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(71) Applicant(s)
Sulzer Management AG

(72) Inventor(s)
Becker, Klaus

(74) Agent / Attorney
Watermark Intellectual Property Pty Ltd, L 1 109 Burwood Rd, Hawthorn, VIC, 3122, AU

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Abstract

The invention relates to a submersible pump comprising a bearing arrangement (1) having a bearing cover (32) and a bearing flange (31) and having one or more bearing elements (2) each having an inner bearing ring (21), an outer bearing ring (23) and a roller element (22), and comprising a rotor shaft (4) which is rotatably supported in the bearing element (2) about an axis of rotation (A) extending in a longitudinal axial direction such that the inner bearing ring (21) rotates along with the rotor shaft (4) in the operating state. The bearing element (2) is arranged at the bearing flange (31) such that the bearing cover (32) tensions each outer bearing ring (23) in a longitudinal axial direction and such that a peripheral gap (5) having a predefinable axial width is formed in a radial direction between the outer bearing ring (23) and the bearing cover (32) and between the outer bearing ring (23) and the bearing flange (31). The invention furthermore relates to a bearing arrangement for a submersible pump.

Fig. 1

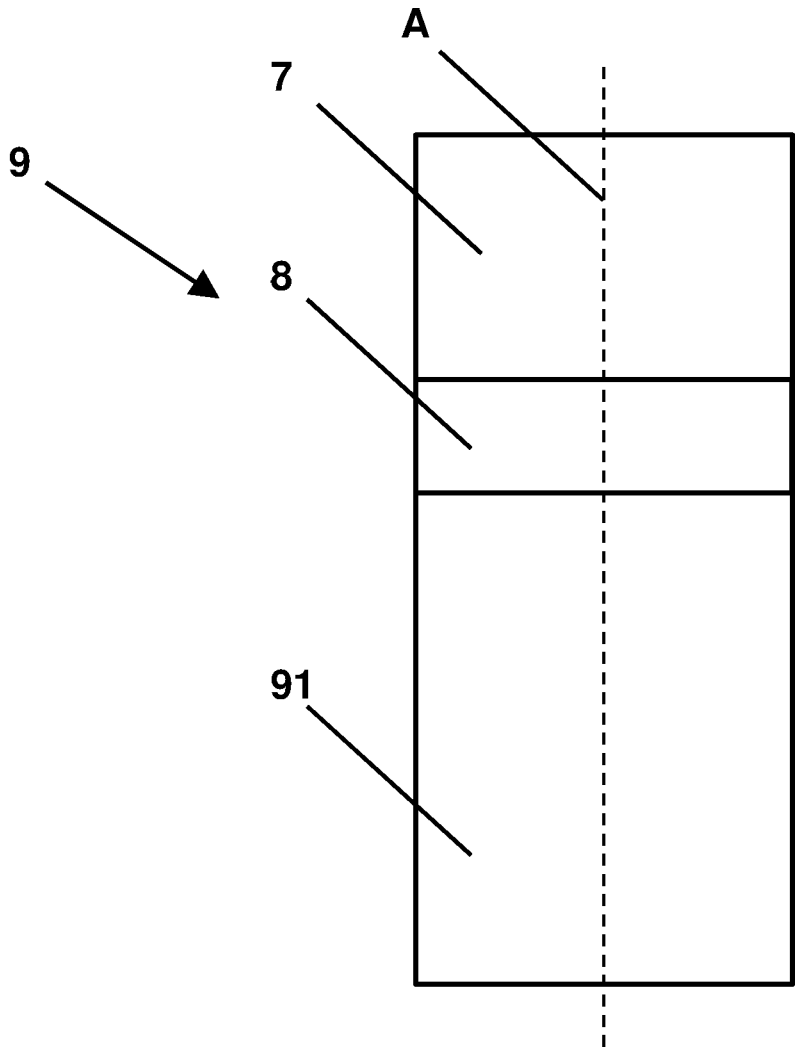


Fig. 1

2015268751 16 Dec 2015

Submersible pump and bearing arrangement

1. FIELD OF THE INVENTION

The invention relates to a submersible pump comprising a bearing arrangement, and a bearing arrangement for such a submersible pump.

2. BACKGROUND OF THE INVENTION

Known submersible pumps have a large number of precision components which require a precise alignment, assembly and interaction among one another. Such known submersible pumps comprise a pump housing, a motor part having an electric motor arranged in a motor housing and having a hydraulic part with a pump wheel as well as having a shaft leadthrough which is arranged between the motor part and the hydraulic part and which is passed through by a rotor shaft.

Submersible pumps are used to pump fluids, for example water or waste water, wherein a gas, in particular a flammable gas, which can be distributed about the submersible pump, can arise depending on the fluid being pumped, for example in fermentation processes. As consequence of operating disturbances, overheating may arise and ignition sources can be produced in the pump, for example due to spark formation as consequence of a short-circuit. If these sparks escape from the pump, they can ignite the gas and damage or destroy the structure in which the pump is installed, as well as the pump itself. Submersible pumps can thus only be operated in environments with a flammable atmosphere with special protective measures for safety reasons.

A submersible pump is described in patent document EP 2 249 042 A1, wherein the support tube at which lower end the hydraulic components of the pump are carried, is at least partly surrounded with an insulating peripheral protective jacket so that the surrounded region of the support tube is insulated thermally and structurally from the environment, in particular from the pump fluid and the gas.

2015268751 11 Feb 2020

Such a protective jacket can in particular be provided in the region of a bearing arrangement so that a direct insulation of the particularly risk-sensitive bearing region is present.

One disadvantage of this apparatus is that it is very complex from a constructional aspect and expensive in manufacture given additional components have to be designed and manufactured which make the bearing arrangement unnecessarily complicated. In addition, more installation space is required in the submersible pump.

Other safety measures provide for the formation of a gap in the bearing arrangement, for example between a bearing cover and a bearing flange of the bearing arrangements of the submersible pump. This requires a different constructional configuration of the bearing cover and/or of the bearing flange, which is unnecessarily expensive and complicated. The centration of the bearing cover can thereby be made unnecessarily complicated since it takes place, for example, at the bearing flange, with a spacing having to be present from the bearing elements, in particular from the bearing element directly at the bearing flange and/or at the bearing cover, to compensate concentricity errors. In addition, the constructionally complicated design of the bearing cover may in turn require to design a bearing element, in particular the bearing element arranged directly at the bearing flange and/or at the bearing cover, with a specification that is different by an order of magnitude and/or additionally to fasten it, for example by means of a holding element, to the bearing cover and/or to the bearing flange.

One disadvantage arising from the concentricity errors is an increased load on the bearing element, and thus increased wear. In addition, for example, an additional holding means has to be provided at the bearing cover and/or at the bearing flange, for example an O ring, to hold and fix the bearing element which is

arranged directly at the bearing flange and/or at the bearing cover, in particular an outer bearing ring of this bearing element.

Against this background, it would be advantageous to propose a submersible pump and a bearing arrangement for such pump which has a simple design from a constructional aspect and which can be manufactured inexpensively and which in particular avoids the aforesaid disadvantages.

3. SUMMARY OF THE INVENTION

In accordance with a first aspect off the invention, a submersible pump is proposed, comprising a bearing arrangement having a bearing cover, a bearing flange and one or more bearing elements each having an inner bearing ring, an outer bearing ring and roll elements between the inner and outer bearing rings. The submersible pump further comprises a rotor shaft having a longitudinal axis and which is rotatably supported in the bearing element about an axis of rotation A extending in the direction of the longitudinal axis, the inner bearing ring(s) arranged to rotate along with the rotor shaft in the operating state. The one or more bearing elements is/are arranged at the bearing flange such that the bearing cover forcibly clamps the outer bearing ring(s) at the bearing flange in the longitudinal axial direction while a peripheral gap extending in the axial direction is maintained between the outer bearing ring(s) and (i) the bearing flange and (ii) the bearing cover, the peripheral gap having a predefined axial length (also referred herein as axial width) and a radial extension (also referred herein as radial width) to thereby form a spark gap for explosion prevention.

The submersible pump can, as already mentioned, comprise a pump housing having a pump wheel arranged therein and can comprise a motor housing placed onto the pump housing and having an electric motor which is arranged therein and which drives the pump wheel via a rotor shaft. The motor housing with the electric motor arranged therein and the other devices required to operate the electric

2015268751 11 Feb 2020

motor may be together termed a motor unit for reasons of simplicity. The pump housing and the pump wheel may similarly be termed a hydraulic unit. The submersible pump can be operated in a power range up to approximately 1 MW and at a pressure, for example, of up to 10 bar. In addition, the submersible pump can be used in industrial applications, for example in the conveying of industrial waste waters or as a process pump. A submersible pump is to be understood as a pump which is designed such that, when the submersible pump is arranged partly or completely in a liquid, for example in water, this pump can be operated reliably and permanently. The submersible pump can therefore be flooded partly or completely for a specific time period or also permanently in the operating state. That is, the pump can be arranged in a liquid, with a reliable operation of the pump simultaneously being possible. The submersible pump can, however, also be operated when it is not flooded, that is when it is not arranged in a liquid.

The shaft leadthrough can be arranged between the motor unit and the hydraulic unit. The shaft leadthrough can in particular be formed by/at the bearing cover so as to allow the rotor shaft to pass through the bearing arrangement. In precise terms, the rotor shaft is rotatably supported in the one or more bearing elements about an axis of rotation A extending in the longitudinal axial direction of the shaft whereby the inner bearing ring is secured such at to rotate along with the rotor shaft in the operating state of the pump.

The bearing cover is fastenable to the bearing flange; for example, being able to be screwed-on by means of one or more screws. As noted, the one or more bearing elements are received at the bearing flange. For this purpose, a bearing chamber, for example, a recess, preferably a cylindrical bore, can be present at the bearing flange and the one or more bearing elements can be arranged therein and can in particular be arranged with an exact fit. In embodiments with a plurality of bearing elements, these are arranged one behind one another in axial direction at the bearing flange, that is in the longitudinal axial direction. The roller elements

2015268751 11 Feb 2020

are arranged in a region between the respective inner bearing rings and the outer bearing rings. The bearing chamber and/or the space between bearing elements can be filled with a lubricant and/or a coolant for lubricating and/or cooling the bearing elements; the lubricant and/or coolant can in particular flow into the region between the inner bearing ring and the outer bearing ring and can thus lubricate and cool the roller elements. However, further bearing units, for example a bearing sleeve, can also be arranged at the bearing flange, in particular in the bearing chamber.

The one or more bearing elements are arranged at the bearing flange such that the bearing cover forcibly clamps (i.e. holds) each outer bearing ring against movement in the longitudinal axis direction. For this purpose, the bearing cover exerts a holding force in the longitudinal axial direction onto the outer bearing ring, in particular onto an axial end face of the outer bearing ring, while the outer bearing ring is simultaneously held at the bearing flange or while a compression force of equal amount countering the holding force acts from the bearing flange so that the bearing cover clamps the outer bearing ring of the bearing element in the longitudinal axial direction. That surface which can be oriented in the direction of the bearing cover can in this respect be understood as the end face. However, a further end face can equally be provided at the outer bearing ring, with that surface which can be oriented in the direction of the bearing flange being able to be understood as the further end face. A support surface can then be provided at the bearing cover and a further support surface can be provided at the bearing flange, with the end face lying on the support surface and the further end face lying on the further support surface. The support surfaces can, for example, be formed as a step.

However, a plurality of bearing elements can also be arranged next to one another at the bearing flange so that a plurality of outer bearing rings are arranged axially in a row. In this respect, the bearing cover can, as described, exert a holding force

2015268751 11 Feb 2020

in the longitudinal axial direction on a first outer bearing ring of a first bearing element which is arranged directly at the bearing cover and the first outer bearing ring can transmit the holding force to a second outer bearing ring of a second adjacent bearing element, while the second outer bearing ring is simultaneously held at the bearing flange or a compression force of equal amount countering the holding force acts from the bearing flange so that the bearing cover tensions the first and second outer bearing rings in the longitudinal axial direction

The bearing cover can thus advantageously be seated on the outer bearing ring which is arranged directly at the bearing cover and the bearing cover can be centered at the outer bearing ring of the bearing element. With a plurality of bearing elements, the bearing cover at the outer bearing ring of the bearing element arranged directly at the bearing cover can in particular be centered, whereby the bearing cover and/or the rotor shaft is/are centered better and all the outer bearing rings are completely forcibly clamped (i.e. held) in the longitudinal axial direction and are thus better supported. In addition, the bearing cover can thus have a simpler construction design and can be manufactured inexpensively since, for example, only an inner machining of the bearing cover is necessary. The bearing element, in particular the bearing element which is directly arranged at the bearing cover or at the bearing flange, can additionally have the same size as all the other bearing elements and/or an additional holding element at the bearing cover and/or at the bearing flange which holds the bearing element can be dispensed with. The submersible pump thus has a simpler construction design overall and can be manufactured less expensively and avoids the disadvantages known from the prior art.

As noted above, a peripheral gap having a predefined axial width between the outer bearing ring and both the bearing cover and bearing flange is furthermore formed, having also a radial width. The gap can therefore only be formed between the outer bearing ring and the bearing cover and between the outer bearing ring

2015268751 11 Feb 2020

and the bearing flange. A gap having a predefined axial width can be understood as the extent of the gap in the longitudinal axial direction, that is a length of the gap in the longitudinal axial direction. Since the gap is formed between the outer bearing ring and the bearing cover and between the outer bearing ring and the bearing flange and not as previously between parts of the bearing housing, the bearing arrangement can again be simplified from a construction aspect since a complex and/or expensive machining of the bearing housing can be dispensed with. In addition, the gap, which is inexpensive to manufacture, additionally makes possible a safe use of the submersible pump also in environments with an inflammable atmosphere since said gap will provide a spark gap.

The spark gap is specifically formed for explosion protection. In addition, a further peripheral gap having a predefinable axial width can additionally be formed between the bearing cover and the rotor shaft. An arc or a gap in the submersible pump, in particular in the shaft leadthrough, can thus advantageously be limited in an intrinsically safe manner to a region, to the gap and/or to the further gap which is uncritical in a safety aspect.

In an embodiment of the invention, the predefined axial width of the spark gap peripherally surrounding the outer bearing ring(s) of the bearing element(s) received at the bearing flange and clamped against displacement in axial longitudinal direction, and/or of the further peripheral gap is ≥ 5 mm. A radial width of the spark gap between the outer bearing ring(s) and the opposite faces of the bearing flange and bearing cover and/or of the further peripheral gap is ≤ 0.2 mm.

It is an advantage of the described measures and embodiments that the disadvantage known from the prior art, namely that gaps can only be formed by cast parts, is thus avoided and the gap and the further gap are advantageously formed by means of one or more bearing elements, in particular by means of one or more outer bearing rings. The gap can thus be manufactured simply and

2015268751 11 Feb 2020

inexpensively since the complex and/or expensive machining of the cast parts, in particular of the bearing cover, is omitted.

In an embodiment of the invention, the bearing element is a roller element bearing, in particular a ball bearing or a cylinder roller bearing.

In another aspect, the invention furthermore provides a bearing arrangement for a submersible pump. The bearing arrangement comprises a bearing cover, a bearing flange and one or more bearing elements each having an inner bearing ring, an outer bearing ring and roller elements between the inner and outer bearing rings. In this respect, the bearing element(s) is/are arranged and received at the bearing flange such that the bearing cover is able to forcibly clamp each outer bearing ring against movement in a longitudinal axial direction and such that a peripheral gap having a predefined axial width is formed between the outer bearing ring(s) and both the bearing cover and the bearing flange.

In accordance with the invention, the gap is formed as a spark gap for explosion protection. Provision is made as a further measure that the bearing element is a roller element bearing, in particular a ball bearing or cylinder roller bearing. The bearing arrangement can be arranged in the described submersible pump.

In an embodiment of the invention, the predefined axial width of the peripherally extending radial gap between the outside of the outer bearing ring(s) and the facing faces of the bearing flange and bearing cover is ≥ 5 mm. The radial width of the gap extending peripherally about the outer bearing ring(s) is ≤ 0.2 mm.

In an embodiment of the invention, a further peripheral gap having a predefined axial width (and radial width) can be formed between the bearing cover and a rotor shaft to be received at the bearing arrangement in an operating state. The

predefinable axial width of the further peripheral gap running is ≥ 5 mm and the radial width is ≤ 0.2 mm.

As already mentioned, the advantages of the submersible pump in accordance with the invention and of the bearing arrangement in accordance with the invention are that the bearing cover can be centered at the outer bearing ring of the bearing element or, with a plurality of bearing elements, the bearing cover can be centered at the outermost bearing ring of the bearing elements arranged directly at the bearing cover. The bearing cover is thereby centered better and all the outer bearing rings are completely forcibly clamped in the longitudinal axial direction. The submersible pump and the bearing arrangement, in particular the bearing cover, can thus have a simpler design, can in particular have a simpler design from a construction aspect, and can be manufactured inexpensively. In addition, the gap and the further gap allow the operation of a submersible pump and of a bearing arrangement in an environment which requires explosion protection, by being designed as spark gaps. The explosion protection is required when a malfunction of the submersible pump occurs, e.g. an electrical short-circuit, and the possibility associated therewith occurs of triggering the explosion of a flammable mixture. If, for example, an explosive mixture is in the submersible pump which is ignited by the short-circuit, the propagation of the explosion within the motor is admittedly possible, but the gap or gaps prevent the spark from escaping from the motor, for example into a structure where an explosive atmosphere may be present which could then be ignited.

The invention will be explained in more detail in the following description of preferred embodiments provided with reference to the accompanying drawings.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates in highly schematic manner a first embodiment of a submersible pump in accordance with the invention; and

2015268751 11 Feb 2020

Fig. 2 illustrates schematically a first embodiment of a bearing arrangement in accordance with the invention for use is a submersible pump as per fig. 1.

5. DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Fig. 1 shows a schematic representation of a first embodiment of a submersible pump 9 in accordance with the invention. The submersible pump 9 comprises a pump housing 91 having an impeller (not shown) arranged therein and comprises a motor housing 7 placed onto the pump housing 91 and having an electric motor (not shown) which is arranged therein and which drives the impeller via a rotor shaft (not shown). A shaft leadthrough 8 is arranged between the motor housing 7 and the pump housing 91 of the submersible pump 9. The rotor shaft passes through the shaft leadthrough 8, with the shaft leadthrough 8 being formed by the bearing cover (see Fig. 2).

Fig. 2 shows a schematic representation of a first embodiment of a bearing arrangement 1 in accordance with the invention which is arranged in a submersible pump 9 in accordance with the invention. The rotor shaft 4 is rotatably supported in a bearing element 2 about the axis of rotation A extending in a longitudinal axial direction, with an inner bearing ring 21 rotating along with the rotor shaft 4 in the operating state. The bearing arrangement 1 for the submersible pump comprises a bearing housing 3 having a bearing cover 32 and a bearing flange 31 and further comprises one or more bearing elements 2 each having an inner bearing ring 21, an outer bearing ring 23 and roller elements 22. Each bearing element 2 is arranged at the bearing flange 31 such that the bearing cover 32 forcibly clamps each outer bearing ring 23 in a longitudinal axial direction and such that a peripheral gap 5 having a predefined axial width is formed in a radial direction between the outer bearing ring 23 and the bearing cover 32 and between the outer bearing ring 23 and the bearing flange 31.

2015268751 11 Feb 2020

The gap 5 is in particular formed as a spark gap for explosion protection, that is as a path in which a gap can extinguish a spark which could, for example, ignite an explosive mixture without escaping from the motor. The bearing element 2 is a roller element bearing, in particular a ball bearing or a cylinder roller bearing. Fig. 1 shows two ball bearings and one cylinder bearing arranged sequentially in a longitudinal axial direction.

A further peripheral gap 6 having a predefinable axial width between the bearing cover 32 and the rotor shaft 4 is additionally formed. The bearing arrangement 1 can be filled with a lubrication and cooling liquid for lubrication and/or cooling.

2015268751 11 Feb 2020

Claims:

1. A submersible pump, comprising:

a bearing arrangement composed of a bearing cover, a bearing flange and one or more bearing elements, each bearing element having an inner bearing ring, an outer bearing ring and roller elements disposed between the inner and outer bearing rings; and

a rotor shaft rotatably supported in the bearing element about an axis of rotation extending in a longitudinal axial direction of the rotor shaft, the inner bearing ring mounted to the rotor shaft to rotate along with the rotor shaft in an operating state of the pump,

characterized in that

the one or more bearing elements is/are received and arranged at the bearing flange and the bearing cover cooperates with the bearing flange in such manner as to (a) forcibly clamp the outer bearing ring(s) of the one or more bearing elements at the bearing flange against movement in the longitudinal axial direction and (b) form a peripheral spark gap for explosion protection, having a predefined axial width in the axial direction and a radial width in radial direction, between the outer bearing ring(s) and (i) the bearing and the (ii) bearing flange, the peripheral spark gap.

2. A submersible pump in accordance with claim 1, wherein the one or more bearing elements comprise is / are roller element bearings.

3. A submersible pump in accordance with claim 2, wherein the roller element bearing(s) comprise one or more of a ball bearing and a cylinder roller bearing.

2015268751 11 Feb 2020

4. A submersible pump in accordance with any one of the preceding claims, wherein a further peripheral gap having a predefined axial width is formed and extends in the radial direction between the bearing cover and the rotor shaft.

5. A submersible pump in accordance with any one of the preceding claims, wherein the predefined axial width of the peripheral spark gap and/or of the further peripheral gap is larger than or equal to 5 mm.

6. A submersible pump in accordance with any one of the preceding claims, wherein the predetermined radial width of the peripheral spark gap and/or of the further peripheral gap is smaller than or equal to 0.2 mm.

7. A bearing arrangement for a submersible pump, comprising:
a bearing cover;
a bearing flange;
one or more bearing elements each having an inner bearing ring, an outer bearing ring and roller elements disposed between the inner and outer bearing rings, the bearing element(s) configured to rotatably support a rotor shaft about an axis of rotation extending in a longitudinal direction of the rotor shaft and the inner bearing ring configured to rotate with the rotor shaft in an operational state of the pump,
wherein the one or more bearing elements is/are arranged and received at the bearing flange and the bearing flange and bearing cover cooperate in such manner as to (a) forcibly clamp the outer bearing ring of the one or more bearing elements against movement in the longitudinal axial direction and (b) form a peripheral spark gap for explosion protection, having a predefined axial width and a radial width in a radial direction, between the outer bearing ring(s) and (i) the bearing cover and (ii) the bearing flange.

2015268751 11 Feb 2020

8. A bearing arrangement in accordance with claim 7, wherein the one or more bearing elements is/are a roller element bearing(s)

9. A bearing arrangement in accordance with claim 8, wherein the roller element bearing(s) comprise(s) one or more of a ball bearing and a cylinder roller bearing.

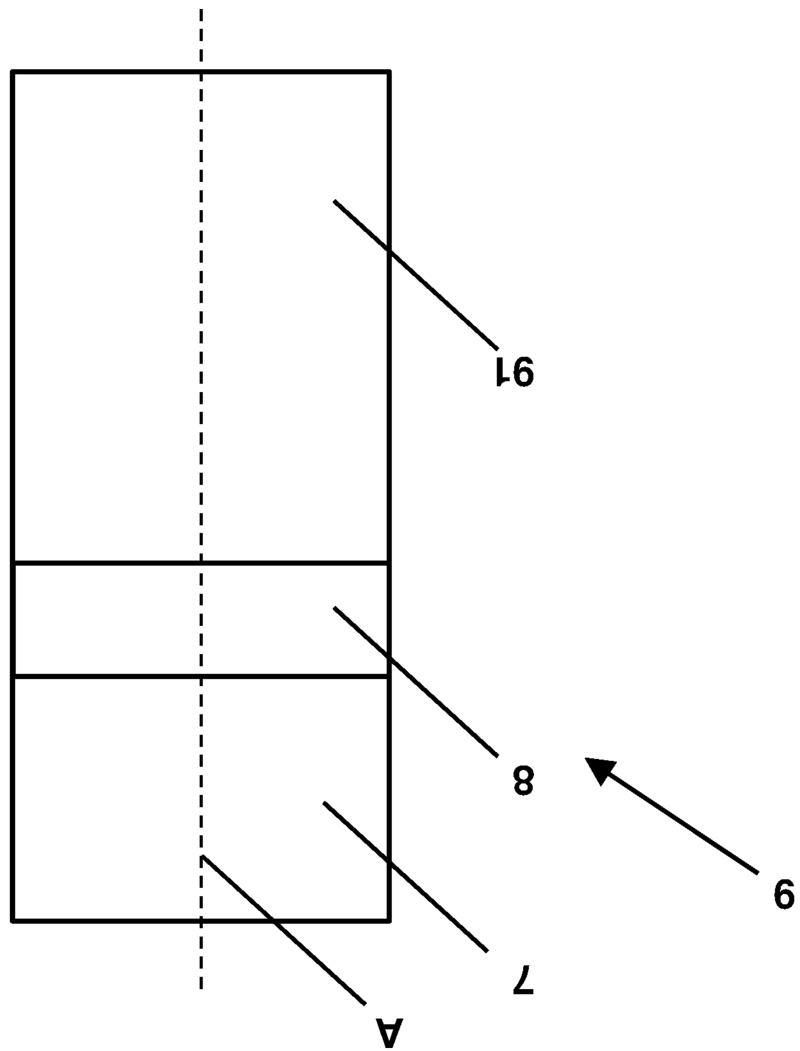
10. A bearing arrangement in accordance with any one of the claims 7 to 9, wherein the predefined axial width of the peripheral spark gap is larger than or equal to 5 mm.

11. A bearing arrangement in accordance with any one of the claims 7 to 10, wherein the radial width of the peripheral spark gap in the radial direction is smaller than or equal to 0.2 mm.

12. A bearing arrangement in accordance with any one of the claims 7 to 11, comprising a further peripheral gap having a predefined axial width formed between the bearing cover and a rotor shaft received therein in the operating state of the pump.

13. A bearing arrangement in accordance with claim 12, wherein the predefined axial width of the further gap is larger than or equal to 5 mm and/or wherein a radial width of the further gap in the radial direction is smaller than or equal to 0.2 mm.

Fig. 1



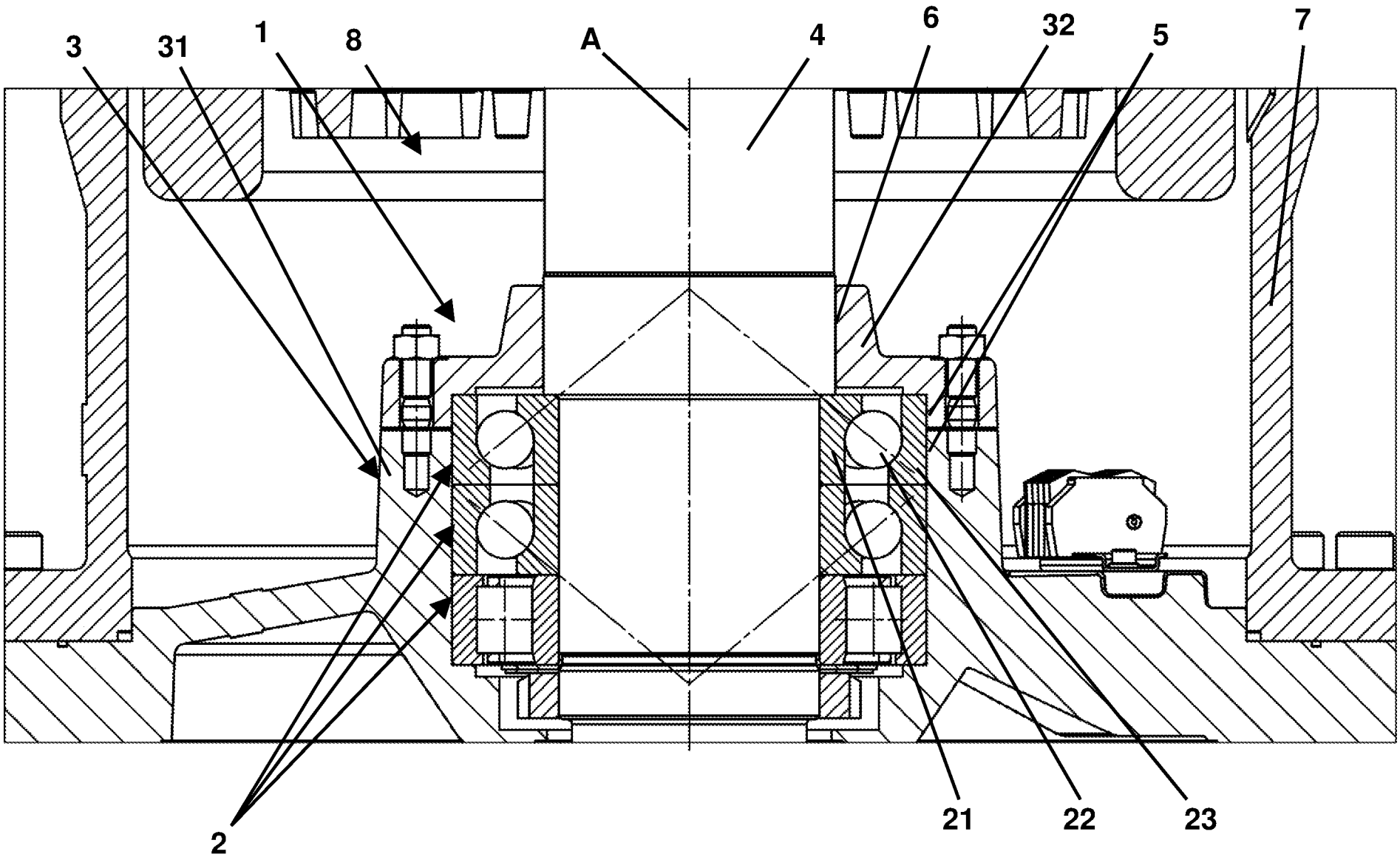


Fig. 2