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(54) **PUMP AND HYDRAULIC UNIT FOR A PUMP**

(57) The invention relates to a hydraualic unit for a pump (1) configured for pumping liquid comprising solid matter, wherein the hydraulic unit comprises an channel impeller (8) and a housing (6) having an axial inlet (2) and a radial outlet (3), the housing (6) defining a volute (4) having a cutwater (16), a cutwater wedge angle (ω) and a cutwater angle (Y), wherein a smallest cross-sectional area of the volute (4) is located in an axial geometrical plane that comprises an axially extending center axis of the inlet (2) of the housing (6) and that extends radially outwards to an upstream end of the cutwater (16). The hydraulic unit is characterized in that in a radial geometrical plane that is perpendicular to an axially extending center axis of the inlet (2) of the housing (6) and that comprises the longest radius of the volute (4) at the smallest cross-sectional area of the volute (4), the cutwater wedge angle (ω) is equal to or greater than 80 degrees and equal to or less than 150 degrees, and the cutwater angle (Y) is equal to or greater than 15 degrees and equal to or less than 70 degrees.

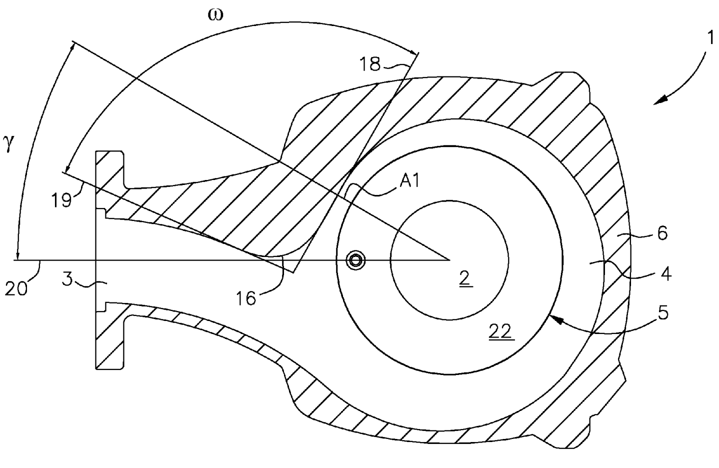

Fig. 7

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Description

Technical field of the Invention

[0001] The present invention relates generally to the field of pumps configured to pump 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 polymers, hygiene articles, fabrics, rags, disposable gloves, face masks, etc. The present invention relates specifically to a hydraulic unit for said pumps and applications, and to a pump comprising such a hydraulic unit and an impeller. The hydraulic unit of a pump comprises an impeller seat is also known under the terms suction cover and inlet insert/plate. The inventive pump may be wet installed and/or dry installed, and may be of submergible type in both applications/installations.

[0002] In accordance with a first aspect, the present invention relates to a hydraulic unit that comprises a channel impeller and a housing having an axial inlet and a radial outlet, the housing defining a volute having a cutwater, a cutwater wedge angle (ω) and a cutwater angle (Y), wherein a smallest cross-sectional area (A1) of the volute is located in an axial geometrical plane that comprises an axially extending center axis of the inlet of the housing and that extends radially outwards to an upstream end of the cutwater.

[0003] In accordance with a second aspect, the present invention relates to a pump for pumping liquid comprising solid matter, the pump comprises a drive unit having an electric motor and an axially extending drive shaft and comprising a hydraulic unit having a channel impeller and a housing, wherein the impeller is operatively connected to said electric motor via said drive shaft and driven in rotation in said housing during operation of the pump, wherein the housing comprises an axial inlet and a radial outlet, the housing defining a volute having a cutwater, a cutwater wedge angle (ω) and a cutwater angle (Y), wherein a smallest cross-sectional area (A1) of the volute is located in an axial geometrical plane that comprises an axially extending center axis of the inlet of the housing and that extends radially outwards to an upstream end of the cutwater.

Background of the Invention

[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, etc. obstruct the pump that is configured to transport the liquid away from the basin/tank, i.e. socalled hard clog of the pump. This means that solid matter has entered the pump inlet and/or the pump volute and prevents the impeller from rotating. Thus, the pump is jammed by some solid matter being wedged between the impeller and the housing/impeller seat.

[0005] When the impeller and the impeller seat are positioned at a fixed distance from each other, the pollutants are sometimes simply too large to pass through the pump. Large pieces of solid matter may in worst case cause the impeller to become wedged, thus 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 1899609 discloses a pump that partly solves the problem of fixed distance between the impeller seat and the impeller. The pump comprises an impeller that is arranged to rotate in the volute 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 to block the pump or wedge the impeller. The guide pin is connected to the inlet wall of the impeller seat and extends towards the centre of the impeller and towards the centre of the impeller seat. The impeller is displaced by the solid matter when the solid matter enters the gap between the leading edge of the blade and the guide pin and/or enters the gap between the lower edge of the blade and the upper surface of the impeller seat.

[0007] However, the inventor has identified that solid matter, especially solid matter having elongated shape and/or long fibres and/or comprises elastic and durable components, when having passed the impeller tends to get caught over the cutwater and will block/clog the volute of the pump and have negative effect on the pumped flow, i.e. the efficiency of the pump. This is the case both for applications having axially fixed impeller and axially displaceable impeller.

[0008] Thereby more solid matter risk to accumulate in the volute and at the inlet of the pump, i.e. the risk for severe clogging of the pump is increasing rapidly. Such an unintentional shutdown, when the pump is stopped and requires maintenance/repair, is costly since it entails expensive, tedious and unplanned maintenance work, and thereto the pump station risk to become flooded due to reduced efficiency of a partly clogged/blocked pump.

[0009] Another way to prevent blockage/clogging at the cutwater is to use a chopper pump as disclosed in EP 1891331, wherein solid matter having long fibers is disintegrated at the inlet of the pump. However, such disintegration of solid matter decrease the efficiency of the pump since it is more energy consuming to cut/tear solid matter apart then having the solid matter pass through the pump undivided.

[0010] Such pumps and applications may be 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 increased the guide pin and/or the volute of the impeller is partly clogged and the monitoring and control unit enters a cleaning sequence that comprises the step of rotating the impeller in the backward direction, i.e. opposite the direction of rotation of the impeller during normal operation of the pump.

Object of the Invention

[0011] The present invention aims at obviating the aforementioned disadvantages and failings of previously known impeller seats and pumps, and at providing an improved hydraulic unit and pump.

[0012] A primary object of the present invention is to provide an improved hydraulic unit and pump of the initially defined type that reduces the risk of having solid matter caught over the cutwater, and thereby reduces or prevents blockage/clogging and avoid reduced efficiency of the pump.

[0013] 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 in a more reliable manner allows solid matter to pass through the pump without having to disintegrate the solid matter.

Summary of the Invention

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

[0015] According to the present invention, there is provided a hydraulic unit and pump of the initially defined type, which are characterized in that in a radial geometrical plane that is perpendicular to the axially extending center axis of the inlet of the housing and that comprises the longest radius of the volute at the smallest cross-sectional area (A1) of the volute, the cutwater wedge angle (ω) is equal to or greater than 80 degrees and equal to or less than 150 degrees, and the cutwater angle (Y) is equal to or greater than 15 degrees and equal to or less than 70 degrees.

[0016] Thus, the present invention is based on the insight of the inventors that it is advantageous to have a cutwater that is less conspicuous, i.e. having a larger radius of curvature, and that is located downstream the outlet of the pump in order to reduce the risk of having solid matter caught over the cutwater when the solid matter is on its way to leave the volute together with the liquid.

[0017] According to various embodiments of the present invention, the cutwater wedge angle (ω) is taken between a first geometrical line that is tangent to an upstream end of the cutwater and a second geometrical line that is tangent to a downstream end of the cutwater. Thus, the cutwater edge angle (ω) is a direct measure concerning the bluntness/sharpness of the cutwater of the volute.

[0018] According to various embodiments of the present invention, the cutwater angle (Y) is taken at the intersection between the axial geometrical plane having the smallest cross-sectional area of the volute and a third geometrical line/plane that extends between the center axis of the inlet of the housing and the center of the outlet of the housing. Thus, the cutwater angle (Y) is a direct measure concerning the location of the cutwater in the volute.

[0019] According to various embodiments of the present invention, the impeller is displaceable back and forth in the axial direction in relation to the drive shaft during operation of the pump. Thereby the solid matter is prevented from getting wedged between the impeller and impeller seat, and is allowed to enter the volute undivided. The inventive ranges of the cutwater wedge angle (ω) and the cutwater angle (Y) minimizes the risk that undivided solid matter entering the volute gets caught over the cutwater, whereby these features in combination provides the bonus effect that the efficiency of the pump during the passing of solid matter therethrough does not decrease.

[0020] According to various embodiments of the present invention, the housing comprises an impeller seat having an inlet wall that defines the axial inlet of the housing, wherein the impeller seat comprises a guide pin connected to and extending radially inwards from said inlet wall. Thereby the solid matter is prevented from getting accumulated at the inlet of the pump, and is forced to enter the volute more rapidly. The inventive ranges of the cutwater wedge angle (ω) and the cutwater angle (Y) minimizes the risk that undivided solid matter entering the volute gets caught over the cutwater, whereby these features in combination provides the bonus effect that the efficiency of the pump during the passing of solid matter therethrough does not decrease.

[0021] 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

[0022] 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 pump taken from a first direction, i.e. a submersible wastewater pump comprising an inventive hydraulic unit,
- Fig. 2 is a schematic cross-sectional side view of the pump according to figure 1 taken from the opposite direction in relation to figure 1,
- Fig. 3 is a schematic cross-sectional view from above of the inventive hydraulic unit according to a first exemplifying embodiment explicitly dis-

closing the cutwater wedge angle (ω), i.e. disclosing the housing of the hydraulic unit and the impeller seat,

Fig. 4 is a schematic cross-sectional view from above of the inventive hydraulic unit according to figure 3 especially disclosing the cutwater angle (Y),

Fig. 5 is a schematic cross-sectional side view seen along arrow xx disclosed in figure 4,

Fig. 6 is a schematic cross-sectional side view seen along arrow yy disclosed in figure 4, and

Fig. 7 is a schematic cross-sectional view from above of the inventive hydraulic unit according to a second exemplifying embodiment.

Detailed description of preferred embodiments of the invention

[0023] The present invention relates specifically to the field of 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 polymers, hygiene articles, fabrics, rags, disposable gloves, face masks, etc., i.e. solid matter comprising elastic and durable components. The present invention relates specifically to the configuration of a hydraulic unit suitable for said pumps and applications. The present invention is also equally suitable when the pumped media comprises long fibers, such as hair, pieces of textile and the like.

[0024] Reference is initially made to figures 1 and 2, disclosing a schematic illustration of an inventive pump, generally designated 1, i.e. a centrifugal pump. The pump 1 comprises a drive unit and a hydraulic unit.

[0025] The hydraulic unit of the pump 1 comprises an axial inlet 2, a radial outlet 3 and a volute 4 located intermediate said inlet 2 and said radial outlet 3, i.e. the volute 4 is located downstream the inlet 2 and upstream the outlet 3. The volute 4 is partly delimited by an impeller seat, generally designated 5, that encloses the inlet 2 and by a housing 6. The volute 4 is also delimited by an intermediate wall structure 7 separating the volute 4 from the drive unit of the pump 1, said intermediate wall structure 7 being schematically disclosed in figures 1 and 2. The intermediate wall structure 7 may also comprise a liquid seal chamber or the like sealing arrangement between the volute 4 and the motor compartment of the drive unit. Said volute 4 is also known as pump chamber and said impeller seat 5 is also known as suction cover, wear plate or inlet insert/plate. Figures 1 and 2 are taken at one and the same axial geometrical plane that comprises an axially extending center axis of the inlet 2 of the housing 6 and a center of the radial outlet 3 of the housing 6. Thus, figure 1 is a cross-sectional side view of the pump 1 taken from a first direction and figure 2 is a cross-sectional side view of the pump 1 from the opposite direction in relation to figure 1.

[0026] According to some applications, the outlet of the hydraulic unit also constitutes the outlet 3 of the pump 1 (as disclosed in the figures), and according to other applications the outlet of the hydraulic unit is connected to a separate outlet 3 of the pump 1, e.g. via a cooling jacket volume. The outlet 3 of the pump 1 is configured to be connected to an outlet conduit (not shown). Thereto the pump 1 comprises a channel impeller, generally designated 8, wherein the impeller 8 is located in the volute 4, i.e. the hydraulic unit of the pump 1 comprises the impeller 8. The impeller 8 is a channel impeller having open, semi-open or closed channels, and the impeller 8 comprises an outer channel height (h). The outer channel height (h) is located at the periphery of the impeller 8, and defines the height of the liquid flow leaving the impeller 8 and entering the volute 4.

[0027] Thus, it shall be pointed out that the inventive hydraulic unit is not a vortex hydraulic unit since such vortex hydraulic units does not face the identified problems to be solved or operational preconditions.

[0028] The drive unit of the pump 1 comprises an electric motor, generally designated 9, arranged in a liquid tight pump housing 10, and a drive shaft 11 extending from the electric motor 9 through the intermediate wall structure 7 and into the volute 4. The channel impeller 8 is connected to and driven in rotation by the drive shaft 11 during operation of the pump 1, wherein liquid is sucked into said inlet 2 and pumped out through said outlet 3 by means of the rotating impeller 8 when the pump 1 is active. The pump housing 10, the 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 9 is powered via an electric power cable 12 extending from a power supply, and the pump 1 comprises a liquid tight lead-through 13 receiving the electric power cable 12.

[0029] According to various embodiments, the pump 1, more precisely the electric motor 9, is operatively connected to a control unit 14, such as an Intelligent Drive comprising a Variable Frequency Drive (VFD). Thus, said pump 1 is configured to be operated at a variable operational speed [rpm], by means of said control unit 14. According to various embodiments, the control unit is located inside the liquid tight pump housing 10, e.g. in an electronics compartment 15, i.e. it is preferred that the control unit 14 is integrated into the pump 1. The control unit 14 is configured to control the operational speed of the pump 1. 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 1 is more precisely the rpm of the electric motor 9 and of the impeller 8 and correspond/relate to a control unit output frequency. The control unit 14 is configured and capable of operating the pump 1 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. backwards, in order to clean or unblock the volute 4 and impeller 8.

[0030] The components of the pump 1 are usually cold down by means of the liquid/water surrounding the pump 1, i.e. when the pump 1 is in a submerged configuration/application. In dry installed applications/configurations the pump 1 comprises dedicated cooling systems. Both configurations may comprise a submergible pump 1. The pump 1 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 1 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.

[0031] The present invention is based on a new and improved configuration of the hydraulic unit, that is configured to be used in pumps 1 suitable for pumping liquid comprising solid matter, for instance wastewater/sewage comprising long fibers and elastic/durable components that risk clogging and block the pump 1. When solid matter clog/block the pump 1 the torque and consumed power increases and in order not to strain the pump 1 the control unit may enter a cleaning sequence whereupon the impeller 8 is rotating backwards for a short period of time. If such backward operation, one or several attempts, is not sufficient, maintenance staff need to visit the pump station and manually clean/service the pump 1. More precisely, the present invention is based on a new and improved configuration of the housing 6 and volute 4 of the hydraulic unit that has less tendency to become blocked.

[0032] Reference is now also made to figures 3 and 4, disclosing a first exemplifying embodiment of the housing 6 and volute 4. Figures 3 and 4 are taken at a radial geometrical plane 17 that is perpendicular to the axially extending center axis of the inlet 2 of the housing 6 and of the pump 1 and that comprises the longest radius of the volute 4 at the smallest cross-sectional area A1 of the volute 4 (see figure 5). Said radial geometrical plane 17 is according to various embodiments located close to the midpoint of the outer channel height (h) of the impeller 8. This is also known as the mean plane of the hydraulic unit. In some pumps the radial geometrical plane 17 comprises the radially extending center axis of the radial outlet 3 of the housing 6. The radial geometrical plane 17 is depicted in figure 2. The normal direction of rotation of the impeller 8 is clockwise in figures 3 and 4.

[0033] The housing 6 and the volute 4 comprises in a conventional way a cutwater 16, wherein the cutwater 16 is configured to separate/divide a rotating liquid flow following the direction of rotation of the impeller 8 and an output liquid flow that is directed towards the outlet 3 of the pump 1. The volute 4, i.e. the cutwater 16, has a cutwater wedge angle (ω) that defines/causes the separation of the two liquid flows in the volute 4. The volute 4, i.e. the cutwater 16, has a cutwater angle (Y) that defines the location of the cutwater 16 in relation to the radial outlet 3, and at least partly defines the size of the portion of the volute 4 at which pressure is added to the liquid, i.e. volute pressure angle (α).

[0034] The cutwater 16 comprises an upstream end at which the liquid flow follows the direction of rotation of the impeller 8 and a downstream end at which the output liquid flow is heading/directed towards the radial outlet 3. At the upstream end of the cutwater 16, the volute 4 has the smallest cross-sectional area of the volute 4, wherein the cross-sectional area of the volute 4 are taken in axial geometrical planes comprising the axially extending center axis of the inlet 2 of the housing 6 and extending radially outwards therefrom. The axial geometrical plane comprising the smallest cross-sectional area of the volute 4 is disclosed in figure 5, thus figure 5 is a cross-sectional side view of the entire hydraulic unit seen along arrow xx disclosed in figure 4. The smallest cross-sectional area has reference A1.

[0035] Seen in the radial geometrical plane 17, at the upstream end of the cutwater 16 the radius of the volute 4 taken from the center axis of the inlet 2 of the housing 6 is the smallest radius of the volute 4, i.e. the shortest radial distance between the impeller 8 and the housing 6 in the radial geometrical plane 17. This "shortest radial distance" is also the longest radius of the volute 4 at the smallest cross-sectional area A1 of the volute 4. Thus, from the upstream end of the cutwater 16, seen in the normal direction of rotation of the impeller 8, the cross-sectional area of the volute 4 increase, and preferably also the radius of the volute 4 in the radial geometrical plane 17 increase, to the end of the volute pressure angle (α). The axial geometrical plane comprising the end of the volute pressure angle (α) is disclosed in figure 6, and the corresponding cross-sectional area in this axial geometrical plane has reference A2. Thus, figure 6 is a cross-sectional side view of the entire hydraulic unit seen along arrow yy disclosed in figure 4.

[0036] The part of the volute 4 at which pressure is added to the liquid, starts at the upstream end of the cutwater 16 and extends/continues the volute pressure angle (α) about the center axis of the inlet 2. At the end of the volute pressure angle (α), seen in the normal direction of rotation of the impeller 8, the inner wall of the housing 6 changes from concave shape to an outlet wall 3a extending to the radial outlet 3, wherein the outlet wall 3a has convex shape or a combination of straight shape and convex shape.

[0037] According to the invention, seen in the radial geometrical plane 17, the cutwater wedge angle (ω) is equal to or greater than 80 degrees and equal to or less than 150 degrees, and the cutwater angle (Y) is equal to or greater than 15 degrees and equal to or less than 70 degrees. Having a cutwater wedge angle (ω) in said range entails that long pieces of solid matter will not fasten across the cutwater 16, i.e. partly following the rotating liquid flow and partly following the output liquid flow, which is a great risk when the cutwater wedge angle (ω) is small and the cutwater consequently being sharp. A cutwater wedge angle (ω) greater than said range entails that separation/division between the rotating liquid flow and the output liquid flow is unprecise and the efficiency of the pump 1 decrease, i.e. the amount of rotating liquid flow in relation to the amount of output liquid flow becomes too high. Having a cutwater angle (Y) in said range entails that solid matter will more easily follow the output liquid flow since the cutwater 16 is located offset the radial outlet 3, seen in the direction of rotation of the impeller 8. Many conventional prior art pumps have a negative cutwater angle (Y), seen in the direction of rotation of the impeller.

[0038] According to various embodiments, the cutwater wedge angle (ω) is taken at the intersection between a first geometrical line 18 that is tangent to the upstream end of the cutwater 16 and a second geometrical line 19 that is tangent to the downstream end of the cutwater 16. The geometrical lines are located in the radial geometrical plane 17.

[0039] The downstream end of the cutwater 16 is located at the transition between the convex shape of the cutwater 16 and the outlet wall 3a extending to the outlet 3, wherein the outlet wall 3a has concave shape or straight shape or a combination of straight shape and concave shape.

[0040] According to various embodiments, the axial geometrical plane having the smallest cross-sectional area of the volute 4, i.e. the upstream end of the cutwater 16, is located at the transition from the convex shape of the cutwater 16 to concave shape, seen in the direction of rotation of the impeller 8.

[0041] According to various embodiments, the cutwater angle (Y) is taken at the intersection between the axial geometrical plane having the smallest cross-sectional area of the volute 4 and a third geometrical line/plane 20 that extends between the center axis of the inlet 2 of the housing 6 and the center of the outlet 3 of the housing 6. Preferably, the third geometrical line/plane 20 coincide with the radially extending center axis of the outlet 3 of the housing 6. The third geometrical plane 20 comprises the axially extending center axis of the inlet 2 of the housing 6 and extends radially outwards therefrom.

[0042] According to various embodiments, the cutwater angle (Y) is equal to or more than 20 degrees. Thereby, the solid matter will more easily follow the output liquid flow.

[0043] According to various embodiments, the cutwater wedge angle (ω) is equal to or more than 90 degrees. Thereby it is more difficult for long pieces of solid matter to fasten over the cutwater 16. According to various embodiments, the cutwater wedge angle (ω) is equal to or less than 130 degrees.

[0044] Reference is now made to figure 7 disclosing a second exemplifying embodiment of the hydraulic unit, wherein this is just an example of another set of cutwater wedge angle (ω) and cutwater angle (Y), both the cutwater wedge angle (ω) and the cutwater angle (Y) has been decreased in relation to the embodiment disclosed in figures 3 and 4. According to figure 7 the cutwater 16 is a little more sharp than the cutwater 16 disclosed in figures 3 and 4. It shall be emphasized that the embodiments of figures 3-5 are examples, especially it shall be pointed out that one of the angles of the cutwater wedge angle (ω) and the cutwater angle (Y) may increase and the other angle decrease in relation to the first embodiment disclosed in figures 3 and 4, or both angles may increase. It shall be pointed out that the present invention is not limited to the illustrative embodiments disclosed in the drawings.

[0045] According to various embodiments the impeller 8 is displaceable back and forth in the axial direction in relation to the impeller seat 5 during operation of the pump 1, in order to let larger pieces of solid matter pass through the pump 1.

[0046] The axial inlet of the impeller seat 5 is defined by an inlet wall 21, wherein the impeller seat 5 has an inlet radius measured from the axially extending centre axis of the inlet 2 to the circular intersection between the inlet wall 21 and an upper surface 22 of the impeller seat 5.

[0047] The inlet wall 21 is more or less cylindrical or slightly conical having a decreasing flow area in the downstream direction, i.e. upwards in figures 1 and 2. The upper surface 22 of the impeller seat 5 is the surface that is seen from above, i.e. figures 3-5, and the circular intersection is the plane of the impeller seat 5 having the smallest flow area, i.e. the transition between the inlet wall 21 and the upper surface 22. The upper surface 22 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 21. According to various embodiments the upper surface 22 only comprises an arc-shaped section extending all the way from the inlet wall 21 to the periphery of the impeller seat 5. According to other various embodiments the upper surface 22 only comprises a flat section extending all the way from the inlet wall 21 to the periphery of the impeller seat 5.

[0048] According to various embodiments, exemplified in figures 1-6, said impeller seat 5 comprises a guide pin, generally designated 23, connected to and extending radially inwards from said inlet wall 21. The main function of the guide pin 23 is to scrape off solid matter from the impeller 8 and feed the solid matter outwards, during normal operation of the pump 1.

[0049] According to various embodiments, said impeller seat 5 also comprises a feeding groove 24 arranged in the upper surface 22 of the impeller seat 5 and extending from the inlet wall 21 to the periphery of the impeller seat 5. An inlet of the feeding groove 24 is located adjacent the guide pin 23. The feeding groove 24 is preferably swept/curved in the direction of rotation of the pump 1, more precisely the direction of rotation of the impeller 8, seen from the inlet wall 21 towards the periphery. Part of the inlet of the feeding groove 24 may be arranged in the inlet wall 21 of the impeller seat 5. The function of the feeding groove 24 is to feed the solid matter outwards towards the wall of the housing 6, during normal operation of the pump 1, in cooperation with the impeller 8. It shall be pointed out that the impeller seat 5 may comprise such feeding groove 24 but no guide pin 23, and vice versa. The embodiment of figure 7 is disclosed without guide pin and without feeding groove.

[0050] The impeller 8 is a channel impeller and is preferably a socalled open impeller, wherein the impeller 8 comprises a cover plate 25, a centrally located hub 26 and at least two spirally swept blades 27 connected to the cover plate 25 and to the hub 26. The blades 27 are equidistant located around the hub 26. The blades 27 are also known as vanes, and the cover plate 25 is also known as upper shroud.

[0051] Each blade 27 comprises a leading edge 28 adjacent the hub 26 and a trailing edge 29 at the periphery of the impeller 8. The leading edge 28 of the impeller 8 is located upstream the trailing edge 29, wherein two adjacent blades 27 together defines a channel extending from the leading edges 28 to the trailing edges 29. The leading edge 28 is located at the inlet of the impeller seat 5, and the leading edge 28 is spirally swept from the hub outwards, in the direction opposite the direction of rotation of the impeller 8 during normal (liquid pumping) operation of the pump 1. During operation, the leading edges 28 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 29. Thereafter the liquid is guided by the volute 4 of the hydraulic unit towards the outlet 3. Thus, the liquid is sucked to the impeller 8 and pressed out of the impeller 8. Said channels are also delimited by the cover plate 25 of the impeller 8 and by the impeller seat 5. The downstream end of the channels comprises the outer channel height (h), i.e. the axial height between cover plate 25 and the impeller seat 5.

[0052] The distance, i.e. the gap height, between the leading edge 28 of the blade 27 and the upper surface of the guide pin 23 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.

[0053] According to various embodiments, the radially inner most part of the guide pin 23 is located radially outside the hub 26 of the impeller 8. Thereby, solid matter may not be trapped between the hub 26 of the impeller 8 and the upper surface of the guide pin 23, and solid matter raked off inwards during reverse operation of the pump 1 will more easily leave the guide pin 23.

[0054] According to alternative embodiments, the impeller 8 is a socalled closed impeller (not disclosed in drawings). A closed impeller comprises a lower cover plate having a central inlet in addition to the upper cover plate, wherein the blades extend in the axial direction between the upper cover plate and the lower cover plate. The channels are thereby delimited by two adjacent blades, the upper cover plate and the lower cover plate. The downstream end of the channels comprises the outer channel height (h), i.e. the axial height between upper cover plate and the lower cover plate.

[0055] According to alternative embodiments, the impeller 8 is a socalled semi-open impeller (not disclosed in drawings). A semi-open impeller comprises winglets connected to a lower edge of the blades in addition to the upper cover plate, wherein the winglets does not extend all the way between adjacent blades. The channels are thereby delimited by two adjacent blades, the upper cover plate, the winglets and by the impeller seat. The downstream end of the channels comprises the outer channel height (h), i.e. the axial height between upper cover plate and the impeller seat.

Feasible modifications of the Invention

[0056] 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.

[0057] It shall also be pointed out that all information about/concerning terms such as above, under, upper, lower, etc., shall be interpreted/read having the equipment oriented according to the figures, having the drawings oriented such that the references can be properly read. Thus, such terms only indicate mutual relations in the shown embodiments, which relations may be changed if the inventive equipment is provided with another structure/design.

[0058] 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. Pump (1) for pumping liquid comprising solid matter, the pump (1) comprising a drive unit having an electric motor (9) and an axially extending drive shaft (11) and comprising a hydraulic unit having a channel impeller (8) and a housing (6), wherein the impeller (8) is operatively connected to said electric motor (9) via said drive shaft (11) and driven in rotation in said housing (6) during operation of the pump (1), wherein the housing (6) comprises an axial inlet (2) and a radial outlet (3), the housing (6) defining a volute (4) having a cutwater (16), a cutwater wedge angle (ω) and a cutwater angle (Y), wherein a smallest cross-sectional area (A1) of the volute (4) is located in an axial geometrical plane that comprises an axially extending center axis of the inlet (2) of the housing (6) and that extends radially outwards to an upstream end of the cutwater (16), **character-**

ized in that in a radial geometrical plane (17) that is perpendicular to the axially extending center axis of the inlet (2) of the housing (6) and that comprises the longest radius of the volute (4) at the smallest cross-sectional area (A1) of the volute (4),

- the cutwater wedge angle (ω) is equal to or greater than 80 degrees and equal to or less than 150 degrees, and
- the cutwater angle (Y) is equal to or greater than 15 degrees and equal to or less than 70 degrees.

2. The pump (1) according to claim 1, wherein the cutwater wedge angle (ω) is taken at the intersection between a first geometrical line (18) that is tangent to the upstream end of the cutwater (16) and a second geometrical line (19) that is tangent to a downstream end of the cutwater (16).

3. The pump (1) according to claim 2, wherein the downstream end of the cutwater (16) is located at the transition between the convex shape of the cutwater (16) and an outlet wall (3a).

4. The pump (1) according to claim 3, wherein the axial geometrical plane having the smallest cross-sectional area of the volute (4), is located at the transition from the convex shape of the cutwater (16) to concave shape.

5. The pump (1) according to any preceding claim, wherein the cutwater angle (Y) is taken at the intersection between the axial geometrical plane having the smallest cross-sectional area of the volute (4) and a third geometrical line/plane (20) that extends between the center axis of the inlet (2) of the housing (6) and the center of the outlet (3) of the housing (6).

6. The pump (1) according to claim 5, wherein the third geometrical line (20) coincide with a radially extending center axis of the outlet (3) of the housing (6).

7. The pump (1) according to any preceding claim, wherein the cutwater angle (Y) is equal to or more than 20 degrees.

8. The pump (1) according to any preceding claim, wherein the cutwater wedge angle (ω) is equal to or more than 90 degrees, and wherein the cutwater wedge angle (ω) is equal to or less than 130 degrees.

9. The pump (1) according to any preceding claim, wherein the impeller (8) is displaceable back and forth in the axial direction in relation to the drive shaft (11) during operation of the pump (1).

10. The pump (1) according to any preceding claim, wherein the housing (6) comprises an impeller seat (5) having an inlet wall (21) that defines the axial inlet (2) of the housing (6), wherein the impeller seat (5) comprises a guide pin (23) connected to and extending radially inwards from said inlet wall (21).

11. The pump (1) according to claim 10, wherein the channel impeller (8) comprises a cover plate (25), a centrally located hub (26) and at least two spirally swept blades (27) connected to the cover plate (25) and to the hub (26), wherein the radially innermost part of the guide pin (23) is located radially outside the hub (26) of the impeller (8).

12. The pump according to claim 10 or 11, wherein the channel impeller (8) comprises a cover plate (25), a centrally located hub (26) and at least two spirally swept blades (27) connected to the cover plate (25) and to the hub (26), wherein each blade (27) of the impeller (8) comprises a leading edge (28) adjacent the hub (26), wherein a gap between the leading edge (28) of the blade (27) of the impeller (8) and an upper surface of the guide pin (23) is equal to or more than 0,05 mm and equal to or less than 1 mm.

13. Hydraulic unit for a pump (1) configured for pumping liquid comprising solid matter, wherein the hydraulic unit comprises a channel impeller (8) and a housing (6) having an axial inlet (2) and a radial outlet (3), the housing (6) defining a volute (4) having a cutwater (16), a cutwater wedge angle (ω) and a cutwater angle (Y), wherein a smallest cross-sectional area (A1) of the volute (4) is located in an axial geometrical plane that comprises an axially extending center axis of the inlet (2) of the housing (6) and that extends radially outwards to an upstream end of the cutwater (16), **characterized in that** in a radial geometrical plane (17) that is perpendicular to the axially extending center axis of the inlet (2) of the housing (6) and that comprises the longest radius of the volute (4) at the smallest cross-sectional area (A1) of the volute (4),

- the cutwater wedge angle (ω) is equal to or greater than 80 degrees and equal to or less than 150 degrees, and
- the cutwater angle (Y) is equal to or greater than 15 degrees and equal to or less than 70 degrees.

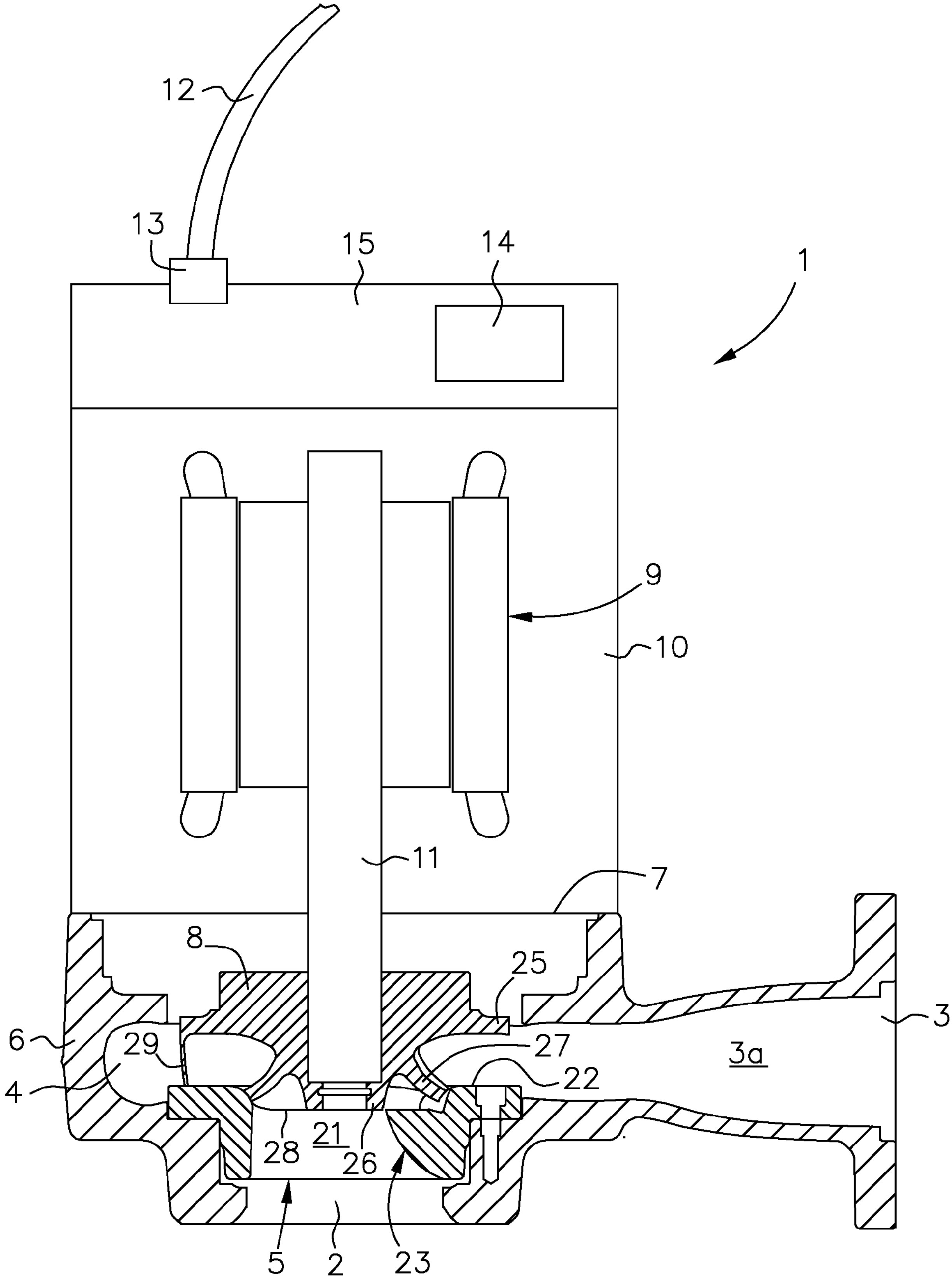

Fig. 1

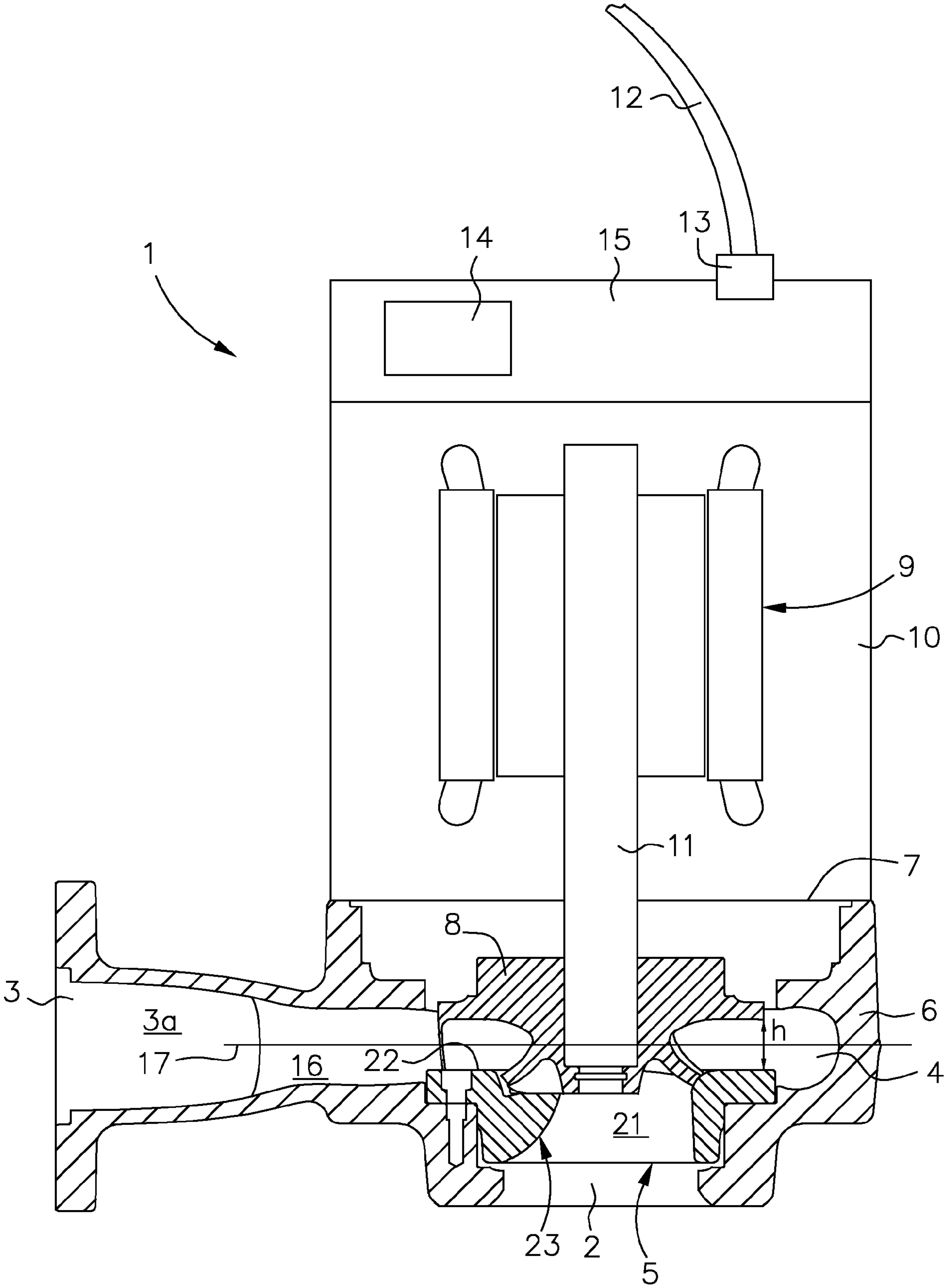

Fig. 2

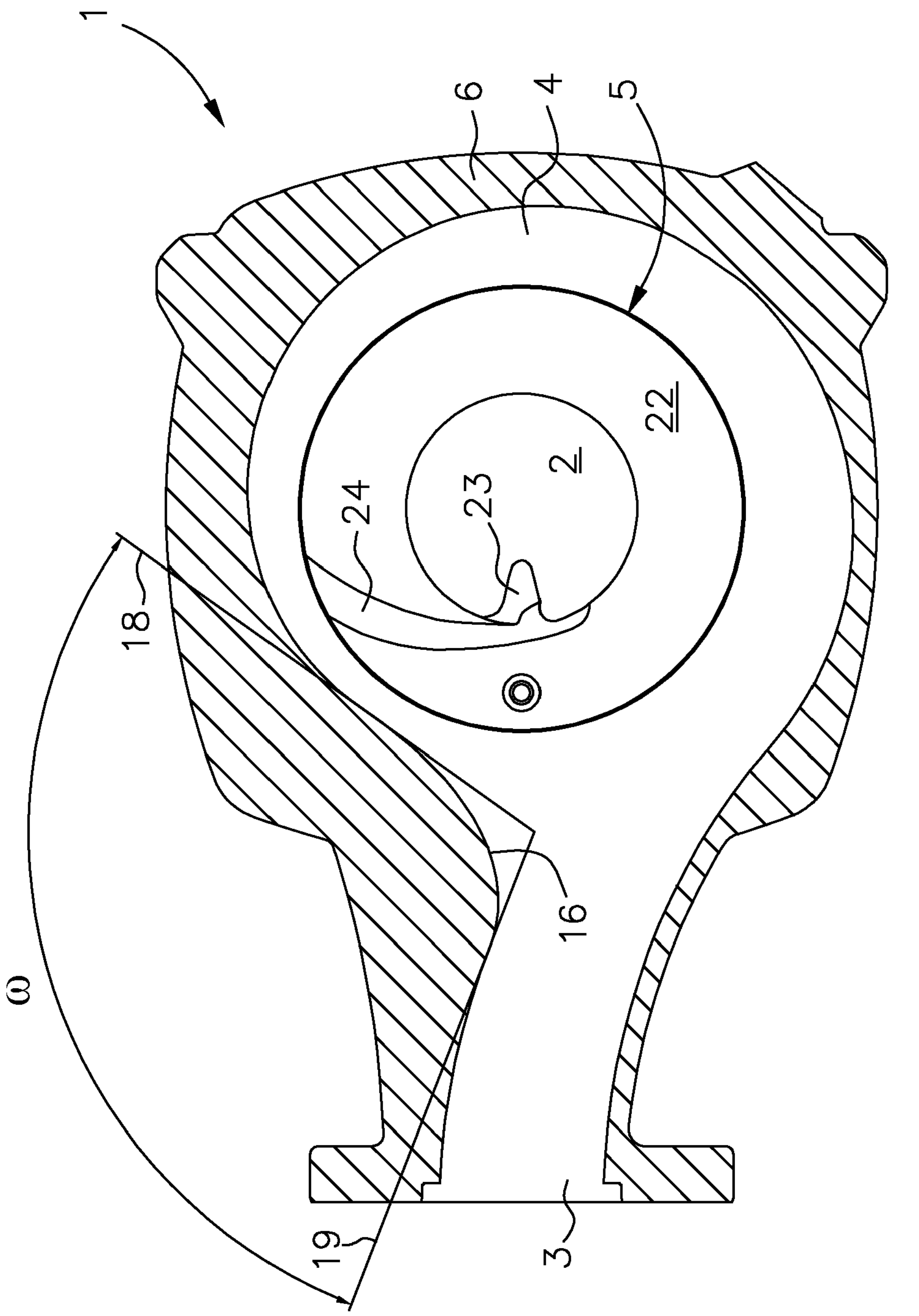

Fig. 3

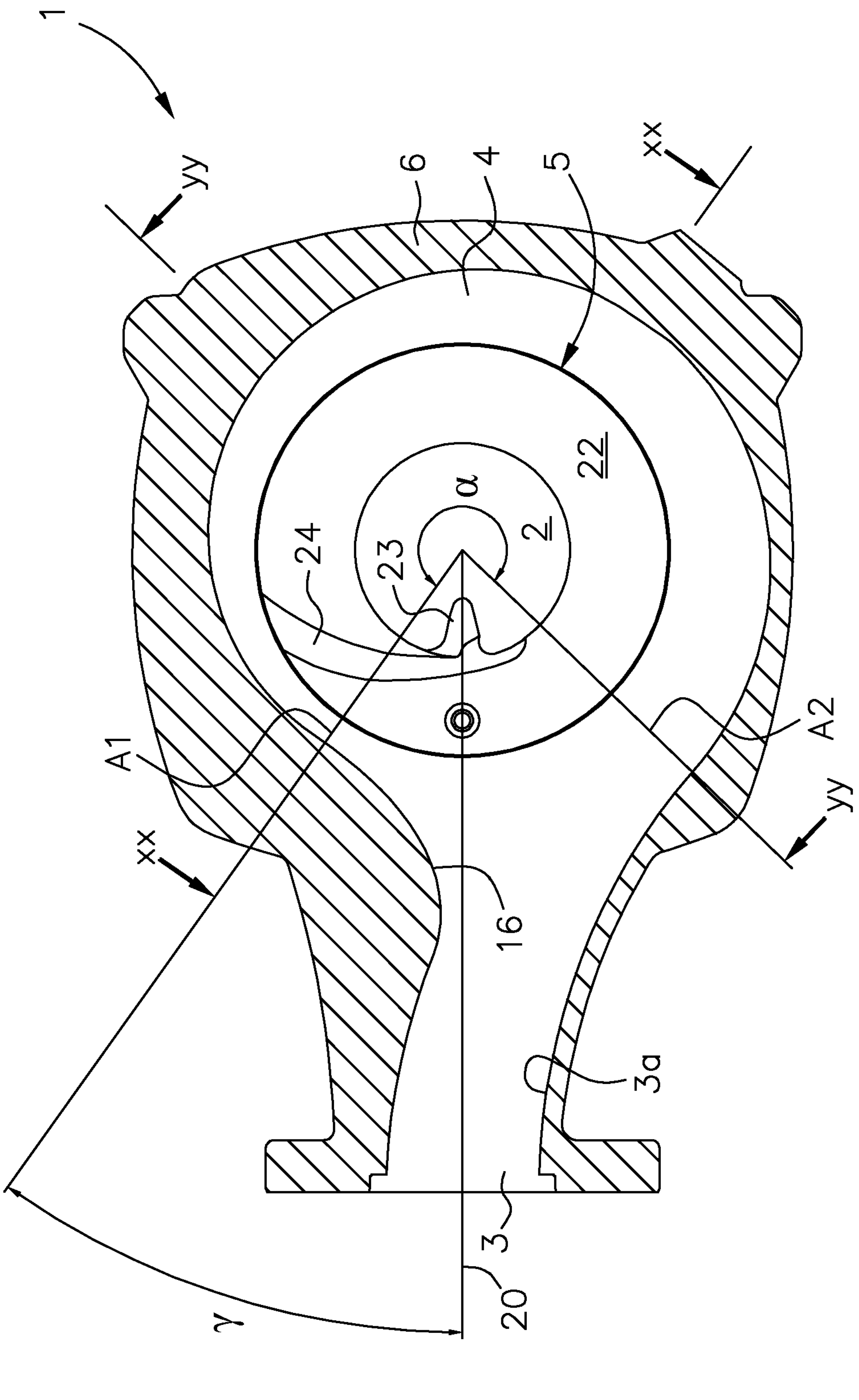

Fig. 4

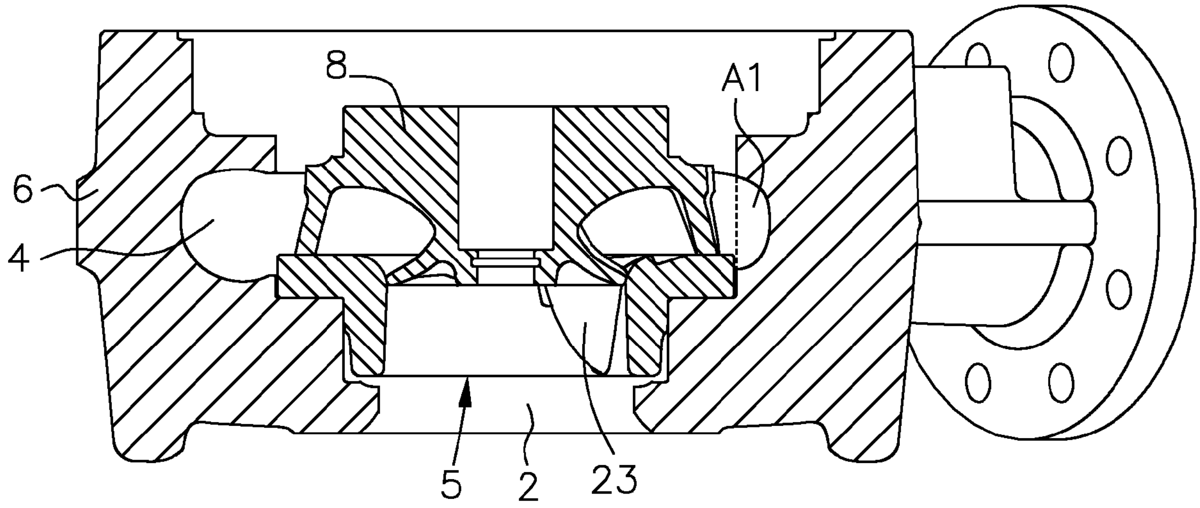

Fig. 5

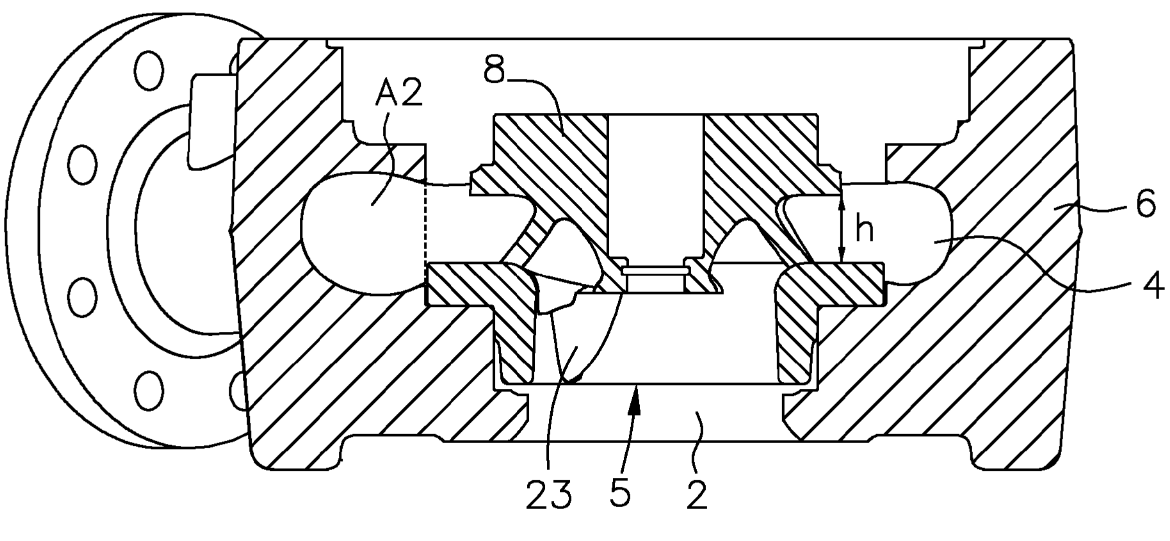

Fig. 6

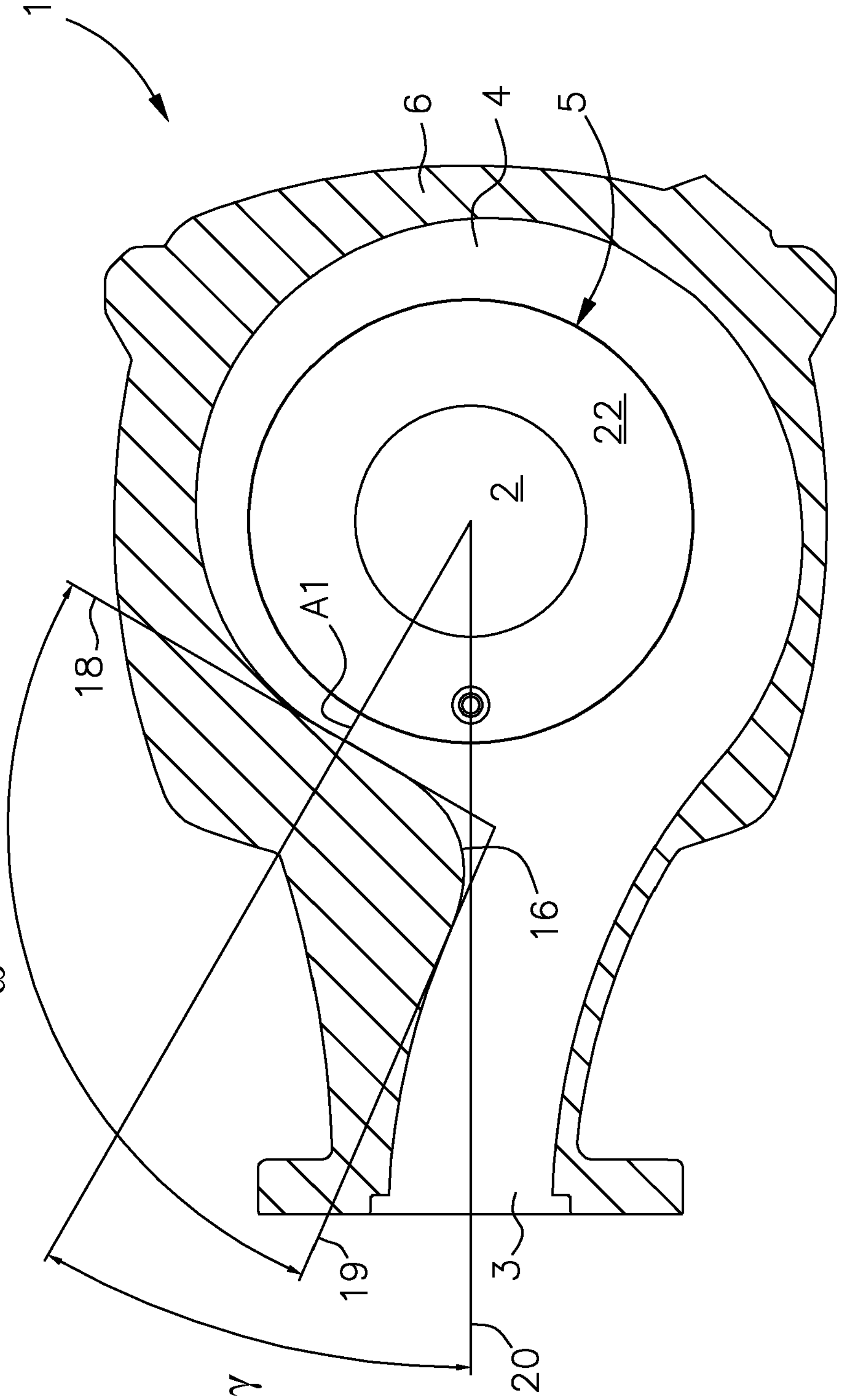

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 8076

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 447 475 A (BLUM ALBERT) 3 June 1969 (1969-06-03) * column 1, lines 19-29, 43-56 * * column 2, lines 35-46 * * figures 1, 2 * -----	1-13	INV. F04D7/04 F04D29/22 F04D29/42
X	FR 577 051 A (BUCHER GUYER AG MASCH) 30 August 1924 (1924-08-30) * page 1, line 43 - page 2, line 36 * * figures 1-5 * -----	1-13	
X	JP 2007 270748 A (SHIN MEIWA IND CO LTD) 18 October 2007 (2007-10-18) * paragraph [0005] * * figures 4, 5 * -----	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	19 April 2023	De Tobel, David

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- EP 1891331 A **[0009]**