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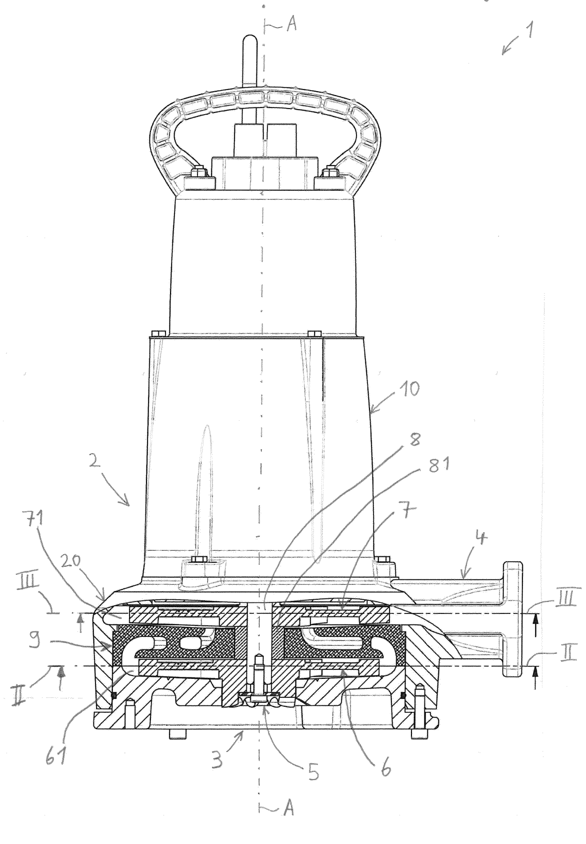
(54) MULTISTAGE CENTRIFUGAL GRINDER PUMP

(57) A multistage centrifugal grinder pump is proposed, comprising a housing (2) with an pump inlet (3) for a fluid to be conveyed, and a pump outlet (4) for discharging the fluid, further comprising a grinder (5) arranged at the pump inlet (3) for grinding constituents of the fluid, a first stage impeller (6) for rotating about an axial direction (A), a second stage impeller (7) for rotating about the axial direction (A), and a shaft (8) for rotating the first impeller (6), the second impeller (7) and the grinder (5), wherein the first stage impeller (6) is arranged in a first chamber (61) of the housing (2), wherein the second stage impeller (7) is arranged in a second chamber (71) of the housing (2), and wherein the first stage impeller (6) and the second stage impeller (7) are connected to the shaft (8) in a torque-proof manner, wherein a disk-shaped diffusor (9) is arranged between the first stage impeller (6) and the second stage impeller (7) regarding the axial direction (A), the disk-shaped diffusor (9) having a central axis (C) extending in the axial direction (A), a bottom face (91) arranged adjacent to the first stage impeller (6) and a top face (92) arranged adjacent to the second stage impeller (7), wherein the bottom face (91) comprises an inlet opening (96) for receiving the fluid from the first chamber (61), and wherein the top face (92) comprises a plurality of outlet openings (97) for suppling the fluid to the second stage impeller (7), the disk-shaped diffusor (9) further comprising a plurality of internal channels (98) with each internal channel (98) extending from the inlet opening (96) to one of the outlet openings (97).

Fig. 1



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Description

[0001] The invention relates to a multistage centrifugal grinder pump in accordance with the preamble of the independent claim.

[0002] In the conveying of sewage or waste water and in particular of domestic waste water, problems result because such liquids contain constituents such as fibrous materials, cloths, textiles, plastic bags or other solids which can very easily become stuck in the region of the pump and can then result in a reduction in the efficiency, in particular the hydraulic efficiency, of the pump up to the complete blocking of the impeller of the pump and can cause servicing or also complex and/or expensive maintenance work. Special measures therefore have to be taken with such pumps in order to effectively prevent clogging.

[0003] A known solution to address this problem are centrifugal grinder pumps that are also referred to as centrifugal macerator pumps. These pumps are provided with a rotating grinder at the pump inlet for grinding the constituents in the sewage. Typically, the grinder is configured as a cutting device rotating in or at the pump inlet for disintegrating or shredding the solid constituents in the sewage and thus preventing a clogging of the pump impeller.

[0004] Quite often residential but also industrial sewer systems are only based upon gravity to discharge the sewage to larger reservoirs or treatment plants.

[0005] However, if gravity is not sufficient to move the sewage to the desired location or if gravity based systems are not economical, grinder pumps are used to lift the sewage or to convey the sewage over longer distances. To this end grinder pumps are integrated for example in residential pressure sewerage systems (PPS) or gravity sewerage systems to provide an effective and economical dewatering. Usually grinder pumps use quite small-diameter discharge lines in all applications, such as in the private or municipal or industrial area.

[0006] Centrifugal grinder pumps may be designed as submersible pumps, i.e. as pumps that are configured to operate even if they are completely submerged and covered by the fluid to be conveyed.

[0007] A critical parameter of sewage pumps is the head-flow range in which they can be operated. In some applications the required head is very high, for example for lifting the sewage a head of up to 200 ft (61 m) or even more may be required. Such a high head in combination with a reasonable flow rate is at least very difficult if not impossible to realize with a centrifugal grinder pump having only one impeller. Therefore two stage centrifugal grinder pumps having to impellers arranged in series have been developed to increase the available head of the sewage pump.

[0008] US 7,357,341, for example, discloses a two stage centrifugal grinder pump with two impellers in series. The pump housing comprises an inlet, at which the grinder is positioned, a first stage volute, in which the first impeller is positioned and a second stage volute, in which the second impeller is positioned. The first stage volute is in fluid communication with the inlet of the pump. The discharge of the first stage volute is connected to the inlet of the second stage volute by an interstage conduit. The discharge of the second stage volute is in fluid communication with the outlet of the pump housing. The interstage conduit is arranged at the outside of the pump housing and wrapping around the pump housing to guide the flow of fluid from the discharge of the first stage volute to the inlet of the second stage volute. This overall design has the disadvantage to require quite a lot of space.

[0009] Starting from this state of the art it is therefore an object of the invention to propose a different and very compact multistage centrifugal grinder pump, which can generate a high head, for example of up to 200 ft (61 m) or even more.

[0010] The subject matter of the invention satisfying this object is characterized by the features of the independent claim.

[0011] Thus, according to the invention a multistage centrifugal grinder pump is proposed, comprising a housing with an pump inlet for a fluid to be conveyed, and a pump outlet for discharging the fluid, further comprising a grinder arranged at the pump inlet for grinding constituents of the fluid, a first stage impeller for rotating about an axial direction, a second stage impeller for rotating about the axial direction, and a shaft for rotating the first impeller, the second impeller and the grinder, wherein the first stage impeller is arranged in a first chamber of the housing, wherein the second stage impeller is arranged in a second chamber of the housing, and wherein the first stage impeller and the second stage impeller are connected to the shaft in a torque-proof manner, wherein a disk-shaped diffusor is arranged between the first stage impeller and the second stage impeller regarding the axial direction, the disk-shaped diffusor having a central axis extending in the axial direction, a bottom face arranged adjacent to the first stage impeller and a top face arranged adjacent to the second stage impeller, wherein the bottom face comprises an inlet opening for receiving the fluid from the first chamber, and wherein the top face comprises a plurality of outlet openings for suppling the fluid to the second stage impeller, the disk-shaped diffusor further comprising a plurality of internal channels with each internal channel extending from the inlet opening to one of the outlet openings.

[0012] By providing the centrifugal grinder pump with two impellers arranged in series, i.e. one after the other with respect to the axial direction, the head-flow range, in which the pump may be operated, is considerably extended as compared to pumps with only one impeller. In particular, the head that can be generated with the multistage centrifugal grinder pump is remarkably increased, so that the pump according to the invention is particularly suited for high head applications requiring a head of, for example, up to 200 feet (61 meters) or even more. In addition, since the centrifugal grinder pump according to the invention is designed with an internal diffusor for guiding the fluid conveyed by the first stage impeller from the first chamber to the second chamber where the second stage impeller is located, the pump according to the invention is very compact, because there is no need for an interstage conduit arranged at the outside of the housing and wrapping around the housing. The disk-shaped diffusor, which is arranged - regarding the axial direction - between the first chamber with the first stage impeller and the second chamber with the second stage impeller, directs the fluid by means of the plurality of internal channels provided within the diffusor, so that there is no need for an interstage conduit at the outside of the housing.

[0013] In view of a very compact design and good hydraulic properties of the pump it is preferred that the bottom face of the disk-shaped diffusor delimits the first chamber with respect to the axial direction, and the top face of the disk-shaped diffusor delimits the second chamber with respect to the axial direction. Thus, the disk-shaped diffusor is directly interposed between the first stage and the second stage impeller, meaning that the diffusor separates the first chamber and the second chamber with respect to the axial direction.

[0014] Due to the disk-shaped diffusor between the first and the second chamber it can be dispensed with designing the first and the second chamber as volute chambers. Therefore it is preferred, that the first chamber and the second chamber each have a circular cross-section perpendicular to the axial direction. This measure makes the design and the manufacturing of the pump considerably simpler.

[0015] In view of the hydraulic properties of the pump it is advantageous, when the outlet openings of the disk-shaped diffusor are arranged on a circle about the central axis, said circle having a diameter, which is preferably smaller than 40% of the diameter of the disc-shaped diffusor. By arranging the outlet openings on a circle about the central axis the flow of fluid towards the second stage impeller becomes particularly homogeneous.

[0016] In order to efficiently guide the flow of fluid from the first to the second chamber it is a preferred measure, that the disc-shaped diffusor comprises a plurality of diffusor vanes, wherein two adjacent internal channels are respectively separated by one of the diffusor vanes.

[0017] Particularly preferred, each diffusor vane is curved when viewed in a radial direction. This increases the efficiency of transforming kinetic energy (velocity) of the fluid flow into pressure of the fluid.

[0018] By the same reason it is advantageous, when each diffusor vane is curved when viewed in the axial direction.

[0019] Most preferred each diffusor vane is curved both when viewed in the radial direction and when viewed in the axial direction.

[0020] According to a preferred embodiment, the inlet opening of the disk-shaped diffusor is configured as an annular opening that is located adjacent to a radially outer rim of the disk-shaped diffusor. In this configuration the inlet opening in the bottom face of the disk-shaped diffusor extends along the entire circumference of the bottom face close to the radially outer rim of the bottom face, so that the inlet opening can receive fluid from the entire outer region of the first chamber when viewed in the circumferential direction.

[0021] In particular in view of the hydraulic properties it is advantageous, when the bottom face of the disk-shaped diffusor comprises a smooth, annular central area which is delimited by the inlet opening with respect to a radial direction.

[0022] Preferably, the central area has an outer diameter that is at least as large as the diameter of the first stage impeller, i.e. the central area of the bottom face is designed such that it covers the first stage impeller with respect to the radial direction. Thus, the fluid can only enter the inlet opening of the diffuser from that part of the first chamber, which is located radially outside of the first stage impeller. Said part of the first chamber is surrounding the radially outer ends of the impeller blades of the first stage impeller.

[0023] According to a preferred embodiment, the radially outer rim of the disk-shaped diffusor is configured to protrude over the central area with respect to the axial direction. Thus, the central area constitutes a recess in the bottom face of the disk-shaped diffusor, into which recess the first stage impeller may extend. By this measure the radially outer rim of the disk-shaped diffusor and the first stage impeller overlap with respect to the axial direction and the outer rim constitutes a part of the wall delimiting the first chamber with respect to the radial direction. The annular inlet opening of the diffusor is located between the central area of the bottom face and the radially outer rim of the diffusor.

[0024] Furthermore it is preferred that the centrifugal grinder pump comprises a drive unit for rotating the shaft about the axial direction, wherein the drive unit is arranged within the housing, and wherein the first stage impeller and the second stage impeller are arranged between the drive unit and the grinder with respect to the axial direction. It is a very compact design to arrange the drive unit within the housing of the pump. Of course, the housing may be designed to comprise two or more housing parts that are assembled and firmly fixed with respect to each other, e.g. by screws or bolts, to form the housing of the pump.

[0025] Most preferred, the multistage centrifugal grinder pump is designed for a vertical operation with the shaft extending in the vertical direction, wherein the drive unit is arranged above the first stage impeller and the second stage impeller. During operation the shaft is oriented in the direction of gravity and the axial direction extends vertically. In this configuration the pump inlet with the grinder is located at the bottom of the pump, the first stage impeller is arranged above the grinder, the second stage impeller is arranged above the first stage impeller and the drive unit is positioned on top of the second stage impeller. The shaft is extending vertically from the drive unit to the grinder for rotating the first and the second stage impeller as well as the grinder about the axial direction.

[0026] In particular for sewage and dewatering applications it is preferred that the pump is configured as a submersible pump.

[0027] According to a particularly preferred embodiment is configured as a two stage pump having exactly two impellers, namely the first stage impeller and the second stage impeller.

[0028] However it is also possible to configure the multistage centrifugal grinder pump according to the invention with three or even more stages, wherein the number of stages equals the number of impellers that are provided in the pump. In embodiments with three or more stages a disk-shaped diffusor is arranged respectively between each pair of adjacent impellers. For example, in a three stage pump having a first, a second and a third stage impeller a first disk-shaped diffusor is arranged between the first and the second stage impeller, and a second disk-shaped impeller is arranged between the second stage and the third stage impeller.

[0029] Further advantageous measures and embodiments of the invention will become apparent from the dependent claims.

[0030] The invention will be explained in more detail hereinafter with reference to the drawings. There are shown in a schematic representation:

Fig. 1: is a break-out section view of an embodiment of a multistage centrifugal grinder pump according to the invention,

Fig. 2: a cross-sectional view perpendicular to the axial direction through the first stage impeller along section line II-II in Fig. 1,

Fig. 3: a cross-sectional view perpendicular to the axial direction through the second stage impeller along section line III-III in Fig. 1,

Fig. 4: a top view of the disk-shaped diffusor as seen from the second stage impeller,

Fig. 5: a perspective view of the bottom face of the disk-shaped diffusor,

Fig. 6: a perspective cross-sectional view of the disk-shaped diffusor in a section along the axial direction,

Fig. 7: a cross-sectional view of the disk-shaped diffusor in a section perpendicular to the axial direction,

Fig. 8: a perspective view on the top face of a variant for the disk-shaped diffusor, and

Fig. 9: a perspective view on the bottom face of the variant shown in Fig. 8

[0031] In the following description reference is made by way of example to the important application that the multistage centrifugal grinder pump is used for conveying sewage or wastewater in private, municipal or industrial areas. The sewage typically comprises solid constituents such as fibrous materials, cloths, textiles, paper, plastic bags or other solids.

[0032] Fig. 1 shows an overall view of an embodiment of a multistage centrifugal grinder pump according to the invention which is designated in its entity with reference numeral 1. This embodiment is configured as a two stage pump 1. The pump 1 comprises a housing 2, in which a pump unit 20 and a drive unit 10 are arranged. Fig. 1 is a break-out section view showing the pump unit 20 in a cross-sectional view and the rest of the centrifugal pump 1 in a view on the housing 2 of the pump 1.

[0033] As shown in Fig. 1 the housing 2 may comprise several housing parts, which are connected to each other to form the housing 2 for the pump unit 20 and the drive unit 10. The centrifugal grinder pump 1 is configured as a submersible pump 1, which can be operated also, when the pump 1 is partially or completely submerged in a liquid, e.g. the sewage or the wastewater that shall be conveyed by the pump 1.

[0034] The housing 2 has a pump inlet 3 for a fluid to be conveyed and a pump outlet 4 for discharging the fluid. The fluid is for example sewage or wastewater comprising beside water also solid constituents as mentioned before. As it is typical for a centrifugal grinder pump 1 a grinder 5 is arranged at the pump inlet 3, so that the fluid can only enter the pump 1 by passing the grinder 5. The grinder 5 comprises a cutting device rotating during operation for shredding or disintegrating the solid constituents of the sewage so that they cannot clog the pump 1. Since the grinder 5, which is also referred to as macerator, as such is well-known in the art in many different designs and configurations, there is no need to describe or explain the grinder 5 in more detail. Basically the grinder 5 may be configured according to any known design that is used for shredding or cutting systems in connection with pumps.

[0035] The centrifugal grinder pump 1 further comprises two impellers 6, 7 arranged in series for acting on the fluid, namely a first stage impeller 6 and a second stage impeller 7. During operation both impellers 6, 7 rotate about the same rotational axis, which defines an axial direction A. For driving the rotation of the impellers 6, 7 as well as the rotation of the grinder 5 a shaft 8 is provided extending in the axial direction A. The shaft 8 is coupled to the drive unit 10, which rotates the shaft 8 about the axial direction A. Thus, the longitudinal axis of the shaft 8 coincides with the rotational axis and therefore defines the axial direction A.

[0036] A direction perpendicular to the axial direction A is referred to as 'radial direction'. The term 'axial' or 'axially' is used with the common meaning 'in axial direction' or 'with respect to the axial direction'. In an analogous manner the term 'radial' or 'radially' is used with the common meaning 'in radial direction' or 'with respect to the radial direction'.

[0037] The two stage centrifugal grinder pump 1 is designed for a vertical operation with the shaft 8 extending in the vertical direction, i.e. the direction of gravity. Hereinafter relative terms regarding the location like "above" or "below" or "upper" or "lower" or "top" or "bottom" refer to the usual operating position of the pump 1. Fig. 1 shows the centrifugal grinder pump 1 in its usual operating position.

[0038] The drive unit 10 is arranged on top of the pump unit 20, i.e. above the first and the second stage impeller 6, 7. Preferably, the drive unit 10 comprises an electric motor for driving the shaft 8. The electric motor may be configured in many different manners which are known in the art. In particular, the electric motor is designed or encapsulated in the housing 2 for being submerged.

[0039] As can be seen in Fig. 1 the pump inlet 3 with the grinder 5 is centrally arranged at the bottom of the pump 1, so that the fluid can enter the pump 1 in a generally axial direction. The first stage impeller 6 is arranged adjacent to the pump inlet 3 and the grinder 5 for receiving the fluid that passed the grinder 5. The second stage impeller 7 is arranged behind the first stage impeller 6 when viewed in the general flow direction of the fluid. The pump outlet 4 is arranged laterally at the housing 2 on the same height (regarding the axial direction A) as the second stage impeller 7. The first stage impeller 6 and the second stage impeller 7 are connected to the shaft 8 in a torque-proof manner. The shaft 8 is extending from the drive unit 10 upwardly to the grinder 5. The grinder 5 is fixed to the shaft 8, preferably in a torque-proof manner. As can be seen in Fig. 1 the grinder 5 is mounted to the lower axial end of the shaft 8 and fixed thereto, e.g. by a screw.

[0040] Between the first stage impeller 6 and the second stage impeller 7 a static and essentially disk-shaped diffusor 9 is arranged for receiving the fluid conveyed by the first stage impeller 6 and guiding the fluid to the second stage impeller 7. A more detailed explanation of the disk-shaped diffusor 9 will be given hereinafter.

[0041] For a better understanding Fig. 2 and Fig. 3 show two cross-sectional views perpendicular to the axial direction A. Fig. 2 shows a section through the midplane of the first stage impeller 6 along the section line II-II in Fig. 1 with the arrows indicating the direction of the view, and Fig. 3 shows a section through the midplane of the second stage impeller 7 along the section line III-III in Fig. 1 with the arrows indicating the direction of the view.

[0042] The first stage impeller 6 (Fig. 2) comprises a plurality of impeller blades 62 for acting on the fluid. The second stage impeller 7 (Fig. 3) comprises a plurality of impeller blades 72 for acting on the fluid.

[0043] The housing 2 comprises a first chamber 61, in which the first stage impeller 6 is arranged, and a second chamber 71, in which the second stage impeller 7 is arranged. As can be best seen in Fig. 2 and Fig. 3, respectively, both the first chamber 61 and the second chamber 71 have an essentially circular cross-section perpendicular to the axial direction A. The diameter of the first and the second chamber 61, 71 is in each case larger than the outer diameter of the respective first or second stage impeller 6, 7, so that there is an essentially annular flow channel 63 or 73, respectively between the radially outer ends of the impeller blades 62 or 72 and the wall delimiting the respective first or second chamber 61, 71 in radial direction. Each flow channel 63, 73 surround the respective first or second stage impeller 6, 7.

[0044] Both the first and the second stage impeller 6, 7 are centered in the respective first and second chamber 61, 71, meaning that the radial distance between the radially outer end of the respective impeller blades 62 or 72 and the wall delimiting the respective first or second chamber 61, 71 in radial direction is constant when viewed in the circumferential direction of the first or second stage impeller 6, 7, respectively. Thus, both the flow channel 63 of the first chamber 61 and the flow channel 73 of the second chamber 71 have a constant width in radial direction when viewed in the circumferential direction.

[0045] It has to be noted that both the first chamber 61 and the second chamber 71 are not designed as volute chambers but with a circular cross-section perpendicular to the axial direction A which renders the manufacturing simpler.

[0046] Regarding the design of the first and the second stage impeller 6, 7, in particular the number and the configuration of the respective impeller blades 62, 72, there is a huge amount of possibilities. For a skilled person it is no problem to choose an appropriate design for the first and the second stage impeller 6, 7. The choice of an appropriate impeller design may depend on the specific application, for example the required head, the required flow and so on. It is however preferred that the first stage impeller 6 and the second stage impeller 7 have the same design.

[0047] The first stage impeller 6 (Fig. 2) and the second stage impeller 7 (Fig. 3) may be designed for example with straight impeller blades 62, 72 as it is shown in Fig. 2 and Fig. 3, meaning that the impeller blades 62, 72 are not curved but extend straightly and preferably in radial direction. This type of impeller is sometimes called "star impeller" or "Barske impeller".

[0048] It goes without saying that the first and the second stage impeller 6, 7 may also be designed differently, for example with curved impeller blades, with splitter ribs between the impeller blades or with other designs that are known for centrifugal pumps.

[0049] Referring now in particular to Fig. 4 - Fig. 7 the disk-shaped diffusor 9 arranged between the first stage impeller 6 and the second stage impeller 7 with respect to the axial direction A will be explained in more detail.

[0050] The disk-shaped diffusor 9 interposed between the first and the second stage impeller 6, 7 directs the fluid that has been acted on by the first stage impeller 6 to the second stage impeller 7, more precisely, the disc-shaped diffusor 9 guides the fluid from the flow channel 63 of the first chamber 61 to the radially inner region of the second stage impeller 7. At the same time the diffusor 9 transforms kinetic energy of the fluid into pressure, i.e. the velocity of the fluid is decreased and the pressure is increased.

[0051] Fig. 6 shows a perspective cross-sectional view of the disk-shaped diffusor 9 in a section along the axial direction A. The disk-shaped diffusor 9 has a central axis C which coincides with the rotational axis, i.e. the central axis C is extending in the axial direction A. The disk-shaped diffusor 9 is arranged concentrically with the first and the second stage impeller 6, 7, and fixed relative to the housing 2. The disk-shaped diffusor 9 comprises a bottom face 91 arranged adjacent to and facing the first stage impeller 6, and a top face 92 arranged adjacent to and facing the second stage impeller 7. The bottom face 91 and the top face 92 delimit the diffusor 9 with respect to the axial direction A.

[0052] The disk-shaped diffusor 9 has a central bore 93 extending in axial direction, through which the shaft 8 passes. Between the shaft 8 and the central bore 93 a bushing 81 (Fig. 1) is provided to allow for a relative movement of the rotating shaft 8 with respect to the non-rotating, stationary diffusor 9.

[0053] For a better understanding Fig. 4, Fig. 5 and Fig. 7 show additional views of the disk-shaped diffusor 9. Fig. 4 is a top view of the diffusor 9 as seen from the second stage impeller 7. Fig. 5 is a perspective view of the bottom face 91 of the diffusor 9 in a viewing direction from the first stage impeller 6. Fig. 7 is a cross-sectional view of the disk-shaped diffusor 9 in a section perpendicular to the axial direction A and along the geometrical midplane of the diffusor 9.

[0054] The disk-shaped diffusor 9 is directly interposed between the first stage impeller 6 and the second stage impeller 7 such that the bottom face 91 delimits the first chamber 61 with respect to the axial direction A and the top face 92 delimits the second chamber 71 with respect to the axial direction A.

[0055] The bottom face 91 of the disk-shaped diffusor 9 comprises a smooth annular central area 94 concentric with the central axis C, and a radially outer rim 95 delimiting the diffusor 9 with respect to the radial direction and surrounding the central area 94. The outer rim 95 is configured to protrude over the central area 94 with respect to the axial direction A, so that the central area 94 delimits an essentially annular recess in the bottom face 91 of the diffusor 9. The central area 94 has an outer diameter D that is at least as large as the diameter of the first stage impeller 6 and preferably somewhat larger than the diameter of the first stage impeller 6. The annular recess delimited by the central area 94 receives the upper part of the first stage impeller 6, i.e. the first stage impeller 6 is located partially within said recess, or extends into said recess, respectively. Consequently, the first stage impeller 6 and in particular the impeller blade 62 of the first stage impeller 6 are completely covered by the central area 94. In addition, since the outer rim 95 of the diffusor 9 protrudes over the central area 94, the outer rim 95 and the impeller blades 62 of the first stage impeller overlap with respect to the axial direction A (Fig. 1). The outer rim 95 of the diffusor 9 constitutes a part of the wall that delimits the flow channel 63 of the first chamber 61 with respect to the radial direction.

[0056] The bottom face 91 of the disk-shaped diffusor 9 comprises an inlet opening 96 for receiving the fluid from the first chamber 61. The inlet opening 96 is configured as an annular opening that is located adjacent to the radially outer rim 95 and concentric with the central axis C. More precisely, the annular inlet opening 96 is located - with respect to the radial direction - between the central area 94 and the outer rim 95. The inlet opening 96 is radially inwardly delimited by the central area 94 and radially outwardly by the outer rim 95. With respect to the axial direction A the inlet opening 94 is facing the flow channel 63 of the first chamber 61, so that the inlet opening 96 is in fluid communication with said flow channel 63.

[0057] The top face 92 of the disk-shaped diffusor 9 (see in particular Fig. 4) is designed as an essentially smooth face and comprises a plurality of outlet openings 97 for supplying the fluid to the second stage impeller 7. The outlet openings 97 are considerably closer to the central axis C than the inlet opening 96, so that the fluid is supplied to the central region of the second stage impeller 7. In Fig. 4 a number of seven individual outlet openings 97 is shown, but this number has to be understood exemplarily. It is also possible to provide more or less outlet openings 97 than seven.

[0058] In particular, to realize a homogenous flow of the fluid towards the second stage impeller 7 all outlet openings 97 are arranged on a circle E about the central axis C, so that all outlet openings 97 have the same radial distance from the central axis C. Preferably, the individual outlet openings 97 are equidistantly distributed along the circumference of the circle E. The diameter of the circle E is preferably smaller than 40% of the outer diameter of the disk-shaped diffusor 9.

[0059] The disk-shaped diffusor 9 further comprises a plurality of internal channels 98 (see in particular Fig. 6) with each internal channel 98 extending from the inlet opening 96 through the interior of the disk-shaped diffusor 9 to one of the outlet openings 97. Preferably, the number of internal channels 98 equals the number of outlet openings 97.

[0060] For separating the individual internal channels 98 from each other the disk-shaped diffusor 9 comprises a plurality of stationary diffusor vanes 99. Each of the diffusor vanes 99 separates two adjacent internal channels 98 from each other.

[0061] As can be best seen in Fig. 7 each diffusor vane 99 is curved when viewed in the radial direction. In addition, each diffusor vane 99 is curved when view in the axial direction A (see Fig. 1, Fig. 6). By means of the curved diffusor vanes 99 each of the internal channels 98 is curved both with respect to the axial direction A and with respect to the radial direction. The fluid entering the internal channels 98 from the flow channel 63 of the first chamber 61 and through the inlet opening 96 is directed by the diffusor vanes 99 radially inwardly towards the central axis C and diverted in the axial direction A, so that the fluid discharged through the outlet openings 97 flows generally in the axial direction towards the second stage impeller 7.

[0062] During operation of the multistage centrifugal grinder pump 1 the fluid, e.g. the sewage, enters the pump 1 through the pump inlet 3 and the grinder 5 at the pump inlet 3. Solid constituents in the sewage such as paper, cloths and so on, are shredded by the grinder 5 and the fluid flows into the first chamber 61 where it is acted upon by the centrifugal first stage impeller 6. The first stage impeller 6 conveys the fluid to the flow channel 63 of the first chamber 61. From there the fluid enters the disk-shaped diffusor 9 through the inlet opening 96, is guided by the internal channels 98 radially inwardly towards the central axis C and diverted into the axial direction A. The fluid is discharged from the diffusor 9 through the outlet opening 97 and enters the second chamber 71 flowing essentially in the axial direction A towards the centrifugal second stage impeller 7. The second stage impeller 7 conveys the fluid into the flow channel 73 of the second chamber 71 from where the fluid is discharged through the pump outlet 4 of the pump.

[0063] In particular regarding the design of the disk-shaped diffusor 9 many variations are possible. For example, the number of the internal channels 98, the number of the outlet openings 97, the configuration of the outlet openings 97, the number of the diffusor vanes 99, the configuration of the diffusor vanes 99 and the layout and the form of the internal channels 98 may be modified.

[0064] It is for example possible to configure each internal channel 98 as a straight channel, i.e. without curvature, so that each internal channel 98 extends straightforward from the inlet opening 96 to one of the outlet openings 97. This may be achieved by designing the diffusor vanes 99 as straight, i.e. non-curved vanes.

[0065] It is also possible to configure the inlet opening 96 as a non-contiguous inlet opening 96 that comprises a plurality of orifices which are separated by a respective partition wall between adjacent orifices.

[0066] In Fig. 8 and Fig. 9 a variant for the disk-shaped diffusor 9 is shown. The reference numerals have the same meaning as described hereinbefore. Only the differences between the variant and the embodiment shown in Fig. 4 -Fig. 7 will be explained. Fig. 8 shows a perspective view on the top face 92 of the variant for the disk-shaped diffusor 9 and Fig. 9 shows a perspective view on the bottom face 91 of this variant for the disk-shaped diffusor 9.

[0067] In this variant the inlet opening 96 in the bottom face 91 of the disk-shaped diffusor 9 comprises a plurality of orifices 961. The overall design of the inlet opening 96 is also an annular design, however the inlet opening 96 is non-contiguous and comprises the plurality of orifices 961 with each orifice 961 having the shape of a segment of a ring. The respective partition wall between adjacent orifices 961 is in each case formed by one of the diffusor vanes 99, i.e. the diffusor vanes 99 are designed such, that they extend into the inlet opening 96 to form a partition wall between two orifices 961. Preferably, the end of each diffusor vane 99 in the inlet opening 96 is in each case flush with the central area 94 of the bottom face 91.

[0068] As can be best seen in Fig. 8 the variant of the disk-shaped diffusor 9 comprises five internal channels 98 and five outlet openings 97.

[0069] The multistage centrifugal grinder pump 1 has been explained referring to an embodiment having two stages. It has to be understood that the invention is not restricted to embodiments with two pump stages. In other embodiments the multistage centrifugal grinder pump may comprise more than two stages, e.g. three or four or even more stages. In an analogous manner as it has been described hereinbefore a disk-shaped diffusor is arranged axially between each pair of adjacent stages. Thus, between each pair of adjacent stage impellers a disk-shaped diffusor is provided to direct the flow of fluid to the next stage impeller. When N designates the number of stages of the multistage centrifugal grinder pump, the number of disk-shaped diffusors is N-1.

Claims

1. A multistage centrifugal grinder pump comprising a housing (2) with an pump inlet (3) for a fluid to be conveyed, and a pump outlet (4) for discharging the fluid, further comprising a grinder (5) arranged at the pump inlet (3) for grinding constituents of the fluid, a first stage impeller (6) for rotating about an axial direction (A), a second stage impeller (7) for rotating about the axial direction (A), and a shaft (8) for rotating the first impeller (6), the second impeller (7) and the grinder (5), wherein the first stage impeller (6) is arranged in a first chamber (61) of the housing (2), wherein the second stage impeller (7) is arranged in a second chamber (71) of the housing (2), and wherein the first stage impeller (6) and the second stage impeller (7) are connected to the shaft (8) in a torque-proof manner, **characterized in that** a disk-shaped diffusor (9) is arranged between the first stage impeller (6) and the second stage impeller (7) regarding the axial direction (A), the disk-shaped diffusor (9) having a central axis (C) extending in the axial direction (A), a bottom face (91) arranged adjacent to the first stage impeller (6) and a top face (92) arranged adjacent to the second stage impeller (7), wherein the bottom face (91) comprises an inlet

opening (96) for receiving the fluid from the first chamber (61), and wherein the top face (92) comprises a plurality of outlet openings (97) for suppling the fluid to the second stage impeller (7), the disk-shaped diffusor (9) further comprising a plurality of internal channels (98) with each internal channel (98) extending from the inlet opening (96) to one of the outlet openings (97).

2. A multistage centrifugal grinder pump in accordance with claim 1,
wherein the bottom face (91) of the disk-shaped diffusor (9) delimits the first chamber (61) with respect to the axial direction (A), and the top face (92) of the disk-shaped diffusor (9) delimits the second chamber (71) with respect to the axial direction (A).

3. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, wherein the first chamber (61) and the second chamber (71) each have a circular cross-section perpendicular to the axial direction (A).

4. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, wherein the outlet openings (97) of the disk-shaped diffusor (9) are arranged on a circle (E) about the central axis (C), said circle (E) having a diameter, which is preferably smaller than 40% of the diameter of the disc-shaped diffusor (9).

5. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, wherein the disc-shaped diffusor (9) comprises a plurality of diffusor vanes (99), and wherein two adjacent internal channels (98) are respectively separated by one of the diffusor vanes (99).

6. A multistage centrifugal grinder pump in accordance with claim 5,
wherein each diffusor vane (99) is curved when viewed in a radial direction.

7. A multistage centrifugal grinder pump in accordance with claim 5 or 6, wherein each diffusor vane (99) is curved when viewed in the axial direction (A).

8. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, wherein the inlet opening (96) of the disk-shaped diffusor (9) is configured as an annular opening that is located adjacent to a radially outer rim (95) of the disk-shaped diffusor (9).

9. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, wherein the bottom face (91) of the disk-shaped diffusor (9) comprises a smooth, annular central area (94) which is delimited by the inlet opening (96) with respect to a radial direction.

10. A multistage centrifugal grinder pump in accordance with claim 9,
wherein the central area (94) has an outer diameter (D) that is at least as large as the diameter of the first stage impeller (6).

11. A multistage centrifugal grinder pump in accordance with claim 9 or 10, wherein the radially outer rim (95) of the disk-shaped diffusor (9) is configured to protrude over the central area (94) with respect to the axial direction (A).

12. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, comprising a drive unit (10) for rotating the shaft (8) about the axial direction (A), wherein the drive unit (10) is arranged within the housing (2), and wherein the first stage impeller (6) and the second stage impeller (7) are arranged between the drive unit (10) and the grinder (5) with respect to the axial direction (A).

13. A multistage centrifugal grinder pump in accordance with claim 12, designed for a vertical operation with the shaft (8) extending in the vertical direction, wherein the drive unit (10) is arranged above the first stage impeller (6) and the second stage impeller (7).

14. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, configured as a submersible pump.

15. A multistage centrifugal grinder pump in accordance with anyone of the preceding claims, configured as a two stage pump.

Fig. 1

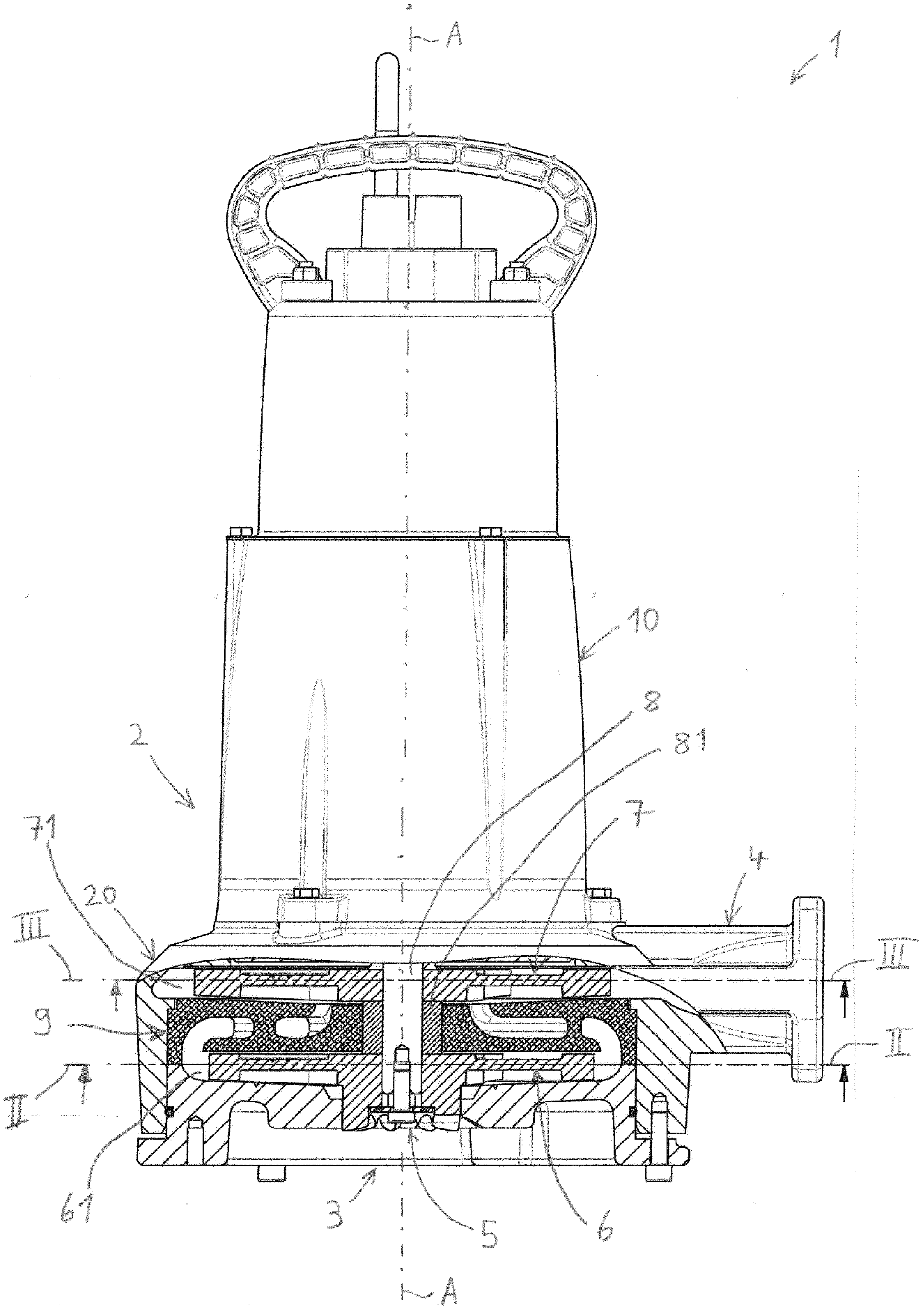
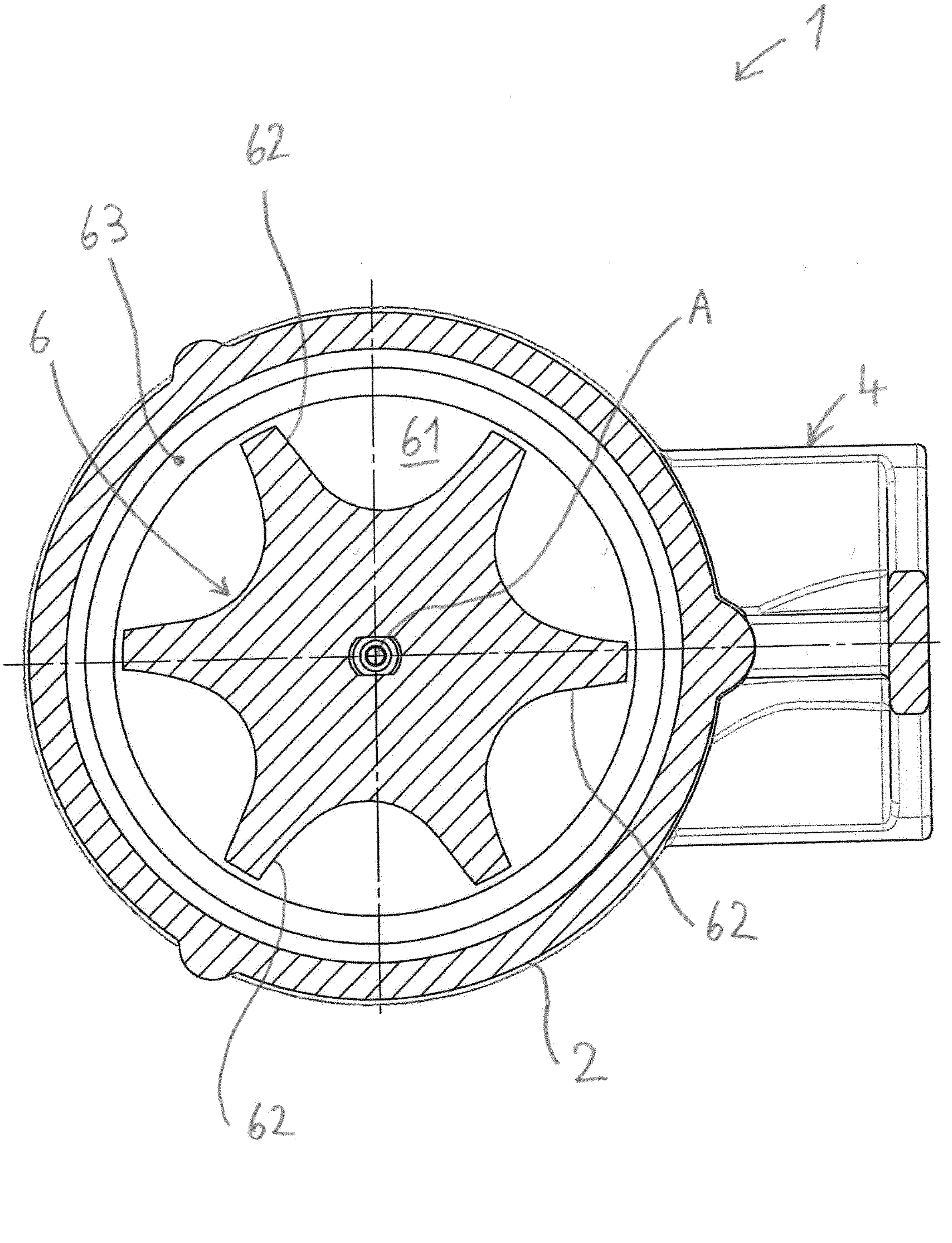


Fig. 2



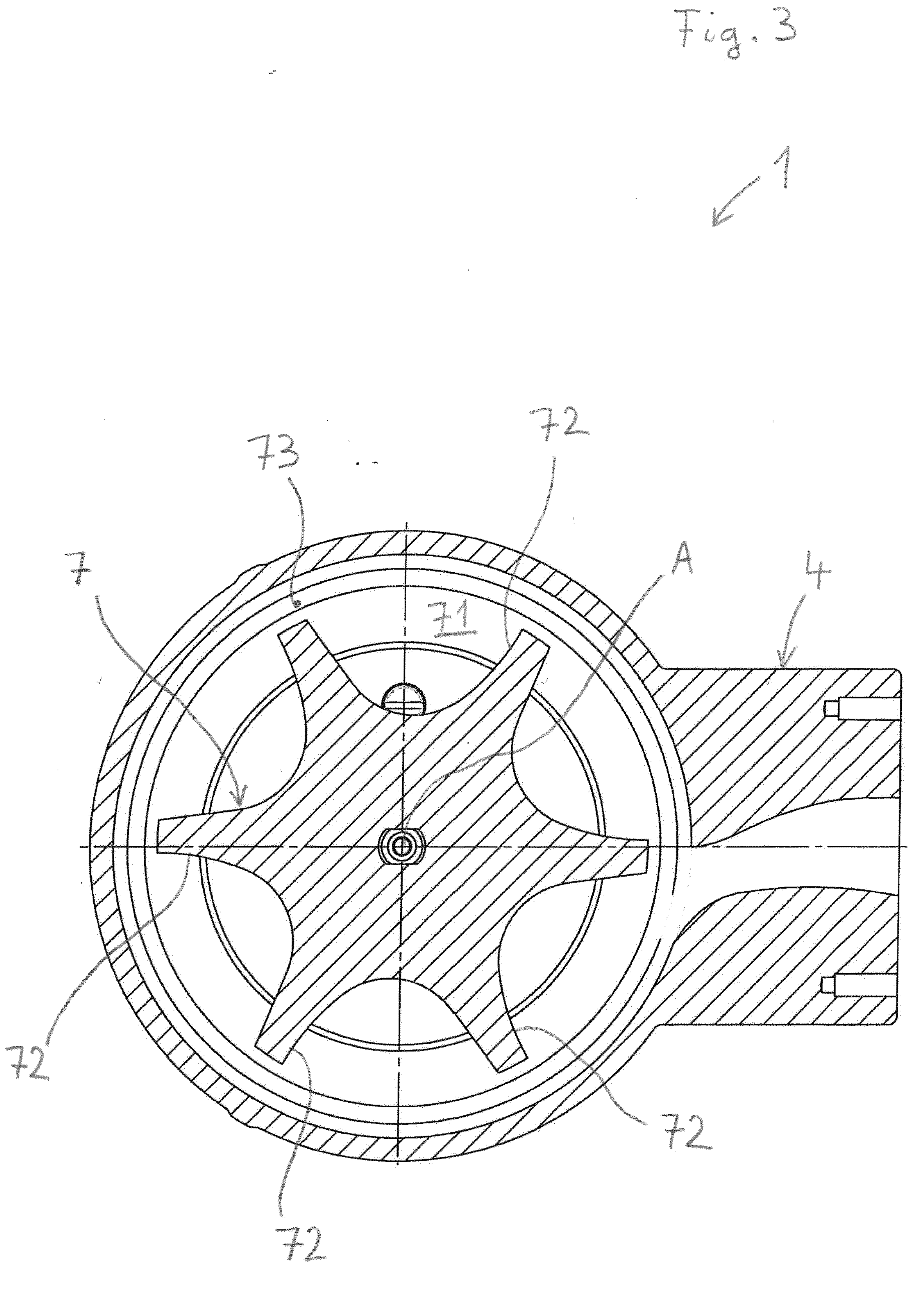


Fig. 3
1
72
73
7
A
4
71
72
72
72
72

Fig. 4

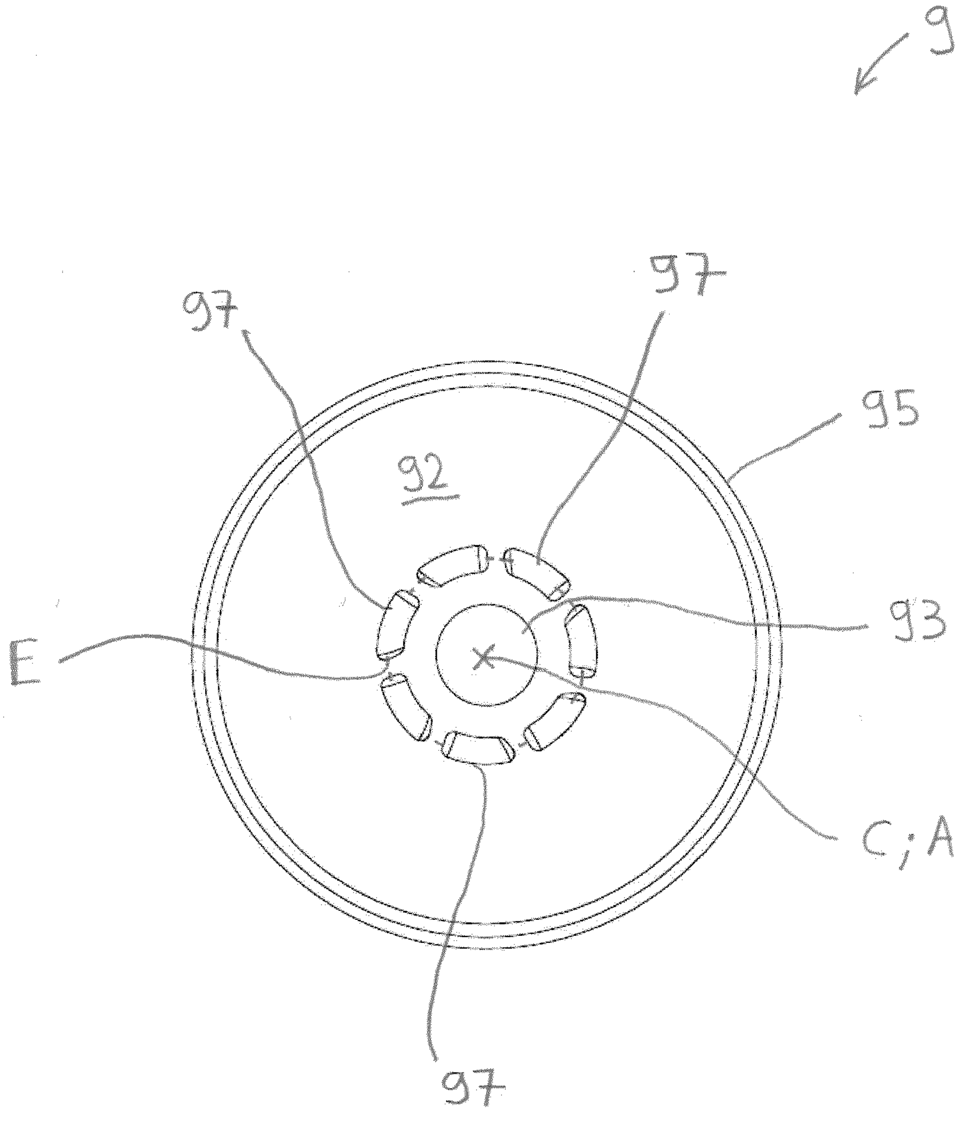


Fig. 5

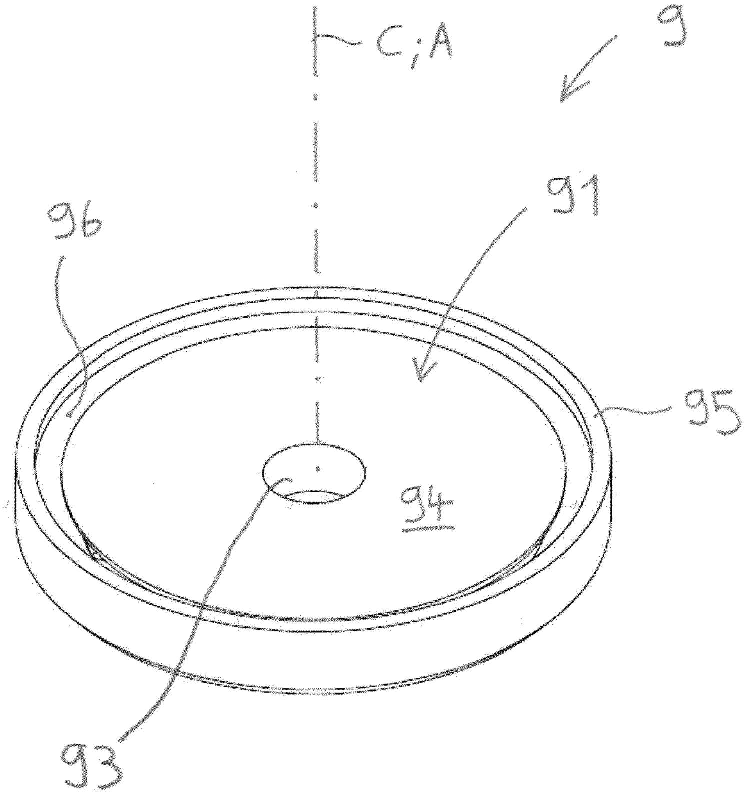


Fig. 6

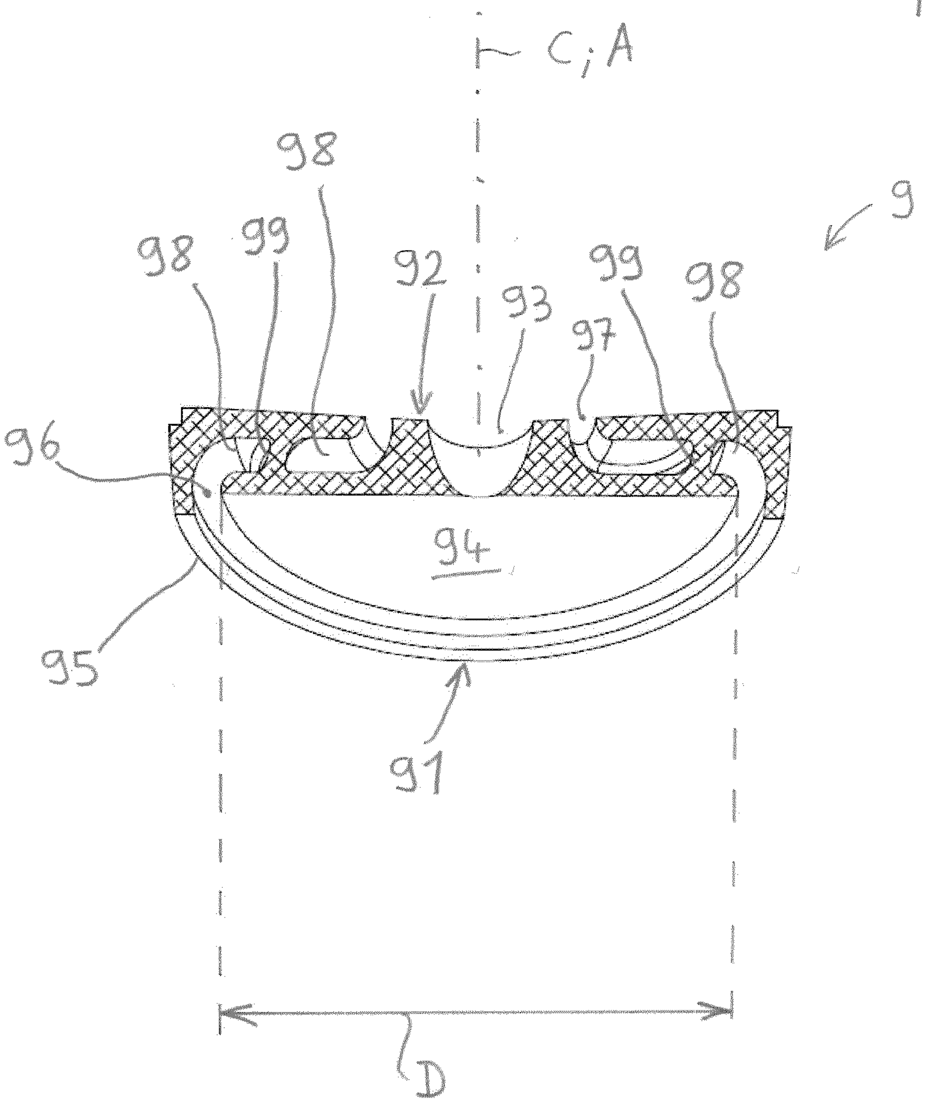


Fig. 7

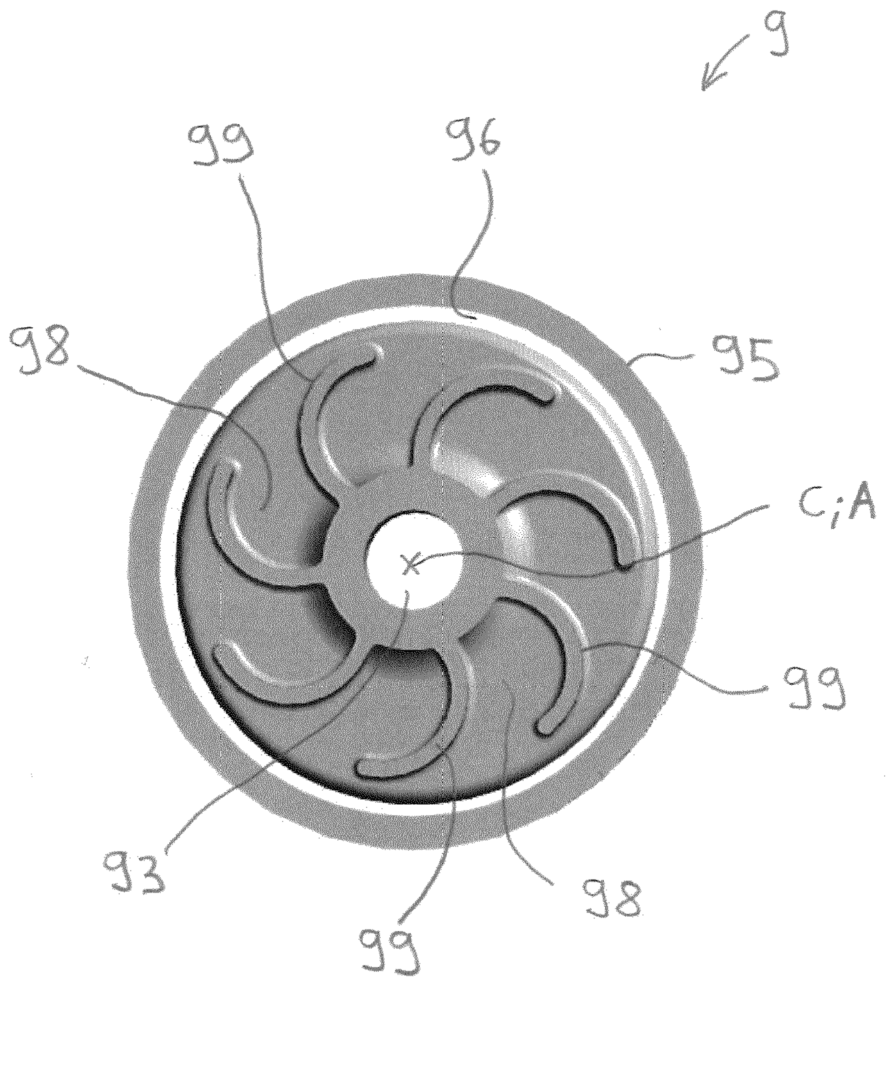


Fig. 8

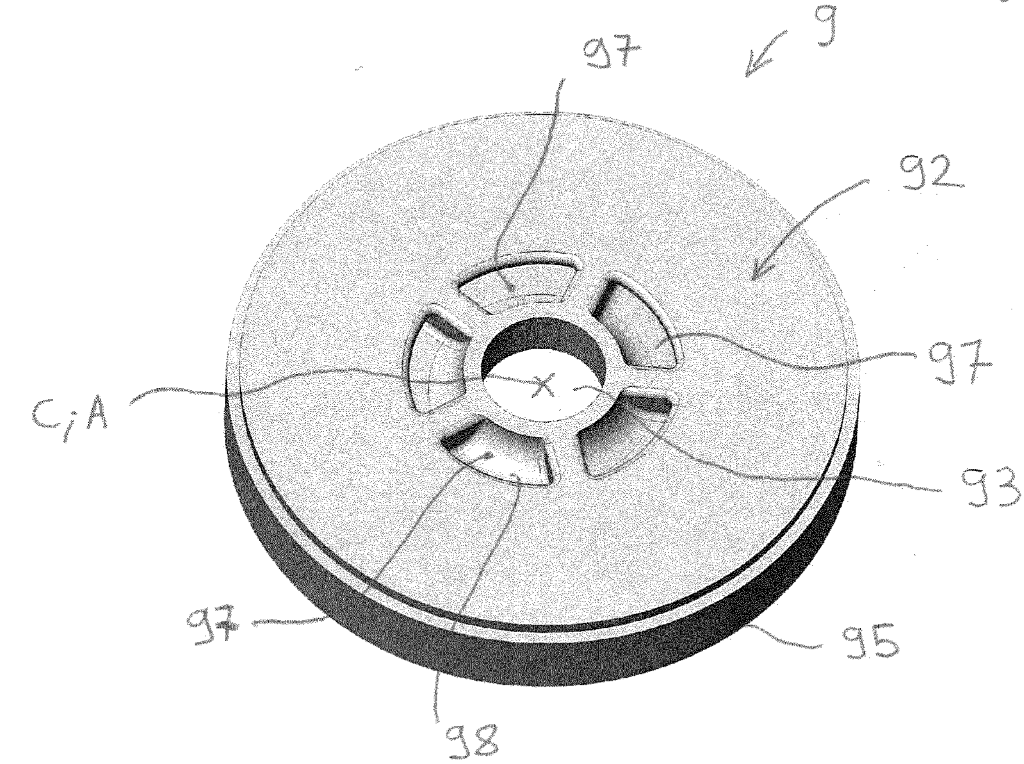
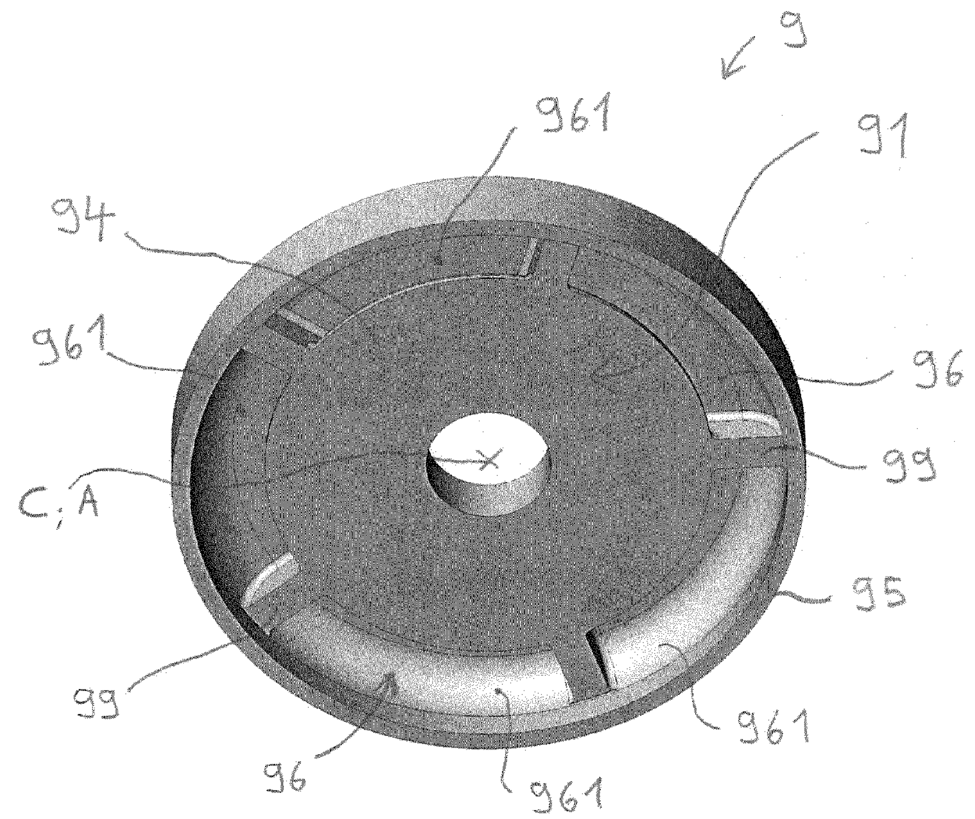


Fig. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 0972

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 195 43 916 A1 (HAENY & CIE AG [CH]) 30 May 1996 (1996-05-30) * column 3, line 30 - line 68 * * column 4, line 1 - line 52 * * figures 1, 5 *	1-15	INV. F04D1/06 E03F5/22 F04D7/04 F04D13/08 F04D29/44
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F04D
E03F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 November 2017	Lovergine, A

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