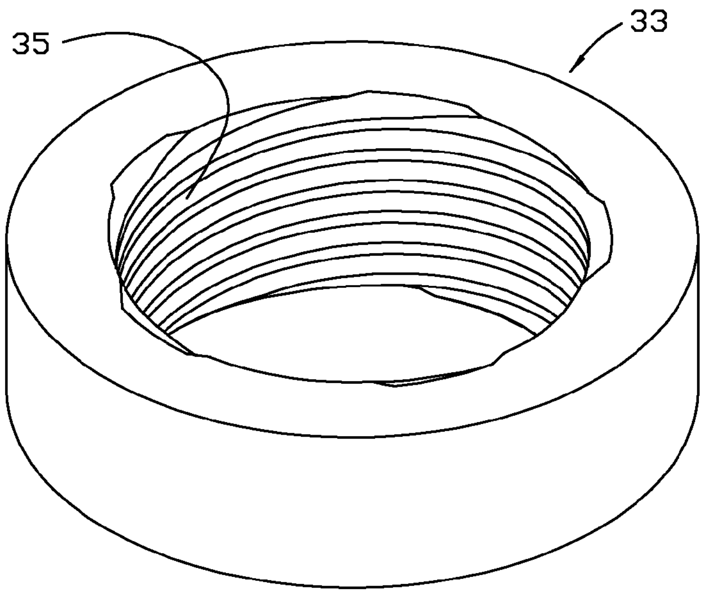

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 5449

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2010/119365 A1 (ANDERSSON PATRIK [SE]) 13 May 2010 (2010-05-13) * paragraph [0007] - paragraph [0045]; figures 1-6 * * abstract *	1-14	INV. F04D7/04 F04D15/00 F04D29/042 F04D29/20
Y	DE 10 2006 027319 A1 (WILO AG [DE]) 20 December 2007 (2007-12-20) * paragraph [0001] - paragraph [0015]; figures 1,2 * * abstract *	1-14	
A	EP 1 293 678 B1 (WILO AG [DE]) 10 October 2007 (2007-10-10) * paragraph [0001] - paragraph [0017]; figures 1-3 * * abstract *	1-14	
A	DE 876 642 C (M A K MASCHB KIEL AG) 15 May 1953 (1953-05-15) * page 1, line 1 - page 2, line 75; figure 1 * * abstract *	1-14	TECHNICAL FIELDS SEARCHED (IPC)
			F04D
A	DE 15 28 747 B1 (LICENTIA GMBH) 24 September 1970 (1970-09-24) * column 1, line 1 - column 3, line 3; figure 1 * * abstract *	1-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 May 2024	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

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13-05-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010119365 A1	13-05-2010	CN 101680453 A	24-03-2010
		EP 2145111 A1	20-01-2010
		US 2010119365 A1	13-05-2010
		WO 2009020420 A1	12-02-2009
DE 102006027319 A1	20-12-2007	DE 102006027319 A1	20-12-2007
		WO 2007144054 A1	21-12-2007
EP 1293678 B1	10-10-2007	DE 10145411 A1	03-04-2003
		EP 1293678 A2	19-03-2003
DE 876642 C	15-05-1953	NONE	
DE 1528747 B1	24-09-1970	CH 439981 A	15-07-1967
		DE 1528747 B1	24-09-1970
		FR 1498891 A	20-10-1967
		NL 6615515 A	10-05-1967

EPO FORM P0459

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Patent documents cited in the description

- EP 1357294 A **[0006]**
- EP 1899609 A **[0007]**