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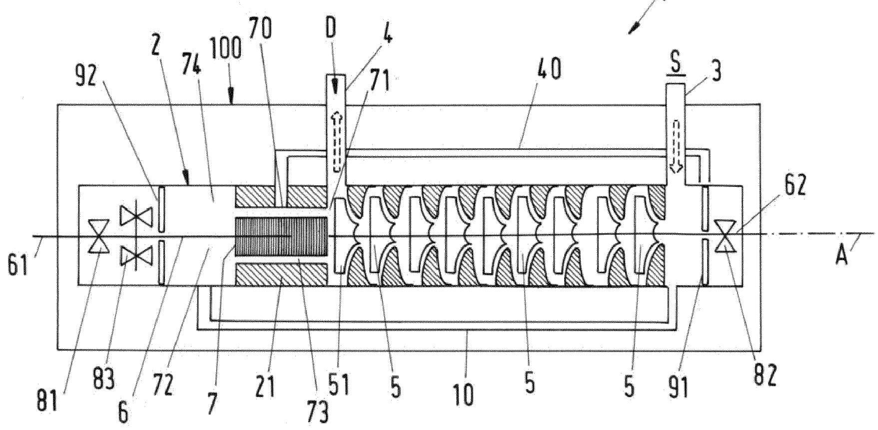
(54) CENTRIFUGAL PUMP FOR CONVEYING A FLUID

(57) A centrifugal pump for conveying a fluid is proposed, comprising a pump housing (2) with an inlet (3) at a suction side (S) and an outlet (4) at a discharge side (D), at least one impeller (5, 51) for conveying the fluid from the inlet (3) to the outlet (4), a shaft (6) for rotating the impeller (5, 51) about an axial direction (A), a first sealing device (91) for sealing the shaft (6) at the suction side (S), a second sealing device (92) for sealing the shaft (6) at the discharge side (D), a balance drum (7) fixedly connected to the shaft (6) and arranged between the at least one impeller (5, 51) and the second sealing device (92), wherein the balance drum (7) defines a front side (71) facing the at least one impeller (5, 51) and a back side (72) facing the second sealing device (92), wherein a relief passage (73) is provided between the balance drum (7) and a stationary part (21) configured to be stationary with respect to the pump housing (2), wherein the relief passage (73) extends from the front side (71) to the back side (72), wherein a balance line (10) is provided connecting the back side (72) with the suction side (S), wherein a discharge opening (70) is arranged at the relief passage (73) between the front side (71) and the back side (72), and wherein a connecting line (40) is provided for connecting the discharge opening (70) with the first sealing device (91).

Fig.1



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Description

[0001] The invention relates to a centrifugal pump for conveying a fluid in accordance with the preamble of the independent claim.

[0002] Centrifugal pumps for conveying a fluid, for example a liquid such as water, are used in many different industries. Examples are the oil and gas industry, the power generation industry, the chemical industry, the water industry or the pulp and paper industry. Centrifugal pumps have at least one impeller and a shaft for rotating the impeller. The at least one impeller may be configured for example as a radial impeller or as an axial or semi-axial impeller or as a helicoaxial impeller. Furthermore, the impeller may be configured as an open impeller or as a closed impeller, where a shroud is provided on the impeller, said shroud at least partially covering the vanes of the impeller.

[0003] A centrifugal pump may be designed as a single stage pump having only one impeller mounted to the shaft or as a multistage pump comprising a plurality of impellers, wherein the impellers are arranged in series on the shaft.

[0004] Many centrifugal pumps are provided with it at least one balancing device for at least partially balancing the axial thrust that is generated by the impeller(s) during operation of the pump. The balancing device reduces the axial thrust that is acting on the axial bearing or the thrust bearing. The balancing device may comprise a balance drum for at least partially balancing the axial thrust that is generated by the rotating impellers. The balance drum is fixedly connected to the shaft of the pump in a torque proof manner. Usually, the balance drum is arranged at the discharge side of the pump between the last stage impeller and a shaft sealing device. The balance drum defines a front side and a back side. The front side is the side facing the last stage impeller. The back side is the side facing the shaft sealing device. A relief passage is provided between the balance drum and a stationary part being stationary with respect to the pump housing. The back side is usually connected to the suction side of the pump by means of a balance line. During operation there is a leakage flow through the relief passage from the front side along the balance drum to the back side and from there through the balance line to the suction side. At the front side of the balance drum the high pressure or the discharge pressure prevails, and at the back side essentially the suction pressure prevails. The pressure difference between the front side and the back side results in a axial force or an axial thrust which is directed in the opposite direction as the axial thrust generated by the rotating impeller(s). Thus, the axial thrust that has to be carried by the axial or thrust bearing is at least considerably reduced. Of course, the leakage flow along the balance drum results in a decrease of the hydraulic performance or efficiency of the pump. Therefore, the relief passage is configured such, that the leakage flow is as low as possible but still sufficient for generating the axial thrust counteracting the axial thrust generated by the impeller(s).

[0005] A centrifugal pump has at least one shaft seal device for sealing the shaft against a leakage of the fluid along the shaft. In a so-called between-bearing design the rotating shaft and all impellers are arranged between two shaft sealing devices, which are typically arranged next to the bearings at the drive end and at the non-drive end of the shaft, respectively.

[0006] The sealing devices may be configured for example as a mechanical seal. Typically, a mechanical seal comprises a stator and a rotor. The rotor is connected in a torque-proof manner with the shaft of the pump and the stator is fixed with respect to the pump housing such that the stator is secured against rotation. During rotation of the shaft the rotor is in sliding contact with the stator thus performing the sealing action. A liquid, e.g. the fluid conveyed by the pump or any other lubricant is supplied to the mechanical seal for generating a fluid film between the stator and the rotor.

[0007] A sealing device such as a mechanical seal requires cooling for removing the heat from the sealing device, as well as flushing to keep particles away from the sealing elements. Therefore a certain flow is required for cooling and flushing. It is a known measure that the flow required to flush and to cool the sealing devices is extracted either at or near the outlet of the pump or at an intermediate stage of the pump. This required flow for flushing the sealing devices causes additional losses which reduces the efficiency of the pump.

[0008] Nowadays in many applications the most efficient use of the pump is strived for. It is desirable to have the highest possible ratio of the power, especially the hydraulic power, delivered by the pump to the power needed for driving the pump. This desire is mainly based upon an increased awareness of environment protection and a responsible dealing with the available resources as well as on the increasing costs of energy.

[0009] It is therefore an object of the invention to propose a centrifugal pump for conveying a fluid, having a high efficiency without a reduction in the operating safety of the pump.

[0010] The subject matter of the invention satisfying these objects is characterized by the features of the respective independent claim.

[0011] Thus, according to the invention, a centrifugal pump for conveying a fluid is proposed, comprising a pump housing with an inlet at a suction side and an outlet at a discharge side, at least one impeller for conveying the fluid from the inlet to the outlet, a shaft for rotating the impeller about an axial direction, a first sealing device for sealing the shaft at the suction side, a second sealing device for sealing the shaft at the discharge side, a balance drum fixedly connected to the shaft and arranged between the at least one impeller and the second sealing device, wherein the balance drum defines a front side facing the at least one impeller and a back side facing the second sealing device, wherein a relief passage is provided between the balance drum and a stationary part configured to be stationary with respect to the pump housing, wherein the relief passage extends from the front side to the back side, wherein a balance line is provided connecting the back side with the suction side, wherein a discharge opening is arranged at the relief passage between the front side and the back side, and wherein a connecting line is provided for connecting the discharge opening with the first sealing device.

[0012] Thus, a part of the flow passing through the relief passage along the balance drum is guided away from the relief passage through the connecting line to the first sealing device and used for flushing and cooling the first sealing device. Therefore, there is no need to extract an additional flow of the fluid e.g. at the discharge side or at an intermediate stage of the pump. This results in an increase of the efficiency of the pump, because only the unavoidable leakage flow through the relief passage is used for flushing the first sealing device. There is no need for an additional take-off of pressurized fluid in order to flush the first sealing device.

[0013] At the first sealing device, or in the first seal housing/chamber, respectively, a pressure prevails that is at most slightly higher than the suction pressure at the suction side of the pump. The pressure at the discharge opening in the relief passage is considerably higher than the suction pressure. Therefore the flow of fluid in the connecting line is directed towards the first sealing device and may be used for flushing the first sealing device.

[0014] Preferably, the connecting line comprises at least one flow control element for controlling the flow through the connecting line. This has the advantage that the volumetric flow for flushing the first sealing device may be adjusted. The flow control element may be, for example, a valve or an orifice.

[0015] In order to make the pump even more efficient it is preferred that the connecting line comprises a first branch and a second branch, wherein the first branch is connected with the first sealing device, and the second branch is connected with the second sealing device. Thus, the flow discharged from the relief passage through the discharge opening and the connecting line is additionally used to also flush the second sealing device.

[0016] According to a preferred configuration, the first branch comprises a first flow control element for controlling the flow through the first branch, and the second branch comprises a second flow control element for controlling the flow through the second branch. By this measure both the flow to the first sealing device and the flow to the second sealing device can be controlled.

[0017] Furthermore, it is preferred that the connecting line comprises a third branch, wherein the third branch is connected to the suction side. The third branch may be connected for example to the inlet of the pump or to the balance line or to a suction tank being in fluid communication with the inlet of the pump. By means of the third branch the flow extracted from the relief passage may be routed directly back to the suction side, i.e. without passing through one of the sealing devices, for example if the extracted flow exceeds the required flow for the sealing devices or if the pressure requires an adjustment. The third branch is particularly advantageous to adjust the leakage flow through the relief passage.

[0018] Preferably, the third branch comprises a third flow control element for controlling the flow through the third branch.

[0019] According to a preferred design at least one of the flow control elements is configured as an adjustable valve.

[0020] For many embodiments it is advantageous that each flow control element is configured as an adjustable valve.

[0021] Preferably, the first sealing device comprises a mechanical seal.

[0022] It is also preferred that the second sealing device comprises a mechanical seal.

[0023] According to a preferred embodiment the pump is configured as a multistage pump having a plurality of impellers, wherein the impellers are arranged one after another on the shaft.

[0024] Furthermore, it is preferred that the pump is configured as a between-bearing pump.

[0025] In particular, the pump may be configured as a barrel type pump comprising an outer barrel casing, in which the pump housing is arranged.

[0026] Further advantageous measures and embodiments of the invention will become apparent from the dependent claims.

[0027] The invention will be explained in more detail hereinafter with reference to embodiments of the invention and with reference to the drawings. There are shown in a schematic representation:

Fig. 1: a schematic cross-sectional view of an embodiment of a centrifugal pump according to the invention, and

Fig. 2: a cross-sectional view illustrating a configuration of the balance drum and the connecting line.

[0028] Fig. 1 shows a schematic cross-sectional view of an embodiment of a centrifugal pump according to the invention, which is designated in its entity with reference numeral 1. The pump 1 is designed as a centrifugal pump for conveying a fluid, for example a liquid such as water.

[0029] The centrifugal pump 1 comprises a pump housing 2 having an inlet 3 and an outlet 4 for the fluid to be conveyed. The inlet 3 is arranged at a suction side S, where a suction pressure prevails, and the outlet 4 is arranged at a discharge side D, where a discharge pressure prevails. The suction pressure is also referred to as low pressure, and the discharge pressure is also referred to as high pressure. The centrifugal pump 1 further comprises at least one impeller 5, 51 for conveying the fluid from the inlet 3 to the outlet 4 as indicated by the dashed arrows without reference numerals, as well as a shaft 6 for rotating each impeller 5, 51 about an axial direction A. The axial direction A is defined by the axis of the shaft 6. Each impeller 5, 51 is mounted to the shaft 6 in a torque proof manner. The shaft 6 has a drive end 61, which may be connected to a drive unit (not shown) for driving the rotation of the shaft 6 about the axial direction. The drive unit may comprise, for example, an electric motor. The other end of the shaft 6 is referred to as non-drive end 62.

[0030] In the following description reference is made by way of example to an embodiment, which is suited for many applications, namely that the centrifugal pump 1 is configured as a multistage pump 1 having a plurality of impellers 5, 51, wherein the impellers 5, 51 are arranged one after another on the shaft 6. The reference numeral 51 designates the last stage impeller 51, which is the impeller 51 closest to the outlet 4. The last stage impeller 51 pressurizes the fluid to the discharge pressure. The embodiment shown in Fig. 1 has nine stages, which has to be understood exemplary. The plurality of impellers 5, 51 may be arranged in an in-line configuration as shown in Fig. 1 or in a back-to-back configuration.

[0031] The multistage centrifugal pump 1 shown in Fig. 1 is designed as a horizontal pump, meaning that during operation the shaft 6 is extending horizontally, i.e. the axial direction A is perpendicular to the direction of gravity. In particular, the centrifugal pump 1 shown in Fig. 1 may be designed as a horizontal barrel casing multistage pump 1, i.e. as a double-casing pump. The multistage pump 1 may be designed, for example, as a pump 1 of the pump type BB5 according to API 610. When configured as a BB5 type pump, the centrifugal pump 1 comprises an outer barrel casing 100, in which the pump housing 2 is arranged.

[0032] It has to be understood that the invention is not restricted to this type of centrifugal pump 1. In other embodiments, the centrifugal pump may be configured without an outer barrel casing, for example as a BB4 type pump, or as an axially split multistage pump, or as a single stage pump, or as a vertical pump, meaning that during operation the shaft 6 is extending in the vertical direction, which is the direction of gravity, or as any other type of centrifugal pump.

[0033] The centrifugal pump 1 comprises bearings on both sides of the plurality of impellers 5, 51 (with respect to the axial direction A), i.e. the centrifugal pump 1 is designed as a between-bearing pump. A first radial bearing 81, a second radial bearing 82 and an axial bearing 83 are provided for supporting the shaft 6. The first radial bearing 81 is arranged adjacent to the drive end 61 of the shaft 6. The second radial bearing 82 is arranged adjacent or at the non-drive end 62 of the shaft 6. The axial bearing 83 is arranged between the plurality of impellers 5, 51 and the first radial bearing 81 adjacent to the first radial bearing 81. The bearings 81, 82, 83 are configured to support the shaft 6 both in the axial direction A and in a radial direction, which is a direction perpendicular to the axial direction A. The radial bearings 81 and 82 are supporting the shaft 6 with respect to the radial direction, and the axial bearing 83 is supporting the shaft 6 with respect to the axial direction A. The first radial bearing 81 and the axial bearing 83 are arranged such that the first radial bearing 81 is closer to the drive end 61 of the shaft 6. Of course, it is also possible to exchange the position of the first radial bearing 81 and the axial bearing 83, i.e. to arrange the first radial bearing 81 between the axial bearing 83 and the plurality of impellers 5, 51, so that the axial bearing 83 is closer to the drive end 61 of the shaft 6.

[0034] A radial bearing, such as the first or the second radial bearing 81 or 82 is also referred to as a "journal bearing" and an axial bearing, such as the axial bearing 83, is also referred to as an "thrust bearing". The first radial bearing 81 and the axial bearing 83 may be configured as separate bearings as shown in Fig. 1, but it is also possible that the first radial bearing 81 and the axial bearing 83 are configured as a single combined radial and axial bearing supporting the shaft both in radial and in axial direction.

[0035] The second radial bearing 82 is supporting the shaft 6 in radial direction. In the embodiment shown in Fig. 1, there is no axial bearing provided at the non-drive end 62 of the pump shaft 6. Of course, in other embodiments it is also possible that an axial bearing for the shaft 6 is provided at the non-drive end 62. In embodiments, where an axial bearing is provided at the non-drive end 62, a second axial bearing may be provided at the drive end 61 or the drive end 61 may be configured without an axial bearing.

[0036] The centrifugal pump 1 further comprises two sealing devices, namely a first sealing device 91 for sealing the shaft 6 at the suction side S and a second sealing device 92 for sealing the shaft 6 at the discharge side D. With respect to the axial direction A the first sealing device 91 is arranged between the plurality of impellers 5 an the second radial bearing 82, and the second sealing device 92 is arranged between the last stage impeller 51 and the axial pump bearing 83. Both sealing devices 91, 92 seal the shaft 6 against a leakage of the fluid along the shaft 6 e.g. into the environment. Furthermore, by the sealing devices 91 and 92 the fluid may be prevented from entering the bearings 81, 82, 83. Preferably each sealing device 91, 92 comprises a mechanical seal. Mechanical seals are well-known in the art in many different embodiments and therefore require no detailed explanation. In principle, a mechanical seal is a seal for a rotating shaft 6 and comprises a rotor fixed to the shaft 6 and rotating with the shaft 6, as well as a stationary stator fixed with respect to the pump housing 2. During operation the rotor and the stator are sliding along each other - usually with a liquid as lubricant there between - for providing a sealing action to prevent the fluid from escaping to the environment or entering the bearings 81, 82, 83. In many embodiments a separate bearing isolator is provided which prevents liquids or solids to enter the bearings 81, 82, 83. In such embodiments where separate bearing isolators are provided, the sealing devices 91, 92, e.g. the mechanical seals prevent the fluid from leaking into the environment.

[0037] The centrifugal pump 1 further comprises a balance drum 7 for at least partially balancing the axial thrust that is generated by the impellers 5, 51 during operation of the centrifugal pump 1. The balance drum 7 is fixedly connected to the shaft 6 in a torque proof manner. The balance drum 7 is arranged at the discharge side D between the last stage impeller 51 and the second sealing device 92. The balance drum 7 defines a front side 71 and a back side 72. The front side 71 is the side facing the last stage impeller 51. The back side 72 is the side facing the second sealing device 92. The balance drum 7 is surrounded by a stationary part 21, so that a relief passage 73 is formed between the radially outer surface of the balance drum 7 and the stationary part 21. The stationary part 21 is configured to be stationary with respect to the pump housing 2. The relief passage 73 forms an annular gap between the outer surface of the balance drum 7 and the stationary part 21 and extends from the front side 71 to the back side 72. The front side 71 is in fluid communication with the outlet 4, so that the axial surface of the balance drum 7 facing the front side 71 is exposed essentially to the discharge pressure prevailing at the outlet 4 during operation of the pump 1. Of course, due to smaller pressure losses caused by the fluid communication between the outlet 4 and the balance drum 7 the pressure prevailing at the axial surface of the balance drum 7 facing the front side 71 may be somewhat smaller than the discharge pressure. However, the considerably larger pressure drop takes place over the balance drum 7. At the back side 72 a chamber 74 is provided, which is connected by a balance line 10 with the suction side S, e.g. with the inlet 3. The pressure in the chamber 74 at the back side 72 is somewhat larger than the suction pressure due to the pressure drop over the balance line 10 but considerably smaller than the discharge pressure.

[0038] Since the front side 71 is exposed essentially to the discharge pressure at the outlet 4 a pressure drop exists over the balance drum 7 resulting in a force that is directed to the right side according to the representation in Fig. 1 and therewith counteracts the axial thrust generated by the impellers 5, 51 during operation of the pump 1.

[0039] The balance line 10 is provided for recirculating the fluid from the chamber 74 at the back side 72 to the suction side S. A part of the pressurized fluid passes from the front side 71 through the relief passage 73 to the back side 72, enters the balance line 10 and is recirculated to the suction side S of the centrifugal pump 1. The balance line 10 constitutes a flow connection between the back side 72 and the suction side S at the pump inlet 3. The balance line 10 may be arranged - as shown in Fig. 1 - outside the pump housing 2 and inside the barrel casing 100. In other embodiments the balance line 10 may be designed as internal line completely extending within the pump housing 2. In still other embodiments the balance line may be arranged outside the barrel casing 100.

[0040] According to the invention, a discharge opening 70 is arranged at the relief passage 73 between the front side 71 and the back side 72 and a connecting line 40 is provided for connecting the discharge opening 70 with the first sealing device 91. Thus, a part of the flow passing through the relief passage 73 enters the connecting line 40 through the discharge opening 70 and is guided to the first sealing device 91 for flushing and cooling the first sealing device 91. Due to the location of the discharge opening 70 between the front side 71 and the back side 72 the pressure at the discharge opening 70 is an intermediate pressure, which is smaller than the discharge pressure at the outlet 4 of the pump 1 and larger than the pressure in the chamber 74 at the back side 72 that is a bit larger than the suction pressure at the suction side S of the centrifugal pump 1. The pressure in the first sealing device 91, e.g. the pressure in the sealing chamber of the mechanical seal, is at most slightly higher than the suction pressure, so that this pressure in the first sealing device 91 is considerably lower than the intermediate pressure prevailing at the discharge opening 70. Thus, the flow discharged through the connecting line 40 can be used for flushing the first sealing device 91 in order to cool the first sealing device 91 down and to keep particles away from the sealing elements of the first sealing device 91. During operation of the centrifugal pump 1 a volume of the pumped fluid is constantly extracted from the relief passage 72, guided through the connecting line 40 and injected into the first sealing device 91 for flushing. Consequently, there is no need to extract pressurized fluid at any other location e.g. from the outlet 4 or at an intermediate stage of the pump 1 for flushing the first sealing device 91. Only a part of the unavoidable leakage flow through the relief passage 73 along the balance drum 7 is used for flushing the first sealing device 91. Therefore, the efficiency of the centrifugal pump 1 is enhanced.

[0041] Referring now to Fig. 2 some preferred measures and variants are explained, each of which may be realized in particular in the embodiment shown in Fig. 1. Since it is sufficient for the understanding, in Fig. 2 only one impeller is shown, which may be for example the only impeller of a single stage pump or the last stage impeller 51 of a multistage pump.

[0042] Fig. 2 shows a cross-sectional view illustrating a configuration of the balance drum 7 and the connecting line 40. The connecting line 40 as well as the balance line 10 are at least partially represented as single lines in Fig. 2, wherein the direction of flow trough the particular line is indicated by the arrows without reference numeral. The Fluid flowing through the pump 1 is indicated by the dashed arrows without reference numeral.

[0043] Preferably, the connecting line 40 comprises at least one flow control element, namely a first flow control element 45, for controlling the flow through the connecting line 40 into the first sealing device 91. The first flow control element 45 may be designed as a throttle or as a orifice or as a valve such as a flow control valve or any other adjustable valve. With the first flow control element 45 the flushing volumetric flow injected into the first sealing device 91 may be adjusted.

[0044] As a further advantageous measure the connecting line 40 may comprise a first branch 41 and a second branch 42, wherein the first branch 41 is connected with the first sealing device 91, and the second branch 42 is connected with the second sealing device 92. If the first flow control element 45 is provided in this design, the first flow control element 45 is arranged in the first branch 41.

[0045] Flushing both the first sealing device 91 and the second sealing device 92 with the flow extracted from the relief passage 73 through the discharge opening 70 still increases the efficiency of the centrifugal pump 1, because there is no need to extract the flow for flushing the second sealing device 92 at any other location of the centrifugal pump than at the discharge opening 70 in the relief passage 73. Since the second sealing device 92 faces the chamber 74 at the back side 72 of the balance drum 7, the pressure at or in the second sealing device 92 is at most as high as the pressure at the back side 72, i.e. only slightly higher than the suction pressure. Thus, the pressure in the second sealing device 92, e.g. the pressure in the sealing chamber of the mechanical seal of the second sealing device 92, is considerably lower than the intermediate pressure at the discharge opening 70. Thus, the flow taken from the discharge opening 70 and guided through the connecting line 40 may be injected into the second sealing device 92.

[0046] Preferably, the second branch 42 of the connecting line 40 comprises a second flow control element 46, for controlling the flow through the second branch 42 into the second sealing device 92. The second flow control element 46 may be designed as a throttle or as a orifice or as a valve such as a flow control valve or any other adjustable valve. With the second flow control element 46 the flushing volumetric flow injected into the second sealing device 92 may be adjusted.

[0047] It is a further preferred measure that the connecting line 40 comprises a third branch 43, wherein the third branch 43 is connected to the suction side S. Thus, a part of the flow discharged from the relief passage 73 through the discharge opening 70 may be directly recirculated to the suction side S without passing through any of the sealing devices 91, 92. The third branch 43 may be connected for example to the inlet 3 of the centrifugal pump 1 or to a tank, from which the fluid is supplied to the inlet 3 of the centrifugal pump 1. Furthermore, it is also possible, that the third branch 43 leads into the balance line 10.

[0048] Optionally, the third branch 43 of the connecting line 40 comprises a third flow control element 47, for controlling the flow through the third branch 43 leading to the suction side S. The third flow control element 47 may be designed as a throttle or as a orifice or as a valve such as a flow control valve or any other adjustable valve.

[0049] It has to be noted that the preferred measures, in particular those explained referring to Fig. 2, do not have to be realized all together. Each of the measures may be realized independently from the other measures. In addition, all combinations of specific measures may be realized.

[0050] The centrifugal pump 1 renders possible to control and to adjust the balancing flow passing through the relief passage 72 and the balance line 10, i.e. the flow that is recirculated through the balance line 10 can be adjusted. Said adjustment may be realized by regulating the flow passing through the discharge opening 70 into the connecting line 40. Thus, by controlling the flow through the connecting line 40 the balance flow recirculated to the suction side S can be adjusted. This is in particular advantageous for such embodiments of the centrifugal pump 1, that are designed for high to very high discharge pressures and a low discharge flow.

Claims

1. A centrifugal pump for conveying a fluid, comprising a pump housing (2) with an inlet (3) at a suction side (S) and an outlet (4) at a discharge side (D), at least one impeller (5, 51) for conveying the fluid from the inlet (3) to the outlet (4), a shaft (6) for rotating the impeller (5, 51) about an axial direction (A), a first sealing device (91) for sealing the shaft (6) at the suction side (S), a second sealing device (92) for sealing the shaft (6) at the discharge side (D), a balance drum (7) fixedly connected to the shaft (6) and arranged between the at least one impeller (5, 51) and the second sealing device (92), wherein the balance drum (7) defines a front side (71) facing the at least one impeller (5, 51) and a back side (72) facing the second sealing device (92), wherein a relief passage (73) is provided between the balance drum (7) and a stationary part (21) configured to be stationary with respect to the pump housing (2), wherein the relief passage (73) extends from the front side (71) to the back side (72), and wherein a balance line (10) is provided connecting the back side (72) with the suction side (S), **characterized in that** a discharge opening (70) is arranged at the relief passage (73) between the front side (71) and the back side (72), wherein a connecting line (40) is provided for connecting the discharge opening (70) with the first sealing device (91).

2. A centrifugal pump in accordance with claim 1, wherein the connecting line (40) comprises at least one flow control element (45, 46, 47) for controlling the flow through the connecting line (40).

3. A centrifugal pump in accordance with anyone of the preceding claims, wherein the connecting line (40)

comprises a first branch (41) and a second branch (42), wherein the first branch(41) is connected with the first sealing device (91), and the second branch (42) is connected with the second sealing device (92).

4. A centrifugal pump in accordance with claim 3, wherein the first branch (41) comprises a first flow control element (45) for controlling the flow through the first branch (41), and the second branch (42) comprises a second flow control element (46) for controlling the flow through the second branch (42).

5. A centrifugal pump in accordance with anyone of the preceding claims, wherein the connecting line (40) comprises a third branch (43), wherein the third branch (43) is connected to the suction side (S).

6. A centrifugal pump in accordance with claim 5, wherein the third branch (43) comprises a third flow control element (47) for controlling the flow through the third branch (43).

7. A centrifugal pump in accordance with anyone of claims 2-6, wherein at least one of the flow control elements (45, 46, 47) is configured as an adjustable valve.

8. A centrifugal pump in accordance with anyone of claims 2-7, wherein each flow control element (45, 46, 47) is configured as an adjustable valve.

9. A centrifugal pump in accordance with anyone of the preceding claims, wherein the first sealing device (91) comprises a mechanical seal.

10. A centrifugal pump in accordance with anyone of the preceding claims, wherein the second sealing device (92) comprises a mechanical seal.

11. A centrifugal pump in accordance with anyone of the preceding claims, wherein the pump is configured as a multistage pump having a plurality of impellers (5, 51), wherein the impellers (5, 51) are arranged one after another on the shaft (6).

12. A centrifugal pump in accordance with claim 11, configured as a between-bearing pump.

13. A centrifugal pump in accordance with claim 11 or claim 12, comprising an outer barrel casing (100), in which the pump housing (2) is arranged.

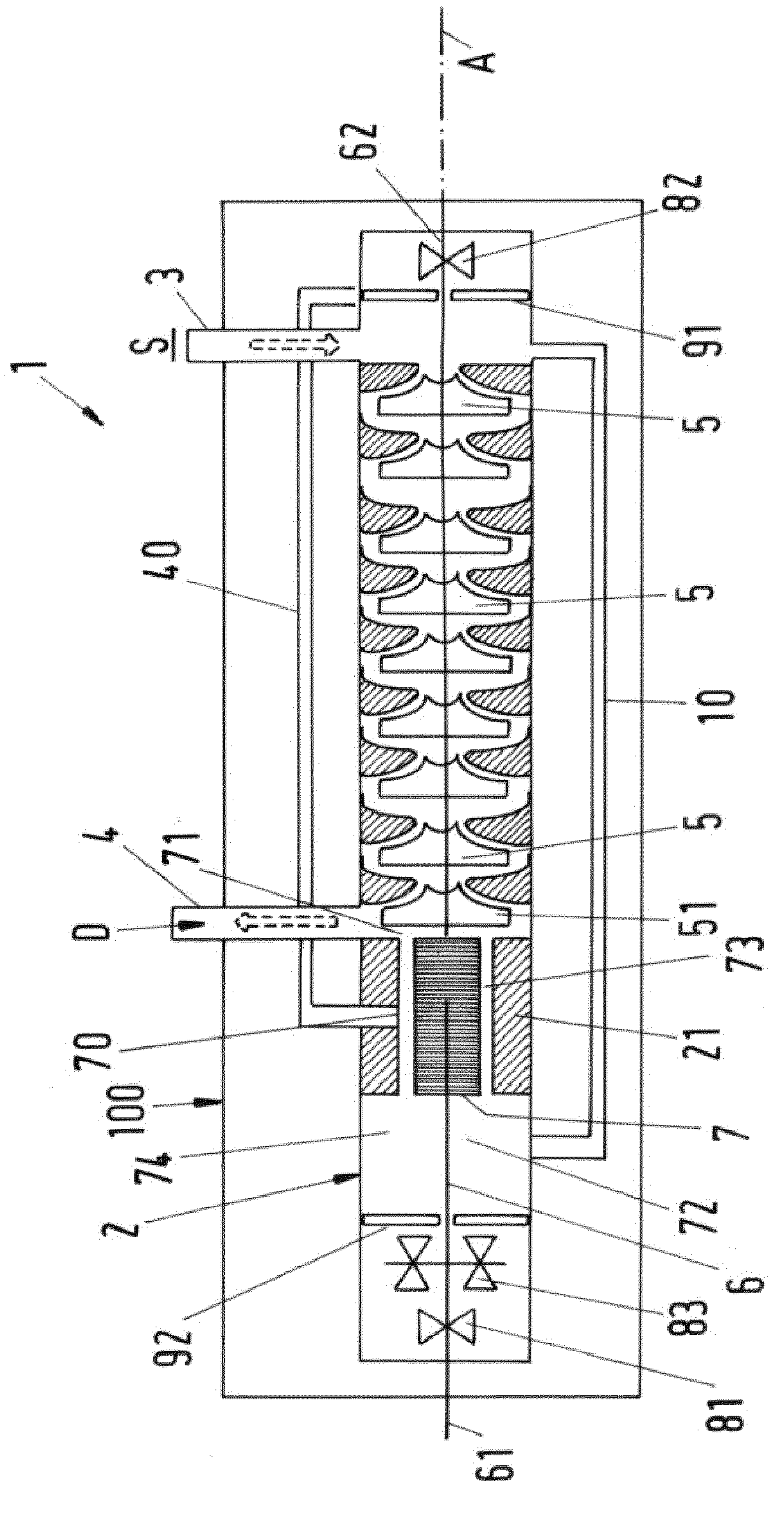
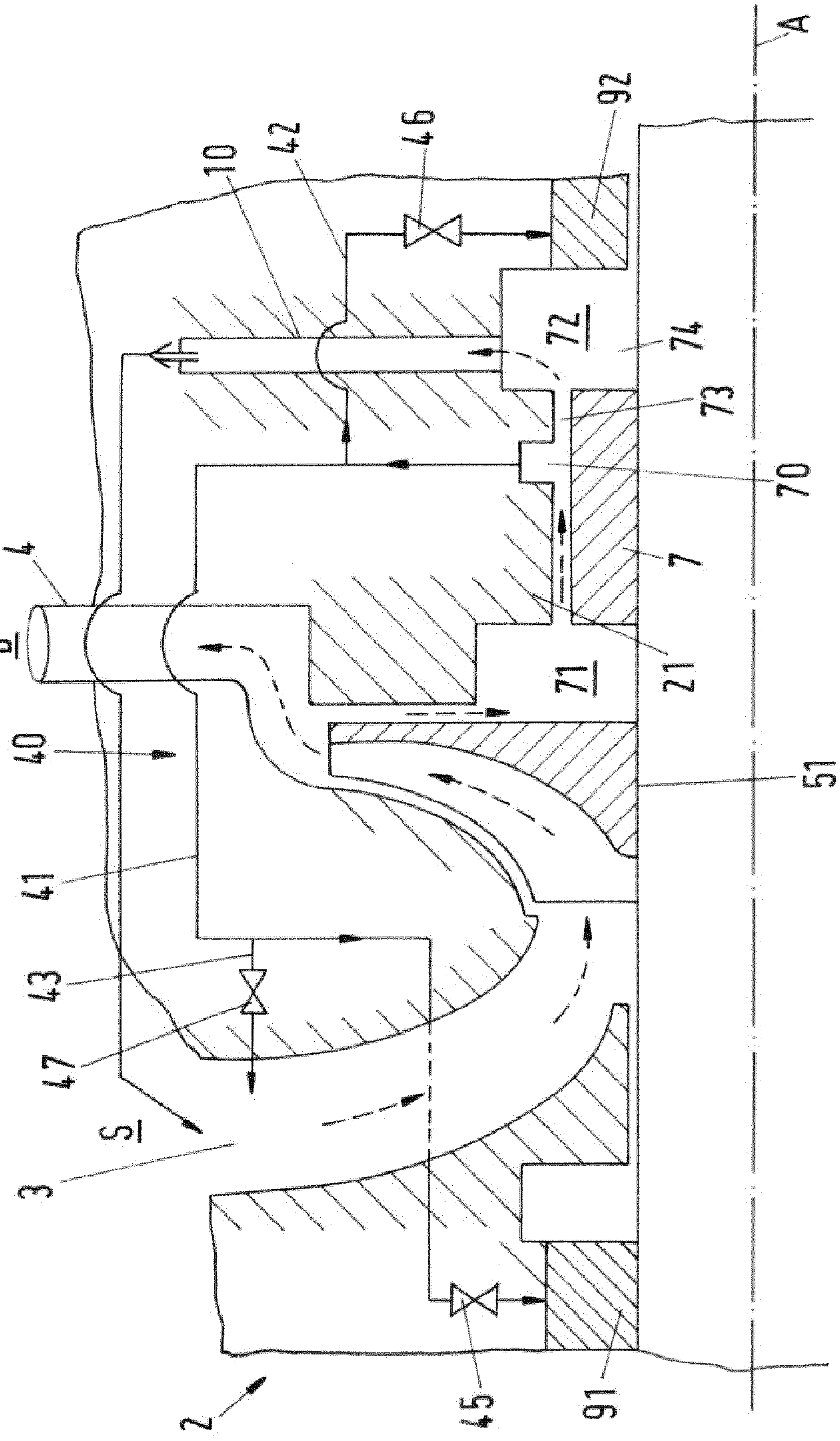


Fig.1

Fig.2



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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 9213

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 3 121 450 A1 (SULZER MANAGEMENT AG [CH]) 25 January 2017 (2017-01-25) * figures 1,4-6 * * claim 1 * -----	1-13	INV. F04D29/041 F04D29/10
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Place of search	Date of completion of the search	Examiner
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