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(71) Applicant: **Sulzer Management AG**
8401 Winterthur (CH)

(72) Inventor: **Maroccia, Bruno**
8404 Winterthur (CH)

(74) Representative: **Intellectual Property Services GmbH**
Langfeldstrasse 88
8500 Frauenfeld (CH)

(54) **INTAKE DEVICE FOR A VERTICAL PUMP, ARRANGEMENT COMPRISING SUCH AN INTAKE DEVICE AND METHOD OF RETROFITTING A VERTICAL PUMP**

(57) An intake device is proposed for a vertical pump having a suction bell (21), an outlet (22) and a column pipe (24) arranged between the suction bell (21) and the outlet (22), the intake device comprising an inlet section (2) with an inlet opening (5) for a fluid to be pumped by the vertical pump, an outlet section (4) for guiding the fluid into the suction bell (21) of the vertical pump, and a cylindrical section (3) extending in an axial direction (A) and connecting the inlet section (2) with the outlet section (4), wherein the intake device is configured to receive and to surround the suction bell (21) and at least a part of the column pipe (24) of the vertical pump (20), and wherein the outlet section (4) comprises a bottom wall (41) for closing the intake device at a lower end, wherein the inlet section (2) is designed as a funnel-shaped inlet section (2) and tapering in the axial direction (A) from the inlet opening (5) towards the cylindrical section (3), wherein the inlet section (5) is configured to surround the column pipe (24) of the vertical pump with the inlet opening (5) extending completely around the column pipe (24). In addition, an arrangement comprising a vertical pump (20) and an intake device (1) is proposed, as well as a method of retrofitting a vertical pump.

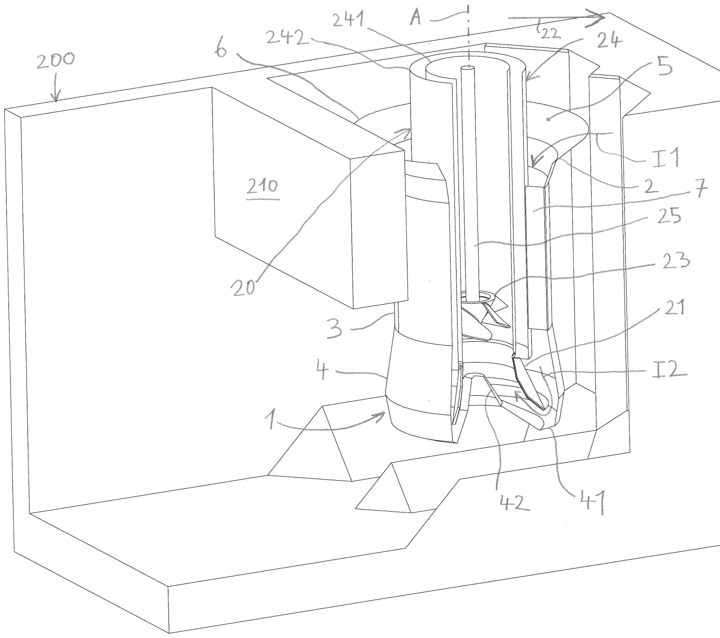

Fig. 2

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Description

[0001] The invention relates to an intake device for a vertical pump, an arrangement comprising a vertical pump and an intake device and a method of retrofitting a vertical pump in accordance with the preamble of the respective independent claim.

[0002] Vertical pumps are used for many different applications for example in the water industry for elevating water from a lower level to a higher level. Some specific applications are e.g. the pumping of waste water, river, lake or sea water, irrigation water, cooling water in power generation plants or their use in firefighting systems, especially in offshore applications. A vertical pump typically comprises a suction bell forming an inlet for the fluid to be pumped, an outlet for discharging the fluid, a column pipe arranged between the suction bell and the outlet, and at least one impeller, but often a plurality of impellers arranged in series on a common shaft, for conveying the fluid from the inlet to the outlet, as well as a drive unit for rotating the shaft with the impeller(s). The impeller(s) may be designed in different types, for example as axial type, semi-axial type or radial type impeller(s). The designation 'vertical pump' indicates that in the normal orientation of use the shaft extends in the vertical direction. Usually the suction bell is arranged at the lower end of the vertical pump and the outlet at its upper end. The impeller that is arranged next to the suction bell is referred to as first stage impeller.

[0003] In a typical application the lower end of the vertical pump comprising the suction bell of the pump is suspended into the fluid to be pumped such that the inlet of the pump is completely submersed. The fluid to be pumped may be a clean or contaminated liquid, for example sewage, a fibrous slurry, or a liquid containing solids. The fluid to be pumped is contained in a sump into which the lower end of the vertical pump is submerged. Upon entering the vertical pump, the flow approaching the first stage impeller inflow area (also referred to as eye of the impeller) should be as homogeneous and uniform as possible across the entire inflow area of the first stage impeller. However, in practice there are usually adverse flow conditions at the suction bell of the vertical pump in the sump, including swirls, vortices or turbulences causing air entrainment or rotation and non-uniform velocity profiles of the fluid adjacent to or in the suction bell. These adverse inflow conditions may considerably reduce the performance and the efficiency of the pump, for example the suction capability, the delivered total head or the delivered flow at the outlet. In addition such adverse inflow conditions may cause enormous mechanical stress acting upon the impeller(s) as well as considerable vibrations of the pump. This results inter alia in high maintenance costs.

[0004] The control or the improvement of the inflow conditions become particularly difficult for vertical pumps that draw the fluid from open pits or sumps having no piping system, because there is no or nearly no guidance for the fluid. In order to improve the inflow conditions at the inlet of the vertical pump, a known measure is to create a specific design of the sump that reduces the occurrence of vortices or disturbances due to sharp corners and obstacles, or to modify the sump design by civil works, for example by dividing walls or guiding structures arranged in the sump. Such civil works may comprise for example providing chamfered corners, plunge walls or pillars in the sump to smooth the flow of the fluid. However, this results in a quite complex design of the sump requiring a considerable amount of civil works and thus causes additional costs. In addition, in many cases it is not possible at all to optimize the design of the sump with reasonable efforts, for example due to the local conditions or spatial confinements.

[0005] It is also known to provide the vertical pump with an intake device attached to the inlet of the pump to improve the flow conditions at the inlet of the pump. US-B-8,177,500 discloses for example an intake device that shall create a uniform flow of liquid entering a vertical pump. The intake device comprises an inlet section having an orifice for receiving a horizontally directed flow, a redirection section for redirecting the flow from the horizontal to the vertical direction, and an outlet section arranged to be connected to the inlet of a vertical pump.

[0006] Starting from this state of the art it is an object of the invention to propose an improved and different intake device for a vertical pump, which generates favorable inflow conditions at the inlet of the vertical pump by at least reducing turbulences and vortices. The device shall be simple in construction and cost efficient. The intake device shall be suited for retrofitting existing pump installations with vertical pumps arranged in a sump to improve the inflow conditions at the pump's inlet. In addition, it is an object of the invention to propose an arrangement comprising a vertical pump and such an intake device. Furthermore it is an object of the invention to propose a method of retrofitting a vertical pump arranged in a sump.

[0007] The subject matter of the invention satisfying these objects is characterized by the features of the respective independent claim.

[0008] Thus, according to the invention an intake device is proposed for a vertical pump having a suction bell, an outlet and a column pipe arranged between the suction bell and the outlet, the intake device comprising an inlet section with an inlet opening for a fluid to be pumped by the vertical pump, an outlet section for guiding the fluid into the suction bell of the vertical pump, and a cylindrical section extending in an axial direction and connecting the inlet section with the outlet section, wherein the intake device is configured to receive and to surround the suction bell and at least a part of the column pipe of the vertical pump, and wherein the outlet section comprises a bottom wall for closing the intake device at a lower end, wherein the inlet section is designed as a funnel-shaped inlet section and tapering in the axial direction from the inlet opening towards the cylindrical section, wherein the inlet section is configured to surround the column pipe of the vertical pump with the inlet opening extending completely around the column pipe.

[0009] Since the intake device with the funnel-shaped inlet section configured to surround the column pipe of the vertical pump in such a manner that the inlet opening of the intake device extends completely around the column pipe of the pump the fluid is smoothly diverted to flow in the axial direction downwardly along the column pipe of the vertical pump prior to entering the suction bell of the pump. Thereby, the flow of fluid is straightened and homogenized when streaming along the cylindrical section of the intake device. The build-up of vortices, turbulences or swirls is at least considerably reduced which results in a more homogeneous velocity profile of the fluid when entering the pump, thus improving the performance and the efficiency of the pump.

[0010] According to a preferred measure the cylindrical section comprises a plurality of radially inwardly directed ribs, each rib extending in the axial direction along the cylindrical section, wherein the ribs are configured to contact the column pipe of the vertical pump. Preferably, the radially inner edges of the ribs are fixed to the column pipe of the pump, for example by welding. By this measure the cylindrical section may be anchored to the column pipe of the vertical pump. The ribs improve the mechanical stability of the intake device. In addition, the ribs further support the straightening and the homogenizing of the flow when descending from the inlet section to the outlet section. Furthermore, the ribs may suppress a rotation of the flow around the column pipe, they further reduce the probability of vortex or swirl generation, and the ribs can break existing vortex structures or swirls before they reach the suction bell of the pump.

[0011] Preferably, the ribs are equidistantly distributed over the inner circumference of the cylindrical section. The preferred number of ribs depends on the specific application, however for most applications a number of four to eight ribs is advantageous.

[0012] A further preferred measure is that the bottom wall is designed with a cone-shaped or frustoconical diverting element for redirecting the fluid into the suction bell, wherein the diverting element is arranged centrally at the bottom wall and tapering when viewed in a direction towards the cylindrical section. The diverting element is advantageous for smoothly diverting the flow moving in a downward direction from the inlet opening through the cylindrical section towards an upward direction. The symmetrical design and the centered arrangement of the diverting element are advantageous for favorable inflow conditions at the suction bell of the pump.

[0013] The intake device may be manufactured by any method known in the art, for example by casting or by subtractive manufacturing processes like machining, metal cutting or milling or combinations thereof. In order to make the intake device particularly cost efficient and especially in view of low manufacturing costs it is a preferred embodiment, that the intake device is fabricated from a plurality of metallic parts which are joined, preferably by welding. In this embodiment the intake device is assembled from a plurality of metallic parts that are prepared by cutting or machining to have an appropriate shape. The individual metallic pieces are then joined by welding to form the intake device. The overall tubular structure of the intake device may be fabricated, for example, by connecting a plurality of essentially ring-shaped parts to each other. It is also possible, to manufacture two half-shells, which are then connected to each other, e. g. by means of screws or bolts, to form the intake device. This may be advantageous for such applications, where the intake device has to be mounted or assembled around the column pipe rather than introducing the vertical pump into the already assembled tubular intake device.

[0014] Preferably the plurality of metallic parts comprises metallic sheets or metallic plates or metallic bands.

[0015] In addition, according to the invention an arrangement is proposed comprising a vertical pump for conveying a fluid and an intake device for the vertical pump, wherein the vertical pump comprises a suction bell for drawing the fluid, an outlet for discharging the fluid, a column pipe extending in an axial direction and being arranged between the suction bell and the outlet, and at least a first stage impeller, for conveying the fluid from the suction bell to the outlet, with the impeller being arranged within the column pipe, and wherein the intake device is arranged and configured to surround the suction bell and at least a part of the column pipe of the vertical pump, wherein the intake device is designed according to the invention, and wherein the inlet section of the intake device surrounds the column pipe of the vertical pump with the inlet opening extending completely around the column pipe.

[0016] In order to even improve the uniformity of the flow of fluid between the intake device and the column pipe of the pump it is advantageous that the column pipe is centered within the intake device, so that the intake device and the column pipe extend coaxially with respect to the axial direction.

[0017] According to a preferred embodiment the suction bell of the pump is arranged within the outlet section of the intake device, and the outlet section is adapted to the shape of the suction bell. By this measure particularly favorable inflow conditions, such as a particularly homogeneous velocity profile of the flow of fluid, may be achieved at the suction bell of the pump.

[0018] For the same reasons as already explained with respect to the intake device it is also preferred for the arrangement, that the cylindrical section of the intake device comprises a plurality of radially inwardly directed ribs, each rib extending in the axial direction along the cylindrical section, wherein each ribs contacts the column pipe of the vertical pump.

[0019] Preferably, the ribs are fixed to the column pipe, for example by welding, to support the intake device. Additionally or alternatively it is also possible to support the intake device by support structures provided at the sump, in which the pump is installed or by mounting the intake device to the sump. The intake device may be supported by structures provided in the sump and arranged below the pump or the intake device, respectively. Furthermore, it is also possible that the sump itself is integrated into the intake device, i.e. parts or structures of the sump may constitute a part of the intake device.

[0020] For the same reasons as already explained with respect to the intake device it is also preferred for the arrangement, that the bottom wall of the intake device is designed with a cone-shaped or frustoconical diverting element for redirecting the fluid into the suction bell, wherein the diverting element is arranged centrally at the bottom wall and tapering when viewed in a direction towards the suction bell, and wherein the diverting element extends into the suction bell.

[0021] According to a preferred embodiment the inlet opening of the intake device has an inlet flow cross-section delimited by the column pipe, and the first stage impeller faces an impeller inflow area having an inflow cross section, wherein the inlet flow cross-section is larger than the inflow cross-section. Since the inlet flow cross-section is larger than the inflow cross-section the fluid is accelerated between the inlet opening of the intake device and the inflow area (also referred to as impeller eye or eye of the impeller), i.e. the velocity of the fluid is larger at the impeller inflow area than at the inlet opening of the intake device. This continuous increase of velocity supports the straightening of the flow of fluid and the avoidance of vortices or swirls.

[0022] In addition, it is preferred that the cylindrical section has a ring-shaped flow cross-section being smaller than the inlet flow cross-section and being larger than the inflow cross-section. By this measure the velocity of the fluid is increased both by the reduction of the flow cross-section from the inlet section to the cylindrical section and by the reduction of the flow cross-section from the cylindrical section to the impeller inflow area.

[0023] The extension of the intake device in the axial direction may be adjusted depending on the specific application. Preferably, said extension is such that the inlet opening of the intake device is located with respect to the axial direction at a level above the first stage impeller. Thus, the axial extension of the intake device is preferably measured such that at least the suction bell and the first stage impeller are completely surrounded by the intake device.

[0024] Regarding the preferred maximum extension of the intake device with respect to the axial direction it is advantageous when the vertical pump has a maximum submergence defining a maximum fluid level location at the column pipe, and when the inlet opening of the intake device is arranged with respect to the axial direction at a distance below the maximum fluid level location, said distance being at least 5%, and preferably at least 10% of the maximum submergence.

[0025] The maximum submergence of the vertical pump defines the upper limit of how deep the vertical pump may be introduced into the fluid, e.g. water, contained in the sump. Thus, during operation of the pump the fluid level in the sump is at most as high that the fluid level coincides with the maximum fluid level location at the column pipe. Since the inlet opening of the intake device is located below the maximum fluid level location, it is ensured that the inlet opening is always located below the fluid level in the sump, so that the fluid can always enter the intake device.

[0026] In addition, according to the invention a method is proposed of retrofitting a vertical pump arranged in a sump and having a suction bell for drawing the fluid, an outlet for discharging the fluid, and a column pipe extending in an axial direction and being arranged between the suction bell and the outlet, said method comprising the steps of:

- providing an intake device being designed according to the invention;
- arranging the intake device around the suction bell and the column pipe of the pump;
- fixing the intake device to the vertical pump and/or to the sump.

[0027] The intake device according to the invention is also particularly suited for retrofitting existing installations of vertical pumps. By providing or fitting the vertical pump with an intake device according to the invention the flow conditions at the inlet of the pump may be considerably improved. The flow becomes more uniform, the occurrence of vortices or swirls at the inlet of the pump is remarkably reduced. Therewith the efficiency and/or the performance of the pump is increased and maintenance costs may be reduced.

[0028] In particular, in such applications where it is not possible or too laborious or too expensive to modify the design of the sump by civil works, the intake device according to the invention is a cost efficient and effective solution to address adverse flow conditions at the inlet of the pump.

[0029] Furthermore, a method is proposed of retrofitting a vertical pump arranged in a sump and having a suction bell for drawing the fluid, an outlet for discharging the fluid, and a column pipe extending in an axial direction and being arranged between the suction bell and the outlet, said method comprising the step of providing the vertical pump with an intake device and forming an arrangement according to the invention.

[0030] Further advantageous measures and embodiments of the invention will become apparent from the dependent claims.

[0031] The invention will be explained in more detail hereinafter with reference to the drawings. There are shown in a schematic representation:

Fig. 1: a perspective view of an embodiment of an arrangement according to the invention comprising a vertical pump and an embodiment of an intake device according to the invention,

Fig. 2: as Fig. 1 with a part of the intake device and a part of the pump housing removed,

Fig. 3: a perspective cross-sectional view of the embodiment in a section perpendicular to the axial direction along section line III-III in Fig. 1, and

Fig. 4: a schematic representation illustrating several extensions.

[0032] Fig. 1 shows a perspective view of an embodiment of an arrangement according to the invention comprising a vertical pump and an embodiment of an intake device according to the invention, wherein the arrangement is located in a sump. The intake device is designated in its entity with reference numeral 1, the vertical pump is designated in its entity with reference numeral 20 and the arrangement is designated in its entity with reference numeral 100. The sump, in which the arrangement 100 is installed, is designated with reference numeral 200. The sump 200 is represented in a sectional view to make the arrangement 100 visible. The sump 200 may comprise guiding structures 210 for the fluid, e.g. produced by civil works.

[0033] For a better understanding Fig. 2 and Fig. 3 show additional representations of the embodiment of the arrangement 100 and the embodiment of the intake device 1. Fig. 2 is similar to Fig. 1, however a part of the intake device 1 as well as a part of the housing of the pump 20 has been removed to make the inside visible. Fig. 3 is a perspective cross-sectional view in a section perpendicular to an axial direction A and along section line III-III in Fig. 1.

[0034] Fig. 4 is a very schematic representation of the arrangement 100 in the sump 200 having the purpose of illustrating several dimensions that will be explained hereinafter.

[0035] Within the scope of this application relative terms like 'top', 'bottom', 'side', 'below', 'above', 'upper end', lower end' and so on are always referring to the normal orientation of the arrangement 100 during operation, i.e. they refer to the operational state. The vertical direction is the direction defined by the gravity. Fig. 1-3 show the arrangement 100 in its operational orientation.

[0036] The term "sump" has to be understood with a broad meaning. The sump 200 may be, for example, a natural sump 200, such as a lake, a sea, a river or a bay, or any other fluid containing structure, such as a tank, a receptacle, a basin, a (sewage) conduit or the like. The sump 200 contains a fluid to be pumped by the vertical pump 20 out of the sump 200, for example a liquid like water or contaminated water, sea water, sewage or a liquid containing solid matters. Furthermore, the sump 200 may be an open sump 200 or a closed sump 200.

[0037] The arrangement 100 comprises the vertical pump 20. In a manner known as such the vertical pump 20 comprises a bell-shaped suction bell 21 arranged at a lower end of the pump 20. The suction bell 21 comprises the inlet of the pump 20, through which the fluid enters the pump 20. The vertical pump 20 further comprises an outlet 22 for discharging the fluid. The outlet 22 is usually arranged in the region of the upper end of the pump 20 and only schematically indicated in the drawings by the arrow with the reference numeral 22. The vertical pump 20 further comprises a column pipe 24 having an overall tubular shape and extending in the axial direction A, which is usually the vertical direction. The column pipe 24 is arranged between the suction bell 21 and the outlet 22. For delivering the fluid from the suction bell 21 to the outlet 22 the vertical pump 20 comprises at least one impeller 23 arranged within the column pipe 24. The vertical pump 20 may be designed as a single stage pump, having only one impeller 23, or the vertical pump 20 may be designed as a multistage pump comprising a plurality of impellers arranged in series on a common shaft 25, to which the impellers are connected in a torque-proof manner. Usually, each impeller belongs to one stage of the pump 20. The shaft 25 is connected to a drive unit (not shown) for rotating the shaft 25 with the impeller(s) 23. Usually the drive unit is mounted on the upper end of the vertical pump 20, or respectively, on top of a bearing unit (not shown) for supporting the shaft 25 with the bearing unit being arranged at the upper end of the vertical pump 20. The shaft 25 is arranged centrally within the column pipe 24.

[0038] Since it is sufficient for the understanding, in Fig. 2 only one impeller 23 is shown, but there may be a plurality of impellers. The impeller 23 shown in Fig. 2 is the first stage impeller 23, which is the impeller that is arranged next, i.e. closest, to the suction bell 21 and facing the inlet of the pump 20. For an efficient operation and a good performance of the vertical pump 20 it is important that in particular the flow of fluid towards the first stage impeller 23, i.e. the flow through the impeller inflow area (also referred to as eye of the impeller) is as homogeneous and uniform as possible. The impeller inflow area is usually located at the exit (downstream side) of the suction bell 21. The impeller inflow area defines an inflow cross-section FP (Fig. 4), which is the area perpendicular to the axial direction A through which the fluid can flow towards the first stage impeller 23.

[0039] The impeller 23 or the plurality of impellers may be of any type which is used in vertical pumps, e.g. axial type, semi-axial type or radial type.

[0040] The vertical pump 20 is a pump 20 in which the shaft 25 for driving the impeller(s) 23 is extending in the vertical direction during operation of the pump. The axis of the shaft 25, i.e. the rotational axis, about which the shaft 25 with the impeller(s) 23 rotates during operation, defines the axial direction A that coincides with the vertical direction.

[0041] 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'.

[0042] The column pipe 24 is usually extending from the suction bell 21 to the bearing unit (not shown) or to a support structure or a foundation at the upper end of the pump 20 for supporting the vertical pump 20. Typically, the vertical pump 20 is supported by a foundation being arranged beneath and in the proximity of the pump outlet, such that the pump 20 and in particular the main part of the column pipe 24 are freely hanging into the sump 200 without further support. The column pipe 24 forms a part of the pump housing and may comprise several walls being arranged coaxially. As can be best seen in Fig. 2 the column pipe 24 may comprise an inner wall 241 surrounding the impeller(s) 23 and delimiting a flow path for the fluid within the pump 20. The column pipe 24 further comprises an outer wall 242 coaxially surrounding the inner wall 241 and forming a part of the pump housing. The outer wall 242 is designed as a tube and has an essentially cylindrical shape. Of course, it is also possible that the column pipe 24 comprises only one wall, delimiting the vertical pump in radial direction. Independent from whether the column pipe 24 comprises one or more walls, the column pipe 24 is designed in such a manner, that the radially outermost surface of the column pipe 24 is essentially formed as a lateral or circumferential surface of a cylinder.

[0043] Since vertical pumps 20 are well known in the art in numerous embodiments and designs, there is no need for further explanations here. The vertical pump 20 may be any kind of known pumps, e.g. a centrifugal pump, a single stage pump or a multistage pump. Each impeller 23 may be an open impeller, a closed impeller or a semi-open impeller.

[0044] The vertical pump 20 is suspended with respect to the sump 200 such that at least the suction bell 21 is completely submerged in the fluid. During operation the impeller(s) 23 of the vertical pump draw(s) the fluid from the sump 200 through the suction bell 21 and convey(s) the fluid to the outlet 22.

[0045] The arrangement 100 further comprises the intake device 1 for generating favorable flow conditions of the fluid at the inlet of the pump 20, meaning in particular that the flow of fluid is very uniform (e.g. has a uniform velocity distribution) upon entering the pump 20 and that the generation or propagation of vortices, swirls or preswirls is prevented or at least considerably reduced, so that a homogenized flow of fluid is created in front of the first stage impeller 23.

[0046] The intake device 1 is configured and arranged to surround the suction bell 21 and at least a part of the column pipe 24 of the pump 20. The intake device 1 has essentially an overall tubular shape and extends in the same direction as the column pipe 24, namely in the axial direction A. Preferably, the intake device 1 is arranged coaxially with the column pipe 24.

[0047] The intake device 1 comprises an inlet section 2 with an inlet opening 5 for receiving the fluid from the sump 200, an outlet section 4 for guiding the fluid into the suction bell 21 of the pump 20 and a cylindrical section 3 extending in the axial direction A and connecting the inlet section 2 with the outlet section 4.

[0048] The inlet section 2 is designed as a funnel-shaped inlet section 2 tapering with respect to the axial direction A from the inlet opening 5 towards the cylindrical section 3. The inlet section 2 has an axially upper rim 6 designed as a circular ring and delimiting the inlet opening 5 with respect to the radial direction. Radially inwardly the inlet opening 5 is delimited by the column pipe 24 of the vertical pump 20. The inlet section 2 is arranged and configured in such a manner that the annular upper rim 6 completely surrounds the column pipe 24, wherein the column pipe 24 is centered with respect to the upper rim 6. Thus, the inlet opening 5 is an annular area delimited by the column pipe 24 and the upper rim 6 and having its center on the centerline of the column pipe 24, i.e. the inlet section 2 with the inlet opening 5 is arranged coaxially with the column pipe 24. The annular area of the inlet opening 5 has an inlet flow cross-section FI (Fig. 4) which is the area perpendicular to the axial direction A through which the flow of fluid can enter the intake device 1. The inlet flow cross-section FI is larger than the inflow cross-section FP of the impeller inflow area in front of the first stage impeller 23, so that the velocity of the fluid at the impeller inflow area is larger than the velocity of the fluid at the inlet opening 5 of the intake device 1.

[0049] The cylindrical section 3 is designed as a cylindrical tube extending in the axial direction A and having a constant inner diameter. The cylindrical section 3 is arranged coaxially with the column pipe 24, i.e. the column pipe 24 is centered with respect to the cylindrical section 3. The cylindrical section 3 and the column pipe 24 delimit a ring-shaped flow cross-section FC (Fig. 4), which is the area perpendicular to the axial direction A through which the fluid can flow when passing the cylindrical section 3. The ring-shaped flow cross-section FC is smaller than the inlet flow cross-section FI, so that the velocity of the fluid in axial direction A is larger in the cylindrical section 3 than in the inlet section 2. The fluid is accelerated in axial direction A between the inlet opening 5 and the cylindrical section 3.

[0050] In addition, the flow cross-section FC of the cylindrical section 3 is measured such that it is larger than the inflow cross-section FP of the impeller inflow area in front of the first stage impeller 23. Thus, the open cross-section for the fluid is reduced from the inlet flow cross-section FI to the flow-cross-section FC of the cylindrical section 3 and further reduced to the inflow cross-section FP in front of the first stage impeller 23. As a consequence the velocity of the flow of fluid is increased from the inlet section 2 to the cylindrical section 3 and further increased from the cylindrical section 3 to the impeller inflow area. This increase in velocity helps to straighten and to homogenize the flow, and to avoid or to at least considerably reduce the generation of vortices or swirls and thus to improve the inflow conditions of the fluid at the impeller inflow area in front of the first stage impeller 23.

[0051] The outlet section 4 comprises a bottom wall 41 that closes the intake device 1 at its lower end with respect to the axial direction A. The outlet section 4 is arranged and configured to receive the suction bell 21 of the vertical pump 20. The suction bell 21 is completely surrounded by and centered with respect to the outlet section 4. The bottom wall 41 is located beneath the suction bell 21 and faces the inlet of the suction bell 21. The lateral wall of the outlet section 4 is configured to essentially follow the outer contour of the suction bell 21, i.e. the outlet section 4 is enlarging in radial direction as compared to the cylindrical section 3.

[0052] The bottom wall 41 is designed with a cone-shaped or frustoconical diverting element 42 for redirecting the fluid to the suction bell 21. The diverting element 42 is rotationally symmetrical with respect to the axial direction A and arranged centrally at the bottom wall 41. The diverting element 42 is designed to taper when viewing towards the cylindrical section 3 or towards the suction bell 21 of the pump, respectively.

[0053] Furthermore, as can be best seen in Fig. 2, the diverting element 42 is arranged and designed to extend into the suction bell 21, so that the flow of fluid is smoothly directed towards the impeller inflow area and towards the first stage impeller 23.

[0054] The diverting element 42 may also be designed for example as a paraboloid, a truncated paraboloid, a hyperboloid, or a truncated hyperboloid.

[0055] The intake device 1 further comprises a plurality of radially inwardly directed ribs 7 provided in the cylindrical section 3. Each rib 7 extends in the axial direction A along the cylindrical section 3, and preferably each rib 7 extends over the entire cylindrical section 3 with respect to the axial direction A, so that each rib 7 has the same length in axial direction A as the cylindrical section 3. Each rib 7 is configured to contact the column pipe 24 of the pump 20, preferably over the entire length of the rib 7 in axial direction A.

[0056] The ribs 7, each of which extends with respect to the radial direction from the radially outer wall of the cylindrical section 3 to the column pipe 24, divide the annular chamber delimited by the cylindrical section 3 and the column pipe 24 into a plurality of adjacent chambers arranged around the column pipe 24. This measure helps to prevent the fluid in the intake device 1 from a rotational movement around the column pipe 24.

[0057] Preferably, the ribs 7 are equidistantly distributed along the inner circumference of the cylindrical section 3 (Fig. 3). The preferred number of ribs 7 is at least four and at most eight, but may be higher or lower. In the embodiment shown in Fig. 3, five ribs 7 are provided.

[0058] Furthermore, it is preferred that some or all of the ribs 7 are fixedly connected to the column pipe 24, for example by welding or any other suited measure. By fixing the ribs 7 to the column pipe 24 the intake device 1 may be supported by the vertical pump 20. Thus, the foundation supporting the vertical pump 20 also supports the intake device 1 connected to the column pipe 24 of the pump 20.

[0059] As an alternative or in addition to the direct anchoring to the pump 20, the intake device 1 may also be supported by the sump 200. For example, the intake device 1 may rest on existing guiding structures 210 already provided in the sump 200, or the intake device 1 may be fixed to a wall of the sump 200. In addition, it is also possible that the sump 200 itself constitutes a part of the intake device 1, for example the cylindrical section 3.

[0060] The intake device 1 may be manufactured by any method known in the art, for example by casting or by any suited subtractive manufacturing processes like machining, metal cutting, milling or combinations thereof. In order to make the intake device 1 particularly cost efficient and especially in view of low manufacturing costs it is preferred to fabricate the intake device 1 from a plurality of metallic parts which are joined, preferably by welding.

[0061] The preferred manufacturing method to fabricate the intake device from a plurality of metallic parts is indicated in Fig. 3 where the individual metallic parts are designated with the reference numerals P. The intake device 1 is assembled from the plurality of metallic parts P. Each individual part P is brought to the appropriate shape before the individual parts are joined to each other to form the intake device 1. The preparation of the individual parts P to bring them in the desired shape may be done by means of different methods, for example by cutting, machining, bending, kinking and so on. The individual metallic parts P are then joined by welding or assembled around the column pipe 24 to form the intake device 1.

[0062] The number of individual parts P for assembling the intake device 1 may be chosen in an appropriate manner according to the specific application. One possibility is for example to assemble first the inlet section 2, the cylindrical section 3 with the ribs 7 and the outlet section 4 each as separate component and afterwards assembling these components to form the intake device 1.

[0063] As feedstock material for the preparation of the metallic parts P for example metallic sheets, metallic plates or metallic bands may be used.

[0064] When the vertical pump 20 provided with the intake device 1 is mounted in the sump 200 the upper rim 6 of the inlet section 2 of the intake device 1 is located below the fluid level 202 (Fig. 4) of the fluid, e.g. water, contained in the sump 200. That is, the upper rim 6 is arranged below the surface of the fluid in the sump 200. The fluid can only enter the suction bell 21 of the pump 20 by passing through the intake device 1.

[0065] During operation the funnel-shaped inlet section 2 smoothly turns the flow of fluid to the axial direction

A as indicated by the arrow I1 in Fig. 2, so that the fluid is flowing downwards along the column pipe 24 through the space between the column pipe 24 and the intake device 1. Thus, the inlet section 2 directs the flow of fluid from the surrounding environment to the cylindrical section 3 of the intake device 1. The cylindrical section 3 defines the annular chamber, or the plurality of chambers separated from each other by the ribs 7, respectively, through which the fluid descends to the outlet section 4 of the intake device 1. The ribs 7 also help straightening and homogenizing the flow of fluid as well as avoiding a rotational movement of the fluid around the column pipe 24. The outlet section 4 redirects the flow of fluid into the suction bell 21 of the vertical pump 20, i.e. within the outlet section 4 the flow of fluid is diverted from flowing in an essentially vertically downward direction to flowing in an essentially vertically upward direction as indicated by arrow I2 in Fig. 2. The centrally arranged diverting element 42 extending into the suction bell 21 supports the smooth redirection of the flow of fluid, so that the flow of fluid passing through the impeller inflow area of the first stage impeller 23 has a very uniform flow profile, in particular said flow of fluid has a uniform velocity distribution and is - at least approximately - free of disturbing vortices or swirls.

[0066] The length L (Fig. 4) of the intake device 1, which is the extension of the intake device 1 with respect to the axial direction A, may be adapted according to the specific application. A suited length L may depend inter alia from the submergence of the vertical pump 20, from the fluid level 202 of the fluid in the sump 200 or from the required performance of the pump 20 (e.g. head, flowrate).

[0067] Usually, the vertical pump 20 (if not designed for being completely submerged) has a maximum submergence MS it is designed for. By this maximum submergence MS a maximum fluid level location MF is defined at the column pipe 24 designating the allowed maximum level for the fluid. Thus, the fluid level 202 in the sump 200 shall not be above the maximum fluid level location MF at the column pipe 24. Fig. 4 illustrates an installation where the vertical pump 20 has a submergence that corresponds to the maximum submergence MS the pump 20 is designed for. The fluid level 202 of the fluid in the sump 200 is at the maximum fluid level location MF of the pump 20. The length L of the intake device 1 is measured such, that the inlet opening 5 of the intake device 1 is arranged with respect to the axial direction A at a distance D below the maximum fluid level location MF, wherein the distance D is at least 5% and preferably at least 10% of the maximum submergence MS of the pump. By this measure it is ensured that the inlet opening 5 is always sufficiently below the fluid level 202 in the sump 200 to allow for a smooth and uniform flow of the fluid into the intake device 1. In case the vertical pump 20 is installed in such a manner that it does not operate at its maximum submergence MS, the length L of the intake device 1 has to be reduced correspondingly to ensure that the inlet opening is always located sufficiently below the fluid level 202 in the sump 200.

[0068] Furthermore, the length L of the intake device 1 is preferably measured such that the inlet opening 5 of the intake device 1 is located - with respect to the axial direction A - at a level that is at least above the first stage impeller 23. That is, with respect to the axial direction A, at least the suction bell 21 and the first stage impeller 23 are completely surrounded by the intake device 1.

[0069] With respect to the radial direction the intake device 1 is designed in such a manner that the cross-section for the flow of the fluid between the intake device 1 and the column pipe 24, in particular the ring-shaped flow cross-section FC of the cylindrical section 3 is sufficiently large to keep the friction losses caused by the streaming of the fluid along the column pipe 24 within an acceptable limit.

[0070] Of course, the extension of the intake device both with respect to the axial direction A and with respect to the radial direction should be adapted to the respective pump installation and/or to the sump 200 and/or to the fluid level 202 in the sump 200. The adaption to the specific application may be based on a computational analysis, e.g. by means of CFD calculations (CFD: computational fluid dynamics).

[0071] By providing a vertical pump 20 with the intake device 1 according to the invention, the inflow conditions at the entrance of the pump 20, in particular at the impeller inflow area of the first stage impeller 23, may be considerably improved. Various flow quality indicators such as the pre-swirl rate, the vortex generation or the nonuniformity of the velocity distribution of the flow of fluid may be improved or brought within the limits specified by relevant regulations, e.g. ANSI regulations. The intake device 1 has the advantage that it provides the possibility of improving the quality of the inflow into a vertical pump 20 without requiring significant changes to the sump 200. The intake device 1 may be provided without or with very limited construction works on the existing sump 200.

[0072] Therefore the intake device 1 according to the invention is also particularly suited for retrofitting existing pump installations in open or closed sumps 200. Instead of doing laborious civil works in the sump 200 of such a pump installation an intake device 1 designed in accordance with the invention may be provided.

[0073] By providing the intake device 1 with dimensions adapted to the existing vertical pump 20 and/or the sump 200, arranging the intake device 1 around the suction bell 21 and the column pipe 24 of the existing vertical pump 20, and fixing the intake device to the vertical pump 20 and/or the sump 200, the inflow conditions at the suction bell 21 of an existing pump installation may be considerably improved.

[0074] Depending on the respective application it is possible to fabricate the entire intake device 1, to arrange it around the column pipe 24 or to insert the suction bell 21 and the column pipe 24 into the intake device 1, and to fix the intake device 1. It is also possible to manufacture the intake device 1 in several parts, for example two axially split halves, to assemble the intake device 1 around the column pipe 24 and to fix the individual parts of the intake device 1 to each other, e.g. by screws or bolts or by welding.

[0075] Depending on the respective sump 200 or the existing guiding structures 210 it is also possible that the sump 200 or one or more of the guiding structures 210 form a part of the intake device 1. For example, when an essentially tubular structure with an essentially circular cross-section is already in place in the sump 200, this tubular structure may be used to form the cylindrical section 3 of the intake device 1 or a part thereof.

Claims

1. An intake device for a vertical pump having a suction bell (21), an outlet (22) and a column pipe (24) arranged between the suction bell (21) and the outlet (22), the intake device comprising an inlet section (2) with an inlet opening (5) for a fluid to be pumped by the vertical pump, an outlet section (4) for guiding the fluid into the suction bell (21) of the vertical pump, and a cylindrical section (3) extending in an axial direction (A) and connecting the inlet section (2) with the outlet section (4), wherein the intake device is configured to receive and to surround the suction bell (21) and at least a part of the column pipe (24) of the vertical pump (20), and wherein the outlet section (4) comprises a bottom wall (41) for closing the intake device at a lower end, **characterized in that** the inlet section (2) is designed as a funnel-shaped inlet section (2) and tapering in the axial direction (A) from the inlet opening (5) towards the cylindrical section (3), wherein the inlet section (5) is configured to surround the column pipe (24) of the vertical pump with the inlet opening (5) extending completely around the column pipe (24).

2. An intake device in accordance with claim 1, wherein the cylindrical section (3) comprises a plurality of radially inwardly directed ribs (7), each rib (7) extending in the axial direction (A) along the cylindrical section (3), wherein the ribs (7) are configured to contact the column pipe (24) of the vertical pump (20).

3. An intake device in accordance with anyone of the preceding claims, wherein the bottom wall (41) is designed with a cone-shaped or frustoconical diverting element (42) for redirecting the fluid into the suction bell (21), wherein the diverting element (42) is arranged centrally at the bottom wall (41) and tapering when viewed in a direction towards the cylindrical section (3).

4. An intake device in accordance with anyone of the preceding claims, wherein the intake device is fabricated from a plurality of metallic parts (P) which are joined, preferably by welding.

5. An intake device in accordance with claim 4, wherein the plurality of metallic parts (P) comprises metallic sheets or metallic plates or metallic bands.

6. An arrangement comprising a vertical pump (20) for conveying a fluid and an intake device (1) for the vertical pump (20), wherein the vertical pump (20) comprises a suction bell (21) for drawing the fluid, an outlet (22) for discharging the fluid, a column pipe (24) extending in an axial direction (A) and being arranged between the suction bell (21) and the outlet (22), and at least a first stage impeller (23) for conveying the fluid from the suction bell (21) to the outlet (22), with the impeller (23) being arranged within the column pipe (24), and wherein the intake device (1) is arranged and configured to surround the suction bell (21) and at least a part of the column pipe (24) of the vertical pump, **characterized in that** the intake device (1) is designed according to anyone of the preceding claims, and **in that** the inlet section (2) of the intake device surrounds the column pipe (24) of the vertical pump with the inlet opening (5) extending completely around the column pipe (24).

7. An arrangement in accordance with claim 6, wherein the suction bell (21) of the pump (20) is arranged within the outlet section (4) of the intake device, and wherein the outlet section (4) is adapted to the shape of the suction bell (21).

8. An arrangement in accordance with anyone of claims 6-7, wherein the cylindrical section (3) of the intake device comprises a plurality of radially inwardly directed ribs (7), each rib (7) extending in the axial direction (A) along the cylindrical section (3), wherein each ribs (7) contacts the column pipe (24) of the vertical pump.

9. An arrangement in accordance with anyone of claims 6-8, wherein the bottom wall (41) of the intake device is designed with a cone-shaped or frustoconical diverting element (42) for redirecting the fluid into the suction bell (21), wherein the diverting element (42) is arranged centrally at the bottom wall (41) and tapering when viewed in a direction towards the suction bell (21), and wherein the diverting element (42) extends into the suction bell (21).

10. An arrangement in accordance with anyone of claims 6-9, wherein the inlet opening (5) of the intake device (1) has an inlet flow cross-section (FI) delimited by the column pipe (24), wherein the first stage impeller (23) faces an impeller inflow area having an inflow cross section (FP), and wherein the inlet flow cross-section (FI) is larger than the inflow cross-section

(FP).

11. An arrangement in accordance with claim 10, wherein the cylindrical section (3) has a ring-shaped flow cross-section (FC) being smaller than the inlet flow cross-section (FI) and being larger than the inflow cross-section (FP).

12. An arrangement in accordance with anyone of claims 6-11, wherein the inlet opening (5) of the intake device is located with respect to the axial direction (A) at a level above the first stage impeller (23).

13. An arrangement in accordance with anyone of claims 6-12, wherein the vertical pump has a maximum submergence (MS) defining a maximum fluid level location (MF) at the column pipe (24), and wherein the inlet opening (5) of the intake device (1) is arranged with respect to the axial direction (A) at a distance (D) below the maximum fluid level location (MF), said distance (D) being at least 5%, and preferably at least 10% of the maximum submergence (MS).

14. A method of retrofitting a vertical pump arranged in a sump and having a suction bell (21) for drawing the fluid, an outlet (22) for discharging the fluid, and a column pipe (24) extending in an axial direction (A) and being arranged between the suction bell (21) and the outlet (22), said method **characterized by** comprising the steps of:

- providing an intake device (1) being designed in accordance with anyone of claims 1-5
- arranging the intake device (1) around the suction bell (21) and the column pipe (24) of the pump (20)
- fixing the intake device (1) to the vertical pump (20) and/or to the sump (200).

15. A method of retrofitting a vertical pump arranged in a sump and having a suction bell (21) for drawing the fluid, an outlet (22) for discharging the fluid, and a column pipe (24) extending in an axial direction (A) and being arranged between the suction bell (21) and the outlet (22), said method being **characterized by** providing the vertical pump (20) with an intake device (1) and forming an arrangement (100) according to anyone of claims 6-13.

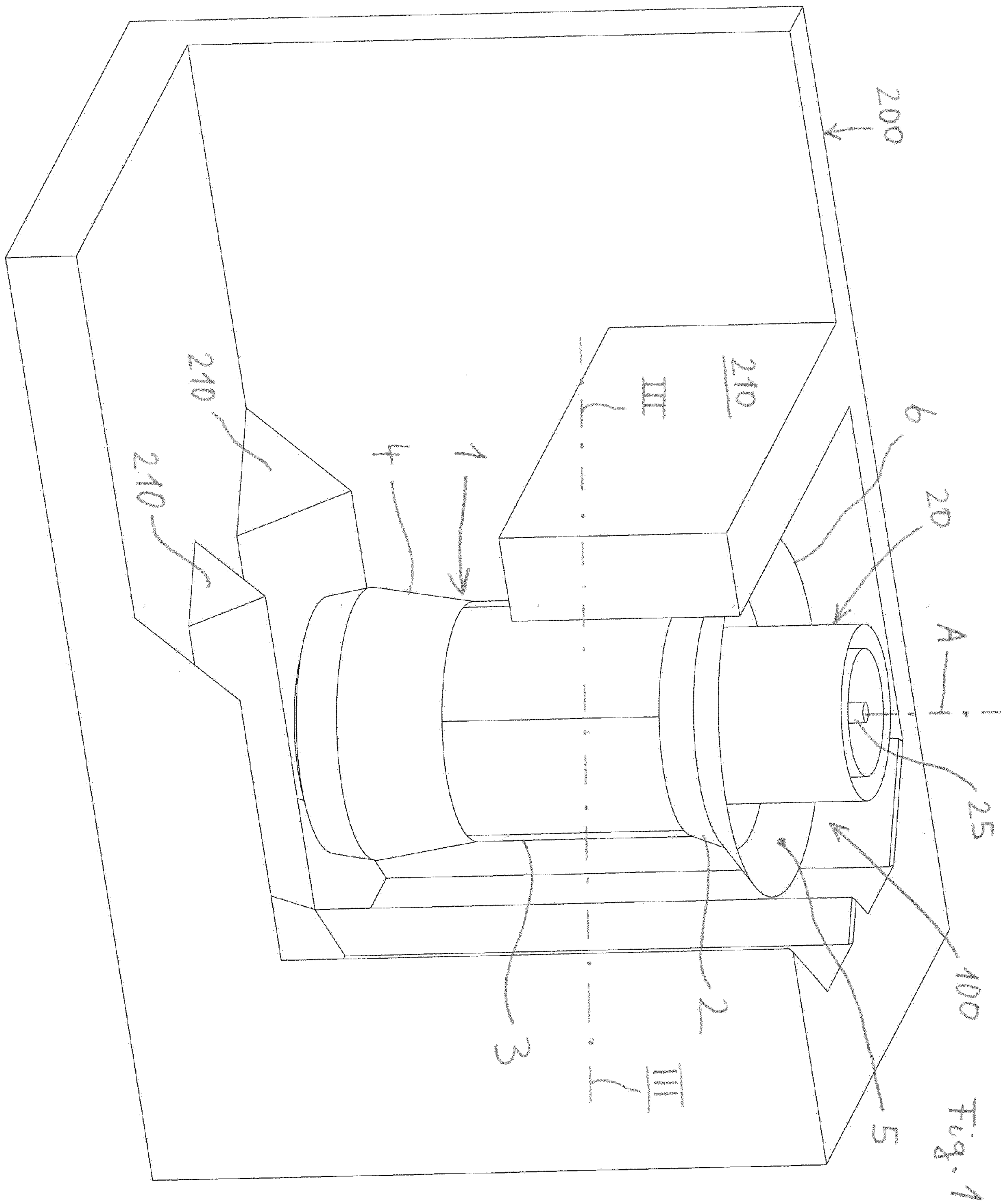


Fig. 1

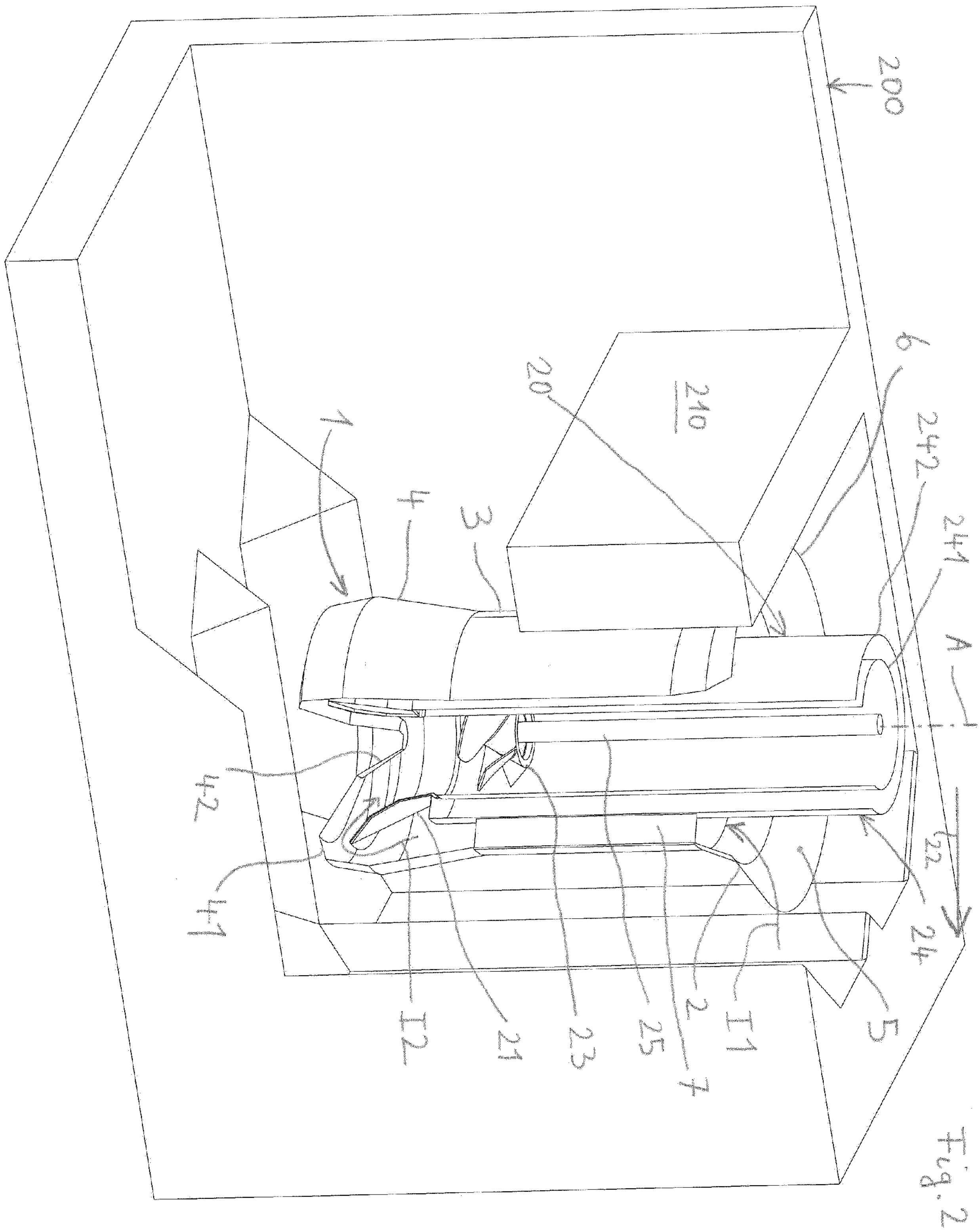


Fig. 2

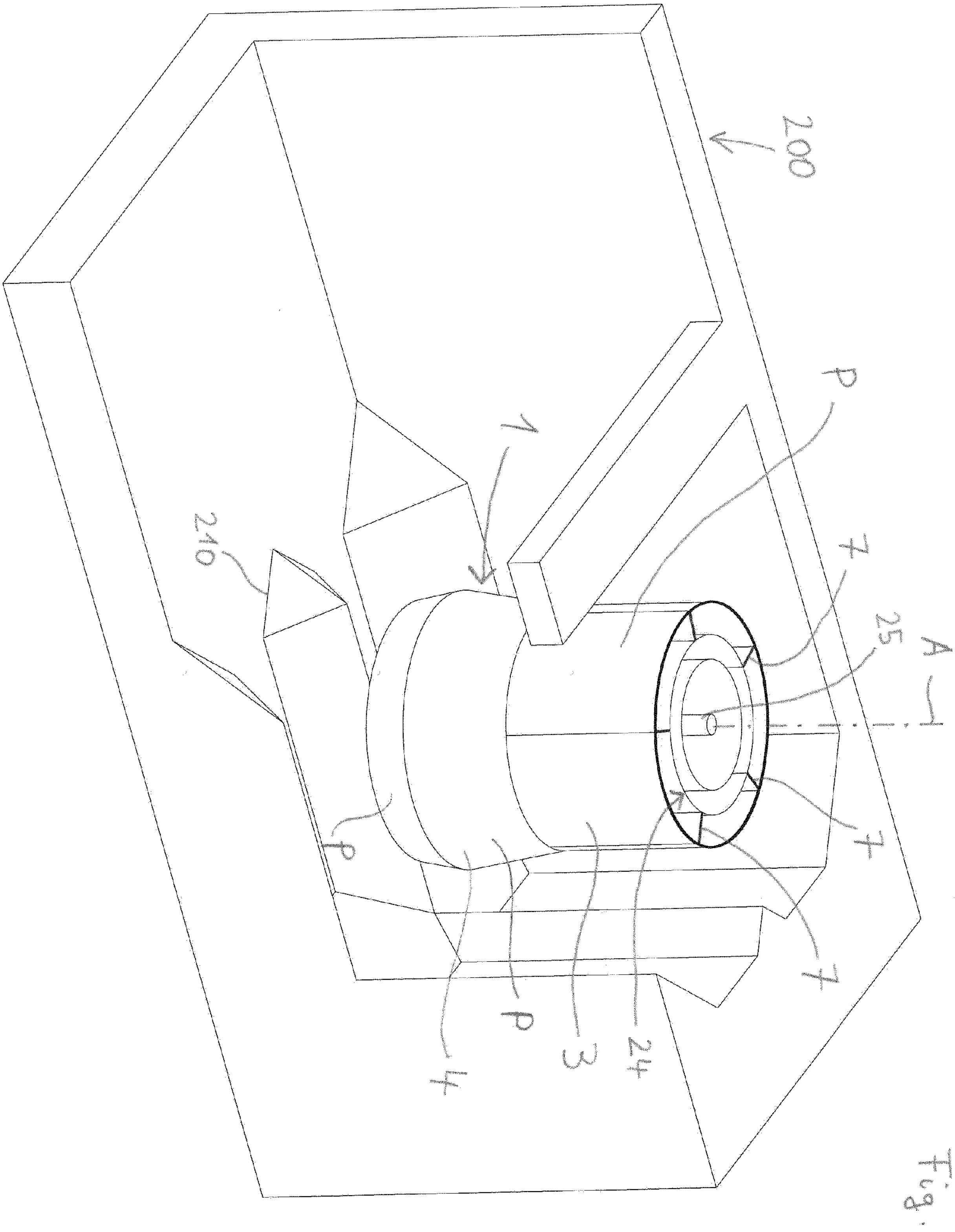
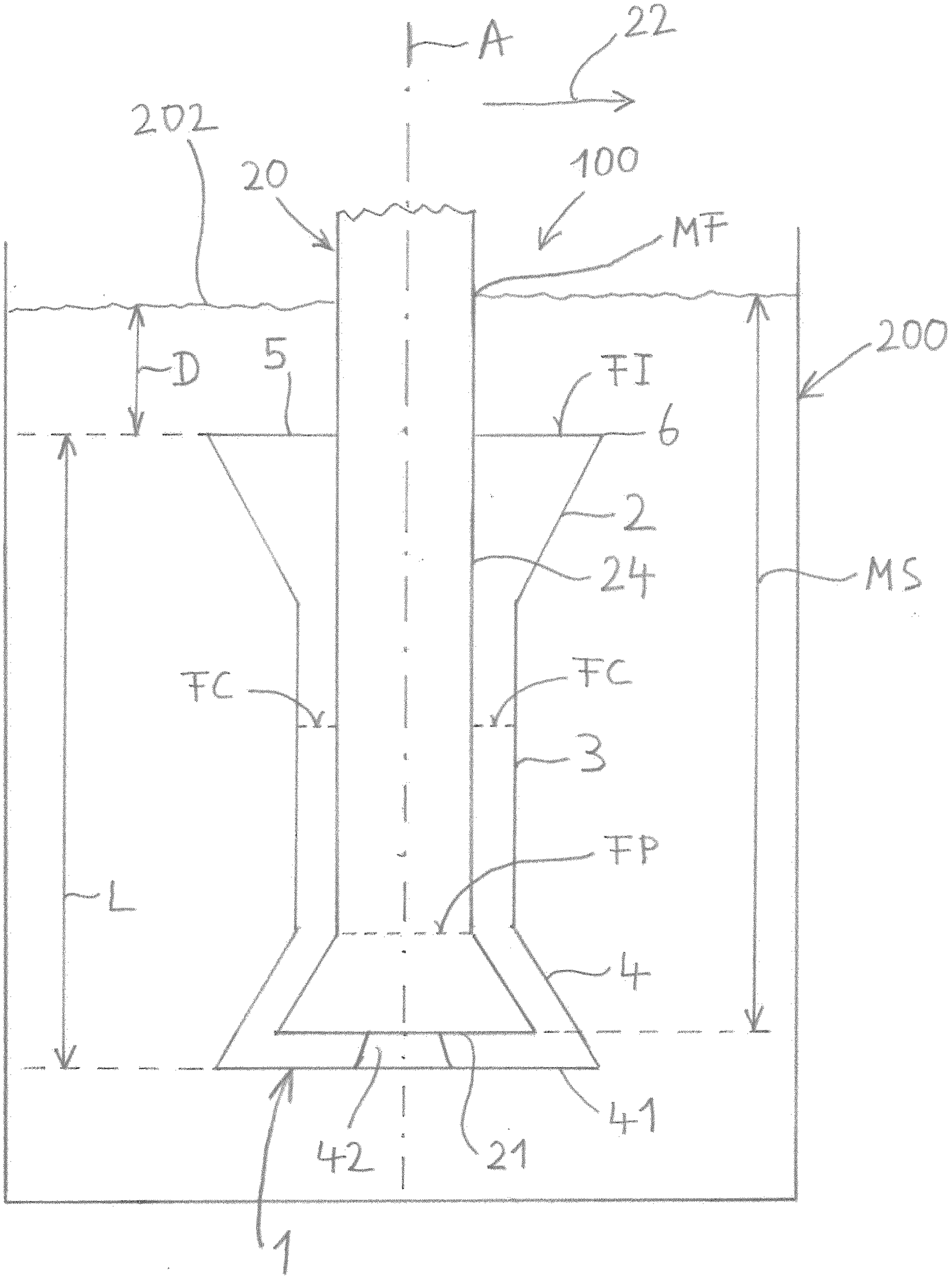


Fig. 3

Fig. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 9670

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Place of search	Date of completion of the search	Examiner
The Hague	13 February 2018	Oliveira, Damien

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