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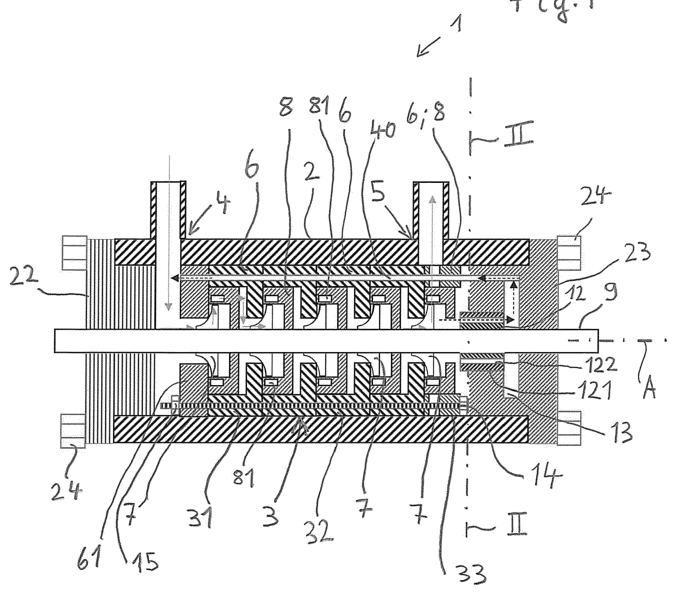
(54) **MULTISTAGE CENTRIFUGAL PUMP WITH A BALANCING LINE THAT EXTENDS AXIALLY THROUGH A PLURALITY OF STAGE CASINGS**

(57) A multistage pump for conveying a fluid is proposed, comprising a pump shaft (9) configured for rotating about an axial direction (A), a plurality of stages (3) arranged one after another with respect to the axial direction (A), said plurality of stages (3) comprising at least a first stage (31) and a last stage (33), each stage comprising a stage casing (6), and an impeller (7) for acting on the fluid, wherein each impeller (7) is mounted to the pump shaft (9) in a torque proof manner, the multistage pump further comprising a pump inlet (4) for supplying the fluid to the impeller (7) of the first stage (31), a pump outlet (5) for discharging the fluid, a balance drum (12) for balancing an axial thrust, and a balance line (40), wherein the balance drum (12) is fixedly connected to the pump shaft (9), and has a front side facing one of the impellers (7), as well as a back side facing a low pressure chamber (13), wherein a relief passage (122) is provided between the balance drum (12) and a stationary part (121) configured to be stationary with respect to the stage casings (6), wherein the relief passage (122) is extending from the front side to the back side, and wherein the balance line (40) is configured to provide a fluid communication between the low pressure chamber (13) and the pump inlet (4), and wherein the balance line (40) is configured to pass through a plurality of the stage casings (6).

Fig.1



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Description

[0001] The invention relates to a multistage pump for conveying a fluid according to the preamble of the independent claim.

[0002] Multistage pumps for conveying a fluid are used in many different industries, in particular for applications where a high pressure shall be generated. Important industries, in which multistage pumps are used, are for example the oil and gas processing industry, the power generation industry, the chemical industry, the clean and waste water industry or the pulp and paper industry.

[0003] In the oil and gas processing industry multistage pumps are designed e.g. for conveying hydrocarbon fluids, for example for extracting the crude oil from the oil field or for transportation of the oil/gas through pipelines or within refineries. Another application is the injection of a process fluid, in most cases water and in particular seawater, into an oil reservoir. For such applications, said pumps are designed as (water) injection pumps supplying seawater at high pressure to a well that leads to a subterranean region of an oil reservoir.

[0004] Regarding further applications a multistage pump may be designed as a boiler feed pump for a power plant, or as a booster pump, e.g. in a reverse osmosis process for desalination of water, to mention just a few examples.

[0005] A multistage pump comprises a plurality of stages each having an impeller, wherein all impellers are arranged on a common pump shaft one after another. The pump shaft is driven for a rotation about an axial direction e.g. by an electric motor so that all impellers are commonly rotating about the axial direction.

[0006] There are several designs known for multistage pumps. A multistage pump may be configured as a vertical pump, i.e. the pump shaft is extending in the vertical direction during the operation of the pump, wherein the vertical direction is the direction of gravity. A multistage pump may be configured as a horizontal pump, i.e. the pump shaft is extending in the horizontal direction during operation. Furthermore, a multistage pump may be configured as a radially split pump or as an axially split pump. Further embodiments of multistage pumps are for example ring section pumps or barrel casing pumps.

[0007] Ring section pumps comprise a plurality of stage casings, which are arranged one after another with respect to the axial direction which is defined by the axis of the pump shaft. The stage casings are fixed with respect to each other by means of tie-rods extending through all the stage casings. The plurality of stage casings comprises a suction casing at the inlet side of the pump and a discharge casing at the outlet side of the pump. All stage casings together form the housing of the multistage pump.

[0008] Barrel casing pumps also comprise a plurality of stage casings similar as a ring-section pump. However, the stage cases are arranged within an outer barrel casing surrounding the stage casings, so that this type of multistage pump is a double-casing pump. The barrel casing is closed at its axial ends by a suction cover and a discharge cover, respectively. It is also possible that the stage casings are configured to commonly build a cartridge which may be removed in its entity from the barrel casing.

[0009] Due to the high pressure that is commonly generated with multistage pumps the plurality of impellers generates a considerable axial thrust acting on the pump shaft. In order to reduce the axial thrust that has to be carried by the axial shaft bearing(s), also referred to as thrust bearing(s), several measures are known in the art, which may be combined or may be used as alternatives. One measure is the so-called back-to-back design. A first group of impellers and a second group of impellers are arranged back to back on the common pump shaft, so that the axial thrust generated by the first group of impellers counteracts the axial thrust generated by the second group of impellers. Thus, the resulting axial thrust is considerably reduced, because the axial thrust generated by the first group of impellers is at least partially balanced by the axial shaft generated by the second group of impellers.

[0010] Another known measure is providing the pump shaft with a balance drum. The balance drum is fixed to the pump shaft and arranged for example behind the last stage impeller when viewed in the flow direction of the fluid through the pump. The balance drum is surrounded by a stationary part, which is stationary with respect to the pump housing. The balance drum and the stationary part are configured coaxially such that a small annular gap is formed between the balance drum and the stationary part. One axial face of the balance drum is exposed essentially to the discharge pressure of the pump. The other axial face of the balance drum faces a low pressure chamber, which is connected to the pump inlet or the suction side of the pump by means of a balance line. Therefore, the axial face of the balance drum facing the low pressure chamber is exposed essentially to the suction pressure at the inlet of the pump. During operation, the fluid passes from the discharge or high pressure side of the balance drum through the annular gap in axial direction along the balance drum to the low pressure chamber. By the pressure difference over the balance drum an axial force is generated, which counteracts the axial thrust generated by the impellers.

[0011] It is usual practice to design the balance line as an external pipe connecting the low pressure chamber with the pump inlet or the inlet casing. This pipe is usually welded or flanged to the outer side of the pump casing.

[0012] Starting from this prior art it is an object of the invention to propose a different multistage pump, in particular a multistage pump which may be configured in a more compact manner.

[0013] The subject matter of the invention satisfying this object is characterized by the features of the independent claim.

[0014] Thus, according to the invention, a multistage pump for conveying a fluid is proposed, comprising a pump shaft configured for rotating about an axial direction, a plurality of stages arranged one after another with respect to the axial direction, said plurality of stages comprising at least a first stage and a last stage, each stage comprising a stage casing, and an impeller for acting on the fluid, wherein each impeller is mounted to the pump shaft in a torque proof manner, the multistage pump further comprising a pump inlet for supplying the fluid to the impeller of the first stage, a pump outlet for discharging the fluid, a balance drum for balancing an axial thrust, and a balance line, wherein the balance drum is fixedly connected to the pump shaft, and has a front side facing one of the impellers, as well as a back side facing a low pressure chamber, wherein a relief passage is provided between the balance drum and a stationary part configured to be stationary with respect to the stage casings, wherein the relief passage is extending from the front side to the back side, and wherein the balance line is configured to provide a fluid communication between the low pressure chamber and the pump inlet, and wherein the balance line is configured to pass through a plurality of the stage casings.

[0015] Since the balance line is arranged to pass through the stage casings, it is no longer necessary to configure the balance line as an external pipe which is welded to the pump housing. Thus, the overall dimensions of the multistage pump are reduced, and the multistage pump becomes particularly compact. In addition, the welding of an external balance pipe to the pump housing is avoided, which increases the operational reliability of the pump, because each welding location has the potential to become a weak spot e.g. regarding leakage.

[0016] Depending on the geometry of the stage casings as well as on the required flow along the balance drum to the low pressure chamber it might be advantageous, that the multistage pump comprises a plurality of balance lines, wherein each balance line is configured to provide a fluid communication between the low pressure chamber and the pump inlet, and wherein each balance line is configured to pass through a plurality of the stage casings.

[0017] According to a preferred configuration the plurality of stages comprises at least one intermediate stage, wherein each intermediate stage is arranged between the first stage and the last stage.

[0018] Furthermore, in view of a simple construction it is preferred that each balance line is configured to pass through each of the stage casings. Thus, each balance line is configured to start at or in the low pressure chamber, to pass through all the stage casings and to deliver the fluid to the pump inlet after having passed the stage casing of the first stage.

[0019] According to a preferred configuration the front side of the balance drum faces the impeller of the last stage, so that the front side of the balance drum is exposed to a pressure which is essentially the same as the discharge pressure at the high pressure side of the multistage pump.

[0020] In addition, it is preferred that each balance line comprises a bore extending parallel to the pump shaft. According to one preferred embodiment the bore itself constitutes the balance line.

[0021] According to another preferred embodiment each balance line comprises a pipe arranged within the bore, wherein each pipe extends at least through the stage casing of the last stage. Of course, it is also possible that for some or all balance lines the respective pipe passes completely through all stage casings.

[0022] According to a preferred design each pipe passes through each stage casing.

[0023] According to a preferred embodiment the multistage pump comprises a plurality of tie rods for bracing the plurality of stage casings, wherein each tie rod passes through each stage casing, wherein each tie rod extends in the axial direction, and wherein the plurality of tie rods is arranged about the pump shaft. According to this embodiment the multistage pump may be designed as a ring section pump, for example as a pump of the pump type BB4. Of course, this embodiment may also be configured with an additional barrel casing surrounding all the stage casings, e.g. as a pump of the pump type BB5.

[0024] Preferably, each balance line is arranged between the tie rods, when viewed in the circumferential direction, meaning that the center lines of all tie rods and of all balance lines are located on a circle around the pump shaft, wherein the center of the circle is located on the center line of the pump shaft.

[0025] According to a preferred configuration the multistage pump comprises a barrel casing, wherein the plurality of stage casings is arranged within the barrel casing. According to this configuration the multistage pump is designed as a double-casing pump. In this configuration it is possible, but not necessary, that all stage casings are clamped against each other by means of tie-rods, which are also arranged within the barrel casing. The stage casings may form a cartridge, which is removable from the barrel casing in its entity. It is also possible that there are no tie-rods provided to brace the stage casings. Then the stage casings are pressed against each other during operation by the pressure generated in the multistage pump.

[0026] Preferably, the barrel casing is configured with a tubular shape and extending coaxially with the pump shaft from a first axial end to a second axial end.

[0027] For embodiments having the barrel casing it is preferred that the multistage pump comprises a suction cover configured for closing the first axial end of the barrel casing, and a discharge cover for closing the second axial end of the barrel casing. Compared to state of the art designs having an external balance line, the discharge cover of a multistage pump according to the invention may be designed with a smaller diameter or with a smaller extension in the radial direction, respectively, which is an advantage from the constructional point of view.

[0028] Preferably each of the suction cover and the discharge cover is secured to the barrel casing by means of fixing elements. The fixing elements may comprise bolts or screws or nuts or tie-rods.

[0029] Furthermore it is preferred that the low pressure chamber is arranged within the discharge cover.

[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 an embodiment 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 multistage pump according to the invention in a section along the axial direction, and

Fig. 2: the embodiment of Fig. 1 in a cross-section perpendicular to the axial direction along the cutting line II-II in Fig. 1.

[0032] Fig. 1 shows a schematic cross-sectional view of an embodiment of a multistage pump according to the invention, which is designated in its entity with reference numeral 1. The multistage pump 1 is designed as a centrifugal pump for conveying a fluid from a pump inlet 4 to a pump outlet 5.

[0033] In the following description of a preferred embodiment of the multistage pump 1 according to the invention reference is mad by way of example to a configuration, where the multistage pump 1 is designed as a horizontal barrel casing multistage pump 1, i.e. as a double-casing pump. The multistage pump may for example be designed as a pump 1 of the pump type BB5.

[0034] It goes without saying that the invention is not restricted to such embodiments. The multistage pump may be designed for example as a ring section pump, i. e. without an outer barrel casing, for example as a BB4 type pump or as an axially split multiphase pump, as a vertical multiphase pump, as a multiphase multistage pump or as any other type of multistage pump.

[0035] The multistage pump 1 comprises a barrel casing 2 and a plurality of stages 3, each of which comprises an impeller 7 for acting on the fluid. All impellers 7 are arranged one after another on a pump shaft 9 configured for rotating about an axial direction A. The pump shaft 9 centrally passes through the barrel casing 2 and is supported by radial bearings also referred to as journal bearings (not shown) and at least one axial bearing also referred to as thrust bearing (not shown). Furthermore, shaft seals (not shown), for example mechanical seals, are provided in a manner which is known in the art. The shaft seals prevent a leakage of the fluid along the pump shaft 9 from the interior of the barrel casing 2 to the exterior of the barrel casing 2.

[0036] The axial direction A is defined by the longitudinal axis of the pump shaft 9, i.e. the rotational axis about which the pump shaft 9 rotates during operation. 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] All impellers 7 are mounted to the pump shaft 9 in a torque proof manner. The pump shaft 9 is driven by a drive unit (not shown), e.g. an electric motor. In the embodiment shown in Fig. 1 the drive unit is arranged outside the barrel casing 2 and coupled to the pump shaft 9 in any manner known in the art. In other embodiments the drive unit may be arranged within the barrel casing 2.

[0038] Fig. 1 shows the multistage pump 1 in a schematic cross-sectional view in a section along the axial direction A. For a better understanding Fig. 2 shows the multistage pump 1 in a cross-section perpendicular to the axial direction A along the cutting line II-II in Fig. 1.

[0039] The barrel casing 2 is closed at its first axial end by a suction cover 22 and at its second axial end by a discharge cover 23. The suction cover 22 and the discharge cover 23 are fixedly mounted to the barrel casing 2 for example by means of nuts and bolts 24. The pump shaft 9 passes centrally both through the suction cover 22 and the pressure cover 23. The barrel casing 2 is squeezed between the suction cover 22 and the discharge cover 23. The barrel casing 2 is configured with a tubular shape and extends coaxially with the pump shaft 9 from the first axial end to the second axial end. Furthermore, the barrel casing 2 is designed for receiving the plurality of stages 3, so that the plurality of stages 3 is enclosed by the barrel casing 2.

[0040] The multistage pump 1 has the plurality of stages 3, which comprises at least a first stage 31 and a last stage 33. The plurality of stages 3 may further comprise one or more intermediate stage(s) 32. All intermediate stages 32 are arranged between the first stage 31 and the last stage 33 with respect to the axial direction A. All stages 31, 32, 33 are arranged one after another inside the barrel casing 2, such that the barrel casing 2 encloses all stages 31, 32, 33. The first stage 31 is located next to the pump inlet 4 near the suction cover 22 and receives the fluid having a low pressure from the pump inlet 4. The last stage 33 is located next to the discharge cover 23 and discharges the fluid having a high pressure through the pump outlet 5. The flow of the fluid through the multistage pump 1 is indicated in Fig. 1 by the solid line arrows without reference numeral.

[0041] In the embodiment shown in Fig. 1 the multistage pump 1 comprises three intermediate stages 32, therefore the multistage pump 1 has five stages 31, 32, 33. It has to be understood that the number of five stages 31, 32, 33 is only an example. In other embodiments the multistage pump may comprise less than five stages for example only two stages, i.e. there is no intermediate stage. In still other embodiments the multistage pump may comprise more than five stages, for example eight stages.

[0042] Each stage 31, 32, 33 of the plurality of stages 3 comprises a stage casing 6, one impeller 7 for acting on the fluid and a diffuser 8 configured to surround the impeller 7 and to receive the fluid from the impeller 7. The diffuser 8 of the last stage 33 is configured to also constitute the stage casing 6 of the last stage 33.

[0043] The stage casings 6 are arranged in series with respect to the axial direction A. The stage casing 6 of the first stage 31 abuts against a stationary part 61 of the multistage pump 1, wherein the stationary part 61 is stationary with respect to the barrel casing 2. Each of the following stage casings 6 abuts against the respective preceding stage casing 6. Thus, the entirety of the stage casings 6 forms an inner pump housing which is also referred to as cartridge.

[0044] The stage casings 6 are fixed with respect to each other by a plurality of tie rods 14. Each tie rod 14 extends in the axial direction A parallel to the pump shaft 9 and through all stage casings 6. The tie rods 14 are tensioned by means of tensioners 15 in a manner that is known in the art.

[0045] All impellers 7 are configured as radial impellers 7 having a plurality of impeller vanes which divert the flow of fluid from a generally axial direction A in the radial direction.

[0046] All diffusers 8 are configured as radial diffusers 8 and arranged to enclose the respective impeller 7 radially outwardly. Downstream of each diffuser 8 of the first stage 31 and all intermediate stages 32 a plurality of guide channels 81 is provided in each case to redirect the generally radial flow of the fluid into the axial direction A and to guide the fluid from the respective diffuser 8 to the suction side of the impeller 7 of the next stage. Preferably, the guide channels 81 are delimited by guide vanes which may be curved to smoothly redirect the fluid. The diffuser 8 of the last stage 33 is configured to guide the fluid to the pump outlet 5.

[0047] The multistage pump 1 in Fig. 1 further comprises a balance drum 12, which is arranged between the last stage 33 and the axially outer surface of the discharge cover 23. More particular, the balance drum 12 is arranged such that it extends into the discharge cover 23. The balance drum 12 has an axial front side facing the impeller 7 of the last stage 33 and exposed to the high pressure behind the impeller of the last stage 33, as well as an axial back side which is exposed to the pressure in a low pressure chamber 13, wherein the pressure in the low pressure chamber 13 is considerably lower than the high pressure. The low pressure chamber 13 is configured as an essentially annular chamber surrounding the pump shaft 9. The low pressure chamber 13 is connected by at least one balance line 40 with the pump inlet 4 so that the pressure in the low pressure chamber 13 is essentially the low pressure at the pump inlet 4 on the suction side of the multistage pump 1. The balance line 40 provides a fluid communication between the low pressure chamber 13 and the pump inlet 4 as indicated by the dashed arrows without reference numeral.

[0048] As can be seen in Fig. 2, this embodiment of the multistage pump 1 comprises a plurality of balance lines 40, namely three balance lines 40, and each balance line 40 is configured to provide a fluid communication between the low pressure chamber 13 and the pump inlet 4. More precisely, each balance line starts at or in the low pressure chamber 13 and extends in axial direction A to the pump inlet 4. The number of balance lines 40 depends on the space which is available, i.e. the diameter with which the balance line 40 can be configured, and from the required flow that is recirculated from the low pressure chamber 13 to the pump inlet 4.

[0049] The balance drum 12 is radially outwardly surrounded by a stationary part 121 which is configured to be stationary with respect to the stage casings 6. The stationary part 121 may be a part of the discharge cover 23 or a separate part, for example a cylindrical bush arranged coaxially with the balance drum12.

[0050] The balance drum 12 and the stationary part 121 are arranged and configured such, that a relief passage 122 is formed between the balance drum 12 and the stationary part 121. The relief passage 122 is configured as an annular gap extending from the front side of the balance drum 12 in axial direction A along the balance drum 12 to the back side of the balance drum 12.

[0051] During operation of the multiphase pump 1 a part of the pressurized fluid flows from the backside of the impeller 7 of the last stage 33, where the high pressure prevails, in axial direction A through the relief passage 122 into the low pressure chamber 13, where the suction pressure prevails and through the balance lines 40 back to the pump inlet 4. This flow through the relief passage 122, the low pressure chamber 13 and the balance lines 40 is indicated in Fig. 1 by the dashed arrows without reference numeral.

[0052] Since the front side of the balance drum 12 is exposed essentially to the high pressure or the discharge pressure and the back side of the balance drum 12 is exposed to the low pressure or the suction pressure a force acting on the pump shaft 9 in axial direction A is generated. Said force is directed from the left to the right according to the representation in Fig. 1. Thus, the force generated by the pressure drop over the balance drum 12 is directed in the opposite direction than the hydraulic force acting on the pump shaft 9 by the action of the impellers 7. These two axial forces compensate each other at least partially so that the axial load acting on the thrust bearing(s) is at least reduced.

[0053] Each balance line 40 extends parallel to the pump shaft 9 Each balance line 40 starts at or in the low pressure chamber 13, passes through the stage casing 6 of the last stage 33, which is the diffuser 8 of the last stage 33, through the stage casings 6 of each intermediate stage 32, through the stage casing 6 of the first stage 31 and through the stationary part 61, thus leading to the pump inlet 4 or the suction side of the impeller of the first stage 31.

[0054] Each balance line 40 comprises a bore extending parallel to the pump shaft. In a preferred embodiment each balance line 40 comprises a pipe, which is arranged in the respective bore, and which extends through all stage casings 6.

[0055] In other embodiments the pipe of the balance line 40 or the balance lines 40 may be configured to pass only through some of the stage casings 6, but not through all stage casings 6. When leaving said pipe the fluid flows through the bore of the balance line 40 to pass through the remaining stage casings 6.

[0056] Particularly preferred each balance line comprises a pipe which in each case extends at least through the stage casing 6 of the last stage 33, which is the diffusor 8 of the last stage 33.

[0057] As can be best seen in Fig. 2 each balance line 40 is arranged between the tie rods 14 when viewed in the circumferential direction, i.e. in the representation of Fig. 2 the center lines of all tie rods 14 and the center lines of all balance lines are arranged on a circle around the pump shaft 9, wherein the center of said circle is located on the center line of the pump shaft 9.

[0058] It has to be understood that in other embodiments the multistage pump may be configured with a back-to-back arrangement of the impellers 7.

Claims

1. A multistage pump for conveying a fluid, comprising a pump shaft (9) configured for rotating about an axial direction (A), a plurality of stages (3) arranged one after another with respect to the axial direction (A), said plurality of stages (3) comprising at least a first stage (31) and a last stage (33), each stage comprising a stage casing (6), and an impeller (7) for acting on the fluid, wherein each impeller (7) is mounted to the pump shaft (9) in a torque proof manner, the multistage pump further comprising a pump inlet (4) for supplying the fluid to the impeller (7) of the first stage (31), a pump outlet (5) for discharging the fluid, a balance drum (12) for balancing an axial thrust, and a balance line (40), wherein the balance drum (12) is fixedly connected to the pump shaft (9), and has a front side facing one of the impellers (7), as well as a back side facing a low pressure chamber (13), wherein a relief passage (122) is provided between the balance drum (12) and a stationary part (121) configured to be stationary with respect to the stage casings (6), wherein the relief passage (122) is extending from the front side to the back side, and wherein the balance line (40) is configured to provide a fluid communication between the low pressure chamber (13) and the pump inlet (4), **characterized in that** the balance line (40) is configured to pass through a plurality of the stage casings (6).

2. A multistage pump in accordance with claim 1, comprising a plurality of balance lines (40), wherein each balance line (40) is configured to provide a fluid communication between the low pressure chamber (13) and the pump inlet (4), and wherein each balance line (40) is configured to pass through a plurality of the stage casings (6).

3. A multistage pump in accordance with anyone of the preceding claims, wherein the plurality of stages (3) comprises at least one intermediate stage (32), and wherein each intermediate stage (32) is arranged between the first stage (31) and the last stage (33).

4. A multistage pump in accordance with anyone of the preceding claims, wherein each balance line (40) is configured to pass through each of the stage casings (6).

5. A multistage pump in accordance with anyone of the preceding claims, wherein the front side of the balance drum (12) faces the impeller (7) of the last stage (33).

6. A multistage pump in accordance with anyone of the preceding claims, wherein each balance line (40) comprises a bore extending parallel to the pump shaft (9).

7. A multistage pump in accordance with claim 6, wherein each balance line (40) comprises a pipe arranged within the bore, and wherein each pipe extends at least through the stage casing (6) of the last stage (33).

8. A multistage pump in accordance with claim 7, wherein each pipe passes through each stage casing (6).

9. A multistage pump in accordance with anyone of the preceding claims, comprising a plurality of tie rods (14) for bracing the plurality of stage casings (6), wherein each tie rod passes through each stage casing (6), wherein each tie rod (14) extends in the axial direction (A), and wherein the plurality of tie rods (14) is arranged about the pump shaft (9).

10. A multistage pump in according with claim 9 wherein each balance line (40) is arranged between the tie rods (14), when viewed in the circumferential direction.

11. A multistage pump in accordance with anyone of the preceding claims, comprising a barrel casing (2), wherein the plurality of stage casings (6) is arranged within the barrel casing (2).

12. A multistage pump in accordance with claim 11,

wherein the barrel casing (2) is configured with a tubular shape and extending coaxially with the pump shaft (9) from a first axial end to a second axial end.

13. A multistage pump in accordance with claim 12, comprising a suction cover (22) configured for closing the first axial end of the barrel casing (2), and a discharge cover (23) for closing the second axial end of the barrel casing (2).

14. A multistage pump in accordance with claim 13, wherein each of the suction cover (22) and the discharge cover (23) is secured to the barrel casing (2) by means of fixing elements (24).

15. A multistage pump in accordance with anyone of claims 13-14, wherein the low pressure chamber (13) is arranged within the discharge cover (23).

Fig. 1

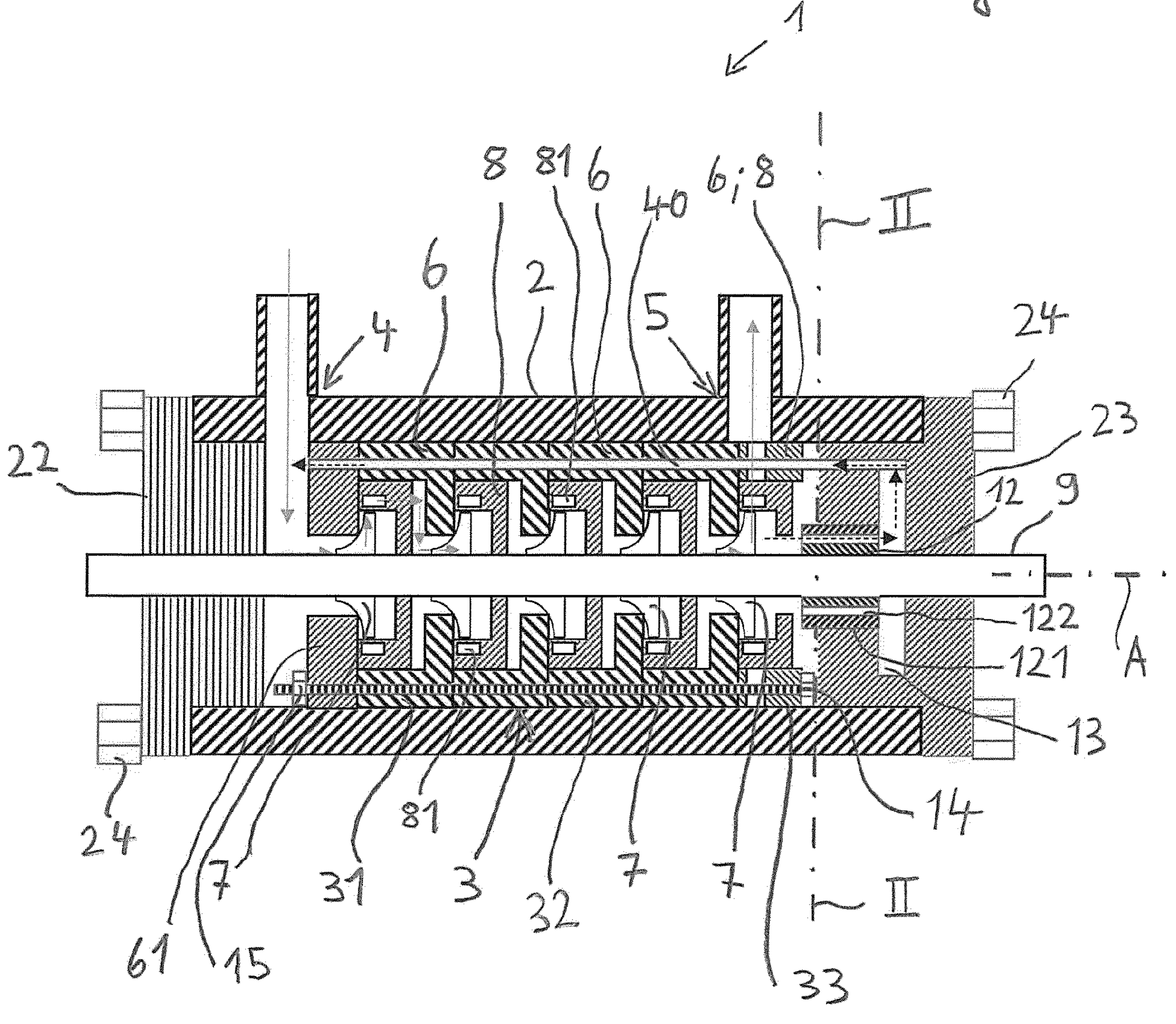
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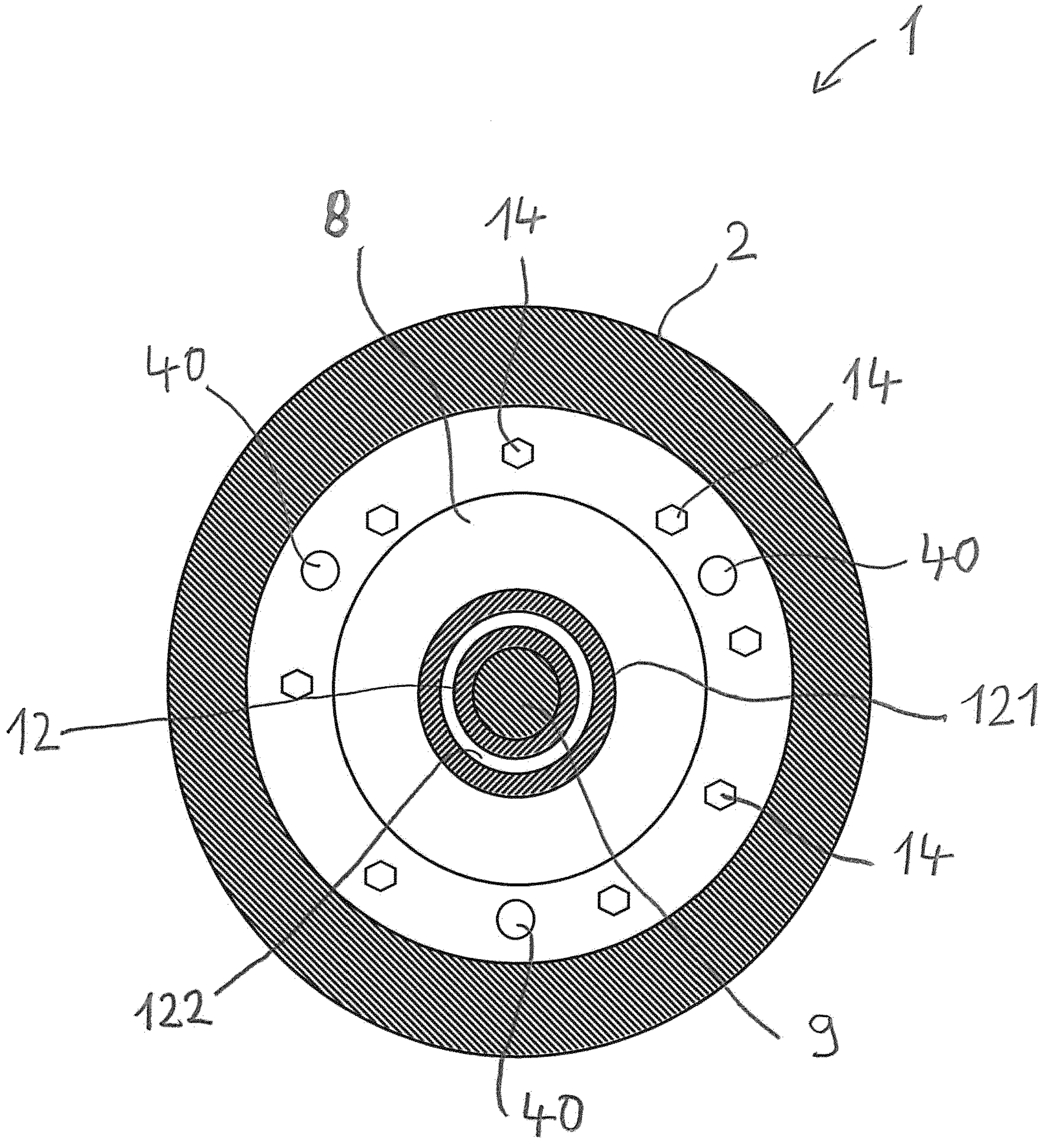
Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 6687

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	US 6 309 174 B1 (OKLEJAS JR ELI [US] ET AL) 30 October 2001 (2001-10-30) * column 8, line 54 - column 9, line 3; figure 11 * -----	1-15	INV. F04D1/06 F04D29/041
A	US 3 718 406 A (ONAL H) 27 February 1973 (1973-02-27) * column 3, line 32 - column 4, line 1; figures 1,3 * -----	1-15	
A	US 2 265 834 A (GARRAWAY GEORGE H) 9 December 1941 (1941-12-09) * page 2, column 2, line 51 - page 3, column 1, line 27; figures 3,4 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 September 2020	Brouillet, Bernard

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 6687

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-09-2020

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