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(71) Applicant: **Pedrollo S.p.a.**
37047 San Bonifacio (Verona) (IT)

(72) Inventor: **PEDROLLO, Silvano**
37047 San Bonifacio (VR) (IT)

(74) Representative: **Manzella & Associati**
Via dell'Indipendenza, 13
40121 Bologna (IT)

(54) **CENTRIFUGAL PUMP STAGE**

(57) The centrifugal pump stage comprises an impeller (10) having an axial hub (11) predisposed to be associated with the motor shaft (2). A diffuser unit (20) is extended at a first face of the impeller (10) and a suction unit (30) extends at a second face of the impeller (10). The impeller (10) is supported in a floating manner between a first position and a second position in which the axial hub (11) is in abutment against respective stop means (4) rigidly associated with the motor shaft (2), so as to be rotatable with the same shaft (2). The impeller (10) has a couple of coaxial annular crowns (15, 16) predisposed to define the suction mouth of the liquid inside the same impeller (10). Sealing means (5, 6) are associated with the annular crowns (15, 16) having the outer edge facing a static zone (22, 31) of the pump stage.

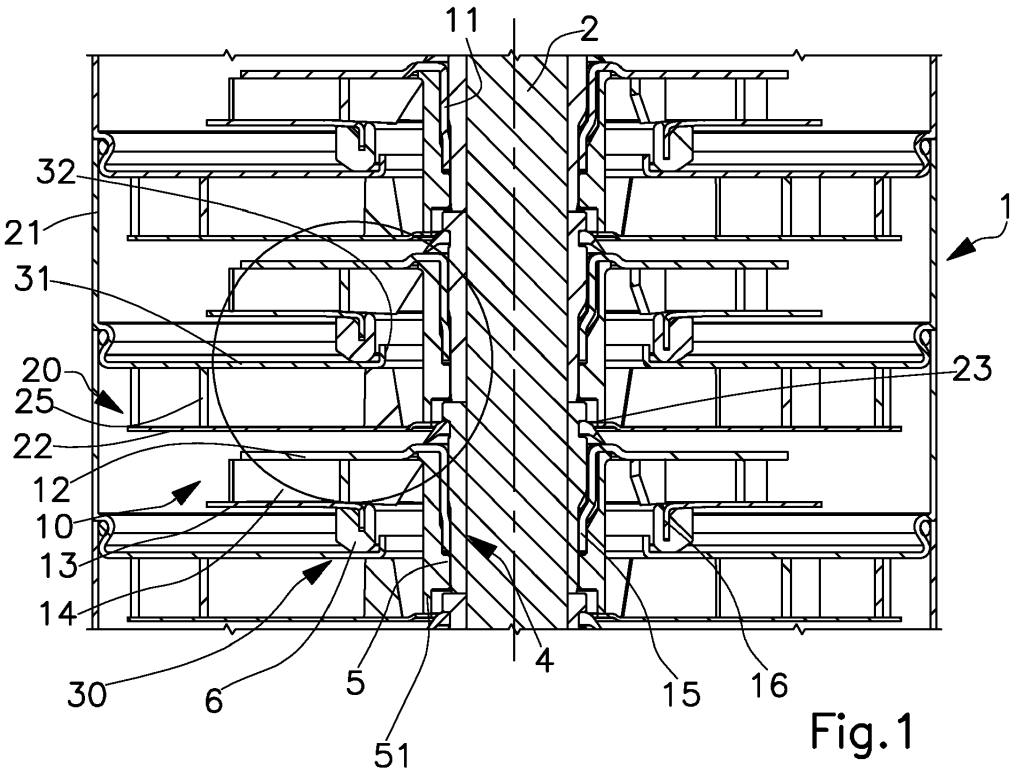

Fig.1

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Description

Technical Field

[0001] The present invention concerns a centrifugal pump stage with floating impeller, intended, in particular, for use in multistage centrifugal pumps

Background Art

[0002] It has been known the use of multiple stage centrifugal pumps for transferring a liquid from a lower space to a higher space. Such centrifugal pumps generally have an outer tubular casing provided with a plurality of radial openings for the entrance of the liquid, usually called suction openings, and with an opening for the exit of the liquid, called outlet opening. The working members of the pump are housed inside the tubular casing. The working members are substantially made up of a pump unit and a motor unit, generally of electric type; the pump unit is predisposed to transfer the liquid from the suction openings to the outlet opening.

[0003] The pump unit is made up of a plurality of stages, arranged in series along the longitudinal axis of the motor shaft of the motor unit, so as to increase the pressure drop at equal flow rates at the pump inlet. Each stage of the centrifugal pump comprises a rotating member, or impeller, predisposed to be driven in rotation by the motor shaft, that extends coaxially to the tubular sleeve of the pump, and a stationary member or diffuser predisposed to convey the liquid from a stage to another, until the outlet opening. More precisely the diffuser is usually extended at a fist face of the impeller and is closed by a suction lid substantially having substantially the shape of a disc extending at a second face of the impeller.

[0004] US 7,290,984 discloses for example a multistage centrifugal pump of this type. In this centrifugal pump, the hub of the impeller is provided with sealing means, at which the impeller is supported, in use, by the diffuser unit in rotatable manner.

[0005] US 2,526,751 discloses a mounting device of the impeller on the motor shaft. The hub of the impeller is rigidly fixed to the motor shaft, in the use position, by a pair of expanding inserts, substantially semi-circular, mounted on a shaft portion of reduced diameter. In the configuration of use, the expanding inserts deform in such a way as to act on the opposing surfaces of the shaft and the impeller hub, creating a rigid coupling.

[0006] A specific problem complained by users of centrifugal pumps of known type is the progressive wear and tear of the mobile parts being in reciprocal contact, at which the seal is obtained. In particular, the impeller is usually sustained in sliding support, for an annular portion thereof, on the disc facing it. The axial thrust which acts on the impeller acts as well on the disc and, due to the shim effect produced during the functioning, this causes a progressive wear and tear of the components. This fact obviously shortens the pump life, especially in presence of grains of sand in the pumped liquid.

[0007] US 3,265,001 discloses a multistage centrifugal pump in which the impeller of each stage is supported floating at the relative diffuser unit. The impeller hub is, in fact, mounted axially slidable on the motor shaft by which is driven in rotation; the stroke of the floating impeller is limited by suitable stop means, for example of annular shape, mounted on the motor shaft. The impeller is supported in sliding contact, along an annular portion, at the cited lid of the diffuser unit, so as to create a sealing area between the rotating part and the static part of the stage. More in particular, the impeller is supported by a thrust bearing placed beneath the hub of the same impeller, in support on a seat of the underlying diffuser.

[0008] WO2015/008224 in the name of the Applicant discloses a multistage centrifugal pump in which the impeller is supported floating at the diffuser unit between a first position and a second position in which the axial hub is in abutment with respective stop rings rigidly associated with the motor shaft of the pump, so as to be rotatable with the same shaft.

[0009] Assembling the impeller in floating manner allows to reduce the wear and tear of the working members, in particular in case the sand or other abrasive grains are present in the liquid to be pumped. This solution thus allows to prevent abrasive grains to stop at the sliding contact sealing areas, thus preventing that such particles increase the wear and tear phenomena.

[0010] At the same time, the presence of sealing areas between the rotating part and the static part of each centrifugal pump stage should be ensured, in order to limit as long as it is possible the phenomena of leakage of the liquid causing a decrease of the pump performances.

[0011] It is therefore felt by users the need for innovative solutions allowing to limit the wear and tear of the sliding contact sealing areas, while still providing high performance and durability of the centrifugal pump.

Disclosure

[0012] The task of the present invention is that of solving the aforementioned problems, by devising a pump stage with floating impeller which is able to limit the wear and tear of the sliding contact sealing areas.

[0013] Within such task, a further scope of the present invention is to provide a centrifugal pump stage, which ensures high levels of performance and durability.

[0014] Another scope of the invention is to provide a centrifugal pump stage that enables to minimize the leakage of fluid phenomena in the above-mentioned sealing areas.

[0015] Yet another scope of the invention is to provide a centrifugal pump stage of simple constructive and functional concept, safely reliable in operation, versatile in use, as well as with relatively economic cost.

[0016] The above scopes are achieved, according to the present invention, by the centrifugal pump stage with floating impeller according to claim 1.

[0017] According to the present invention, the pump stage comprises an impeller made of metallic material and having, at said second face, at least one annular crown, coaxial to the axis of said impeller and predisposed to shape the suction mouth of the liquid inside the same impeller, sealing means with a low friction coefficient being associated with said annular crown and having the outer rim facing a static zone of the pump stage, so as to obtain a sealing area at said suction mouth of the impeller.

[0018] Advantageously, the impeller is provided with an axial hub predisposed to be mounted freely sliding axially on a shaft of the centrifugal pump and is floating, in use, inside a diffuser unit between a first position and a second position in which is in abutment against respective stop means, so as to be rotatable with said shaft.

[0019] Advantageously, said diffuser unit extends at a first face of said impeller and is associated with a suction unit extended at a second face of the impeller.

[0020] Advantageously, said impeller has, at said second face, an inner annular crown, which substantially extends from said axial hub, and an outer annular crown, which extends from said second face of the impeller, both said annular crowns being coaxial to the axis of said impeller and cooperating to define said suction mouth of the liquid inside the impeller.

[0021] According to a first embodiment of the invention, respective sealing means are associated with said crowns with low friction coefficient having the outer rim facing a respective static zone of the pump stage.

[0022] According to a different embodiment of the invention, respective sealing means with low friction coefficient are associated with said outer annular crown having the outer rim facing a respective static zone of the pump stage extended at said second face of the impeller.

[0023] Preferably, said sealing means comprise a shaped ring having a coupling seat for coupling with the outer rim of said annular crown.

[0024] Preferably, said shaped sealing ring has a reduced thickness profile at said rim facing said static zone of the pump stage, so as to reduce the sliding contact.

[0025] Preferably, said stop means are respectively made up of a bush predisposed to be axially inserted on said shaft of the centrifugal pump, in abutment against the opposite edges of corresponding bushes of adjacent pump stages, said axial hub of the impeller being coaxially mounted on said bush.

[0026] Preferably, said bush shapes at one end a collar, outwardly extended, defining a first and a second face transverse to the axis of said shaft.

[0027] Preferably, said bush shapes a shaped portion with prismatic profile, adjacent to said collar, predisposed to engage in use said axial hub of the impeller.

[0028] Preferably, said bush has an axial extension equal to that of the pump stage with which it is associated.

[0029] Preferably, according to said different embodiment of the invention, said inner annular crown has a free end which is spaced, for a distance of limited largeness, from the front surface of said collar of the bush.

[0030] Preferably, according to said different embodiment of the invention, said collar of the bush faces, with play, a cylindrical lip shaped by a disc which is part of said diffuser unit, at an axial opening of the same disc through which said shaft of the centrifugal pump passes.

Description of Drawings

[0031] Details of the invention shall be more apparent from the detailed description of a preferred embodiment of the centrifugal pump stage according to the invention, illustrated for indicative purposes in the attached drawings, wherein:

figure 1 shows an axial cross-sectional view of a plurality of stages assembled in series on the motor shaft of the centrifugal pump;

figure 2 shows an axial cross-sectional view of a detail of the centrifugal pump stage according to the invention;

figure 3 shows a perspective exploded view of the centrifugal pump stage according to the invention;

figures 4, 5 and 6 show corresponding views of a different embodiment of the centrifugal pump stage according to the invention.

Best Mode

[0032] With particular reference to such figures, the centrifugal pump stage with floating impeller according to the invention is indicated in its entirety with 1. The pump stage 1 comprises an impeller 10 having an axial hub 11 intended to be associated with the motor shaft 2 of the centrifugal pump, as it is better specified in the following. In particular, the hub 11 is freely axially slidable as well as coupled in rotation with the motor shaft 2. The motor shaft 2 is predisposed to be carried in rotation by a motor member of the pump, known per se and not shown in the figures.

[0033] The impeller 10 is mounted floating inside a corresponding diffuser unit 20, to which a suction unit 30 is fixed. The diffuser 20 extends at a first face of the impeller 10; the suction unit 30 extends at an opposite second face of the impeller 10. In vertical working position, the first face of the impeller 10 is arranged superiorly, substantially horizontal, while the second face is arranged inferiorly. However, it is possible to use the pump stage according to the invention also in centrifugal pumps with horizontal axis.

[0034] More in particular, the impeller 10 is made up of an upper part 12 and of a lower part 13 that extend substantially in direction transverse to the axis of the motor shaft 2. The upper part 12 defines the above-mentioned first face of the impeller 10; the lower part 13 defines the above-mentioned second face of the impeller 10. Between the upper part 12 and the lower part 13 of the impeller there are, in angularly distributed positions,

a series of fixed blades 14 extending in spiral shape from the central area to the peripheral area of the impeller 10. The blades 14 shape, inside the impeller 10, respective flow channels for the liquid to be pumped.

[0035] The upper and lower parts 12, 13 of the impeller 10 are preferably made of stainless steel.

[0036] The diffuser unit 20 has an outer cylindrical body 21, from which, at one end, inwardly extends a plate 31 shaping the suction unit 30. At the above-mentioned end the cylindrical body 21 has a throat that defines the insertion seat on the cylindrical body of the adjacent pump stage; such throat defines as well the housing for an annular joint 7 predisposed to ensure the seal with the adjacent pump stage.

[0037] In assembled configuration, the plate 31 is facing the lower part 13 of the impeller 10. The plate 31 centrally has a circular opening 32 through which the motor shaft 2 passes.

[0038] A disc 22 being part of the diffuser unit 20 is facing the plate 31. The disc 22 centrally has a circular opening 23 through which the motor shaft 2 passes. At the opening 23, the disc 22 has a flaring predisposed to define a rim 24 raised with respect to the plane of the same disc 22. Between the plate 31 and the disc 22 there are, in angularly distributed positions, a series of blades 25 that extend with spiral shape from the central zone to the peripheral zone of the diffuser unit 20. The blades 25 shape respective flow channels for the liquid to be pumped.

[0039] The axial hub 11 is made up of a sleeve extending from the upper part 12 of the impeller 10, coaxial in assembled position to the motor shaft 2. As it is better specified in the following, this sleeve has, at least for a part, a prismatic profile for allowing its drawing in rotation by the motor shaft 2.

[0040] The impeller 10 is floating in use inside the diffuser unit 20 between a first position and a second position in which is in abutment with respective stop means 4, associated in series with the motor shaft 2 of the centrifugal pump so as to be rotatable with the same shaft 2.

[0041] The stop means 4 are made up of respective bushes that axially insert on the shaft 2, the one close to the other. The bushes 4 are made, for example, of sintered material. The shaft 2 suitably has a polygonal or grooved profile so as to create a prismatic coupling with the inner surface of the bushes 4 having a complementary shape.

[0042] The bushes 4 have an axial extension equal to the one of the pump stage and respectively have a portion 40 with an external cylindrical profile. At one end the bush 4 shapes a collar 41, extended outwardly, that is arranged, in use, at the circular opening 23 of the disc 22 of the diffuser unit 20. Adjacent to the collar 41, the bush 4 shapes a shaped portion 42 with hexagonal profile, predisposed to engage in use the hub 11 of the impeller 10. In particular, the hexagonal profile of the shaped portion 42 of the bush 4 is complementary to the inner profile of the hub 11.

[0043] Between the collar 41 and the hexagonal profile 42 of the bush 4 a throat 43 is defined in which the neck of an elastic lip member 3 is held in use. The lip member 3 is made for example of rubber. The lip member 3 is predisposed to elastically act on the impeller unit 10 to keep it in the correct working position, as it is specified in the following. Suitably, the lip member 3 acts on a raised portion 17 of annular shape, shaped by the upper part 12 of the impeller 10.

[0044] The hub 11 and the lower part 13 of the impeller 10 extend, from the side turned towards the axis of the pump, into a respective annular crown 15, 16 coaxial to the axis of the impeller 10, protruding at said second face of the same impeller 10. The annular crowns 15, 16, respectively inner and outer, are predisposed to define the suction mouth of the liquid inside the impeller 10.

[0045] The annular crowns 15, 16 have the outer rim facing a respective static zone of the pump stage, so as to obtain a sealing area at said suction mouth of the impeller 10. In particular, the outer rim or the annular crowns 15, 16 is facing in use respectively the disc 22 of the diffuser unit 20 and the plate 31 of the suction unit 30.

[0046] According to the present invention, sealing means 5, 6 with low friction coefficient are associated with the annular crowns 15, 16, said sealing means 5, 6 being predisposed to abut the above mentioned static zone of the pump stage to obtain the seal at the suction mouth of the impeller 10. In the illustrated case, the sealing means 5, 6 are made up of suitably shaped rings, for example made of Teflon, having an annular notch through which they insert on the outer rim of the annular crowns 15, 16. However, it is possible to provide that the sealing means of the outer rim of the annular crowns 15, 16 are made differently, for example, of moulded plastic or the like.

[0047] The sealing rings 5, 6, respectively inner and outer, have a reduced thickness at the edge turned towards the static zone of the pump stage, so as to reduce the largeness of the front surface on which the sliding contact is produced. In particular, the inner sealing ring 5 is made up of a cylindrical sleeve 50 which shapes at one end a crown 51 of reduced thickness, intended for abutting the raised rim 24 of the disc 22.

[0048] The functioning of the centrifugal pump stage is easy to understand from the preceding description.

[0049] In use, the annular crowns 15, 16 that shape the suction mouth of the liquid into the impeller 10 are in support through the respective sealing rings 5, 6 on the raised rim 24 of the disc 22 and on the disc 31 of the suction unit 30, being the static zone of the pump stage. In such condition, the inner shoulder of the sealing ring 5, defined between the sleeve 50 and the crown 51 is suitably placed at an approached distance from the front surface of the collar 41 of the bush 4. The lip member 3, elastically acting on the impeller 10, ensures to keep the above-mentioned working position.

[0050] Upon actuation of the centrifugal pump, the sealing rings 5, 6 of the annular crowns 15, 16, inner and

outer, of the impeller 10 are brought in rotation in contact with the cited static zone, so as to obtain the sealing areas at the suction mouth of the same impeller 10.

[0051] In the cited sealing areas, the sliding contact between the sealing rings 5, 6 of the annular crowns 15, 16 of the impeller 10 with the opposite static zone of the pump stage causes, by friction, a limited wear and tear of the same sealing rings 5, 6 made of a low friction coefficient material.

[0052] It is to be observed that the progressive wear and tear of the sealing surface of the sealing rings 5, 6 of the impeller 10 produces a corresponding progressive reduction of the largeness of the space defined between the cited inner shoulder of the sealing ring 5 and the front surface of the collar 41 of the bush 4. When such shoulder enters in contact with the front surface of the collar 41 of the bush 4, in a normal working condition, i.e. at speed, the wear and tear between the sealing areas in contact is stopped. In such condition, the impeller 10, in fact, is in support on the bush 4 and consequently cannot get closer to the static zone of the pump stage; the rotating sealing areas are therefore spaced from such static zone by minimal plays, such as to prevent important drawing phenomena.

[0053] It is to be further observed that that the bush 4 is brought in rotation by the motor shaft 2 along with the impeller 10, therefore no drawing phenomena occur between the surfaces in contact.

[0054] The impeller 10 is floating inside the diffuser unit 20 between a first position, of normal working, in which is in abutment against the bush 4 associated with the shaft 2 of the centrifugal pump, at the same impeller 10, as described above, and a second position, in which the front surface of the sleeve 50 of the inner sealing ring 5 is in abutment against a second bush 4, similarly associated with the shaft 2, at the above pump stage. This allows preventing the contact between the upper surface of the impeller 10 and the opposite static surface of the diffuser unit 20, in case the working conditions cause an upward movement of the same impeller 10.

[0055] In figures 4, 5 and 6 a different embodiment or the centrifugal pump stage according to the invention is shown, in which the annular crown 15 of the hub 11 is deprived of the sealing ring. When mounting, the inner annular crown 15 is not in contact with a static surface, but its edge is spaced, for a portion of limited largeness, from the front surface of the collar 41 of the bush 4. Therefore, in this case, the hydraulic seal in the zone of the hub 11 is not obtained by front shim but rather by the radial play between a cylindrical lip 26 shaped by the disc 22 at the opening 23 and the collar 41 of the bush 4 (see in particular figure 5). Differently from the preceding embodiment, the leakage is not eliminated by wear and tear but remains constant over time.

[0056] The functioning of the pump stage is similar the one previously described for the first embodiment of the invention.

[0057] In use, the outer annular crown 16 is in support through the sealing ring 6 on the disc 31 of the suction unit 30, being the static zone of the pump stage. The sliding contact between the sealing ring 6 and the opposite static zone of the pump stage causes, by friction, a limited wear and tear of the same sealing ring 6, made of a low friction coefficient material.

[0058] Also in this case, the progressive wear and tear of the sealing surface of the sealing ring 6 of the impeller 10 produces a corresponding progressive reduction of the largeness of the space defined between the cited edge of the inner annular crown 15 and the front surface of the collar 41 of the bush 4. When such edge of the annular crown 15 gets in contact with the front surface of the collar 41, in a condition of normal working, i.e., at speed, the wear and tear between the sealing areas in contact is stopped.

[0059] Such solution has the advantage of requiring a component less, i.e., the sealing ring of the hub, with a consequent reduction of the production costs and a simplification of the assembling step. There is also a lesser energy consumption, as there is one single component, i.e., the sealing ring 6 of the impeller 10, moving with sliding contact on the static zone of the pump stage.

[0060] The centrifugal pump stage according to the present invention, therefore, reaches the scope of limiting the wear and tear of the sealing areas in sliding contact, ensuring high levels of performance and durability over time.

[0061] At the same time, the proposed solution allows to minimize the plays between the impeller and the static parts of the pump stage, at the sealing areas. In this way, the hydraulic losses due to leakage in the sealing areas are almost completely eliminated, with obvious improvement in both the production and the flow rate and pressure drop of the centrifugal pump.

[0062] The pump stage described by way of example is susceptible to numerous modifications and variations according to the different needs. It is for example possible to use the described solution also in a single-stage centrifugal pump.

[0063] In practice, the used materials as well as the size and shape may vary according to the needs.

[0064] Should the technical characteristics mentioned in the claims be followed by reference signs, such reference signs were included for the sole purpose of increasing the understanding of the claims and thus they shall not be deemed limiting the scope of the element identified by such reference signs by way of example.

Claims

1. Centrifugal pump comprising a motor shaft (2) and a plurality of centrifugal pump stages (1) mounted in series on said motor shaft (2), each centrifugal pump stage (1) comprising an impeller (10) provided with an axial hub (11) predisposed to be mounted in freely slidable axial manner on said shaft (2) of the centrif-

ugal pump coaxial thereto;
a diffuser unit (20) extended at a first face of said impeller (10);
a suction unit (30) associated with said diffuser unit (20) and extended at a second face of
said impeller (10),
stop means (4) associated in series with said shaft (2) of the centrifugal pump, in such a way as to be rotatable with said shaft (2), said impeller (10) being floating in use in independent manner inside said diffuser unit (20) between a first position and a second position in which said impeller (10) is in abutment against respective stop means (4), in such a way as to be rotatable with said shaft (2),
characterized in that
said impeller (10) is made of metallic material and has, at said second face, at least one annular crown (15, 16), coaxial to the axis of said impeller (10) and predisposed to shape the suction mouth of the liquid inside the same impeller (10), sealing means (5, 6) with a low friction coefficient being associated with said annular crown (15, 16) and having the outer rim facing a static zone (22, 31) of the pump stage, so as to obtain a sealing area at said suction mouth of the impeller (10).

2. Centrifugal pump according to claim 1, **characterized in that** said impeller (10) has, at
said second face, an inner annular crown (15), which substantially extends from said axial hub (11), and an outer annular crown (16), which extends from said second face of the impeller (10), both said annular crowns (15, 16) being coaxial to the axis of said impeller (10) and cooperating to define said suction mouth of the liquid inside said impeller (10).

3. Centrifugal pump according to claim 2, **characterized in that** said sealing means (5, 6), with a low friction coefficient and having said outer rim facing a respective said static zone (22, 31) of the pump stage, are respectively associated with said annular crowns (15, 16).

4. Centrifugal pump according to claim 1 or 3, **characterized in that** said sealing means (5, 6) comprise a shaped ring having a coupling seat for coupling with the outer rim of said annular crown (15, 16).

5. Centrifugal pump according to claim 4, **characterized in that** said sealing ring (5, 6) has a reduced thickness profile at said rim facing said static zone (22, 31) of the pump stage, so as to reduce the sliding contact.

6. Centrifugal pump according to any one of the preceding claims, **characterized in that**
said stop means (4) are respectively made up of a bush predisposed to be axially inserted on said shaft (2) of the centrifugal pump, in abutment at the opposite edges with corresponding bushes of adjacent pump stages, said axial hub (11) of the impeller (10) being coaxially mounted on said bush.

7. Centrifugal pump according to claim 6, **characterized in that** said bush (4) shapes at one end a collar (41), outwardly extending, defining a first and a second face transverse to the axis of said shaft (2).

8. Centrifugal pump according to claim 7, **characterized in that** said bush (4) shapes a shaped portion (42) with prismatic profile, adjacent to said collar (41), predisposed to engage in use said axial hub (11) of the impeller (10).

9. Centrifugal pump according to one of claims 6, 7 or 8, **characterized in that** said bush (4) has an axial extension equal to that of the pump stage with which it is associated.

10. Centrifugal pump according to one of claims 7, 8 or 9, **characterized in that** said collar (41) of the bush (4) is facing, with play, a cylindrical lip (26) shaped by a disc (22) which is part of said diffuser unit (20), at an axial opening (23) of the same disc (22) through which said shaft (2) of the centrifugal pump passes.

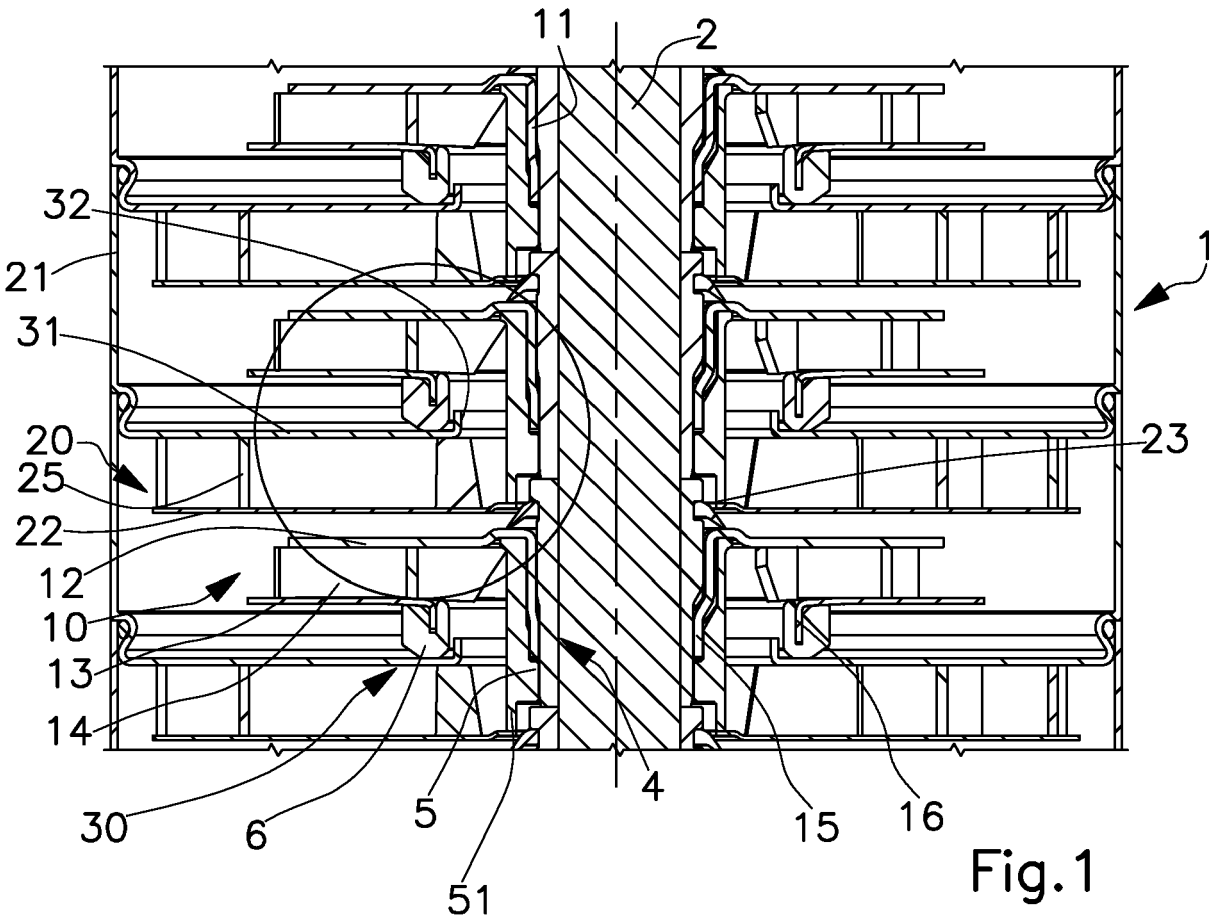
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Fig.1

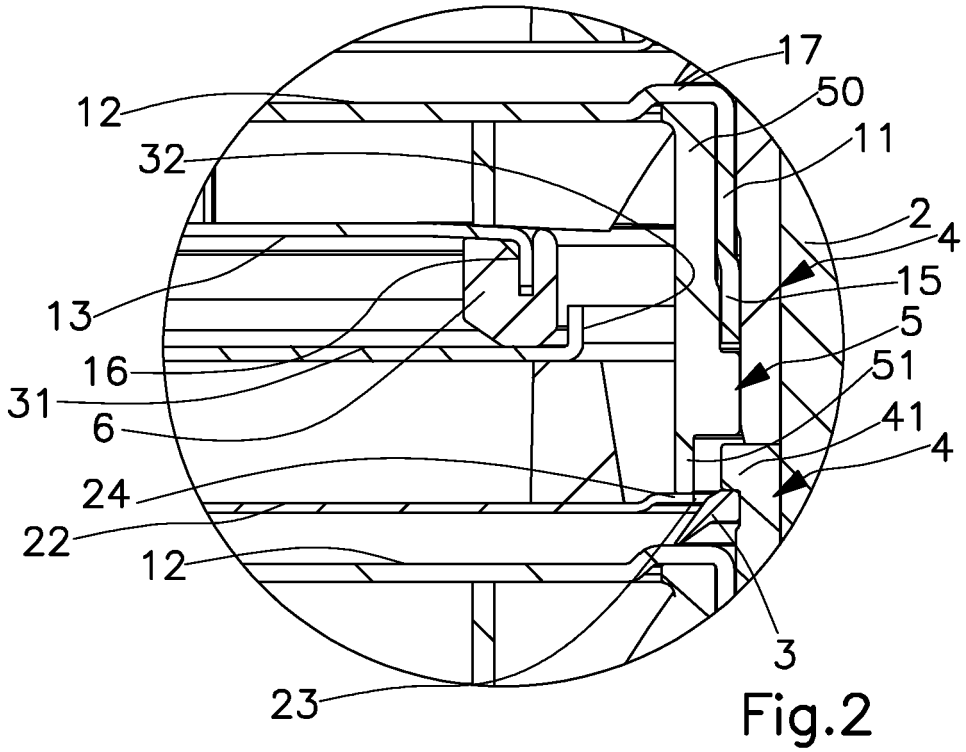
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Fig.2

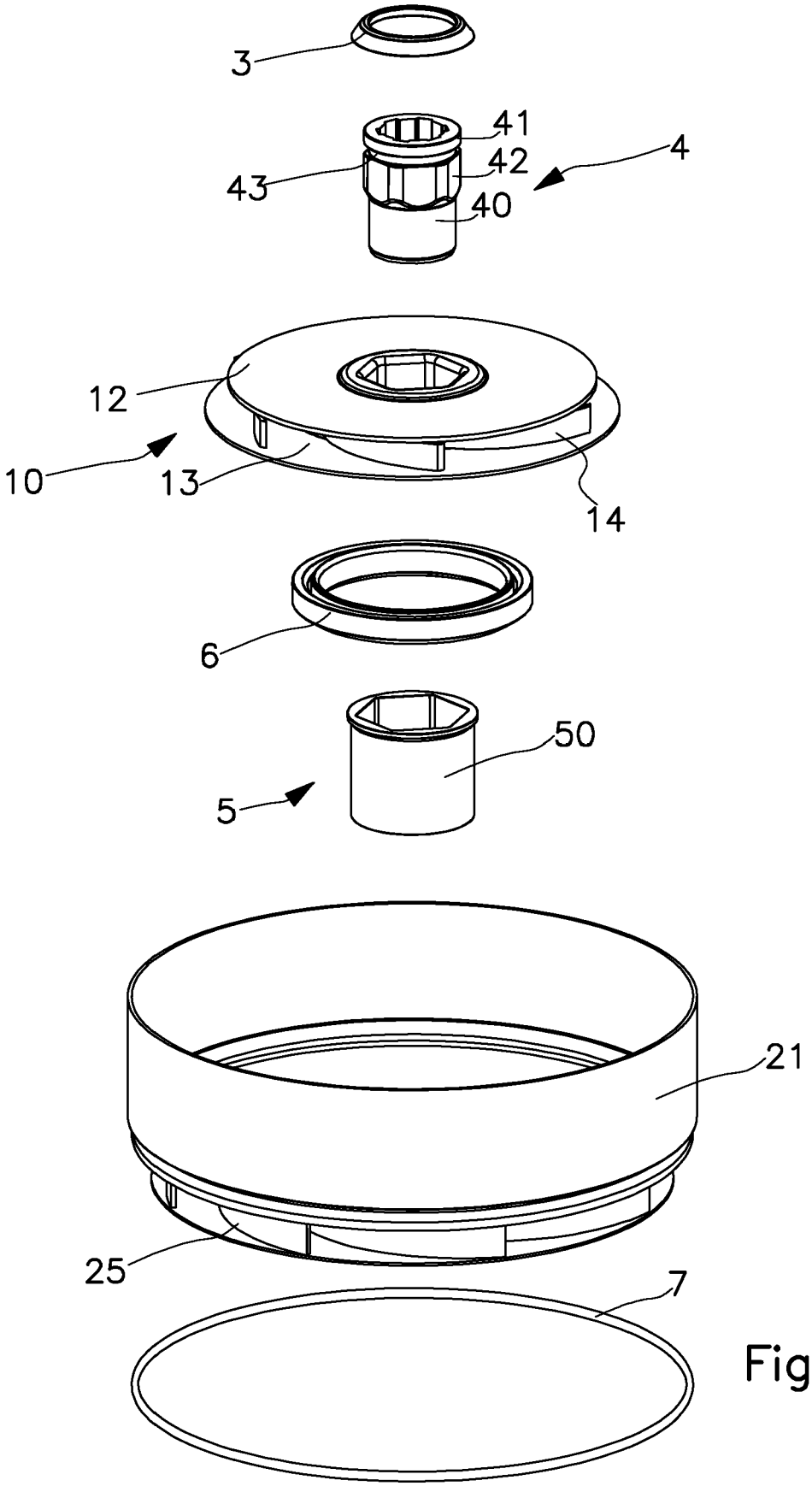

Fig.3

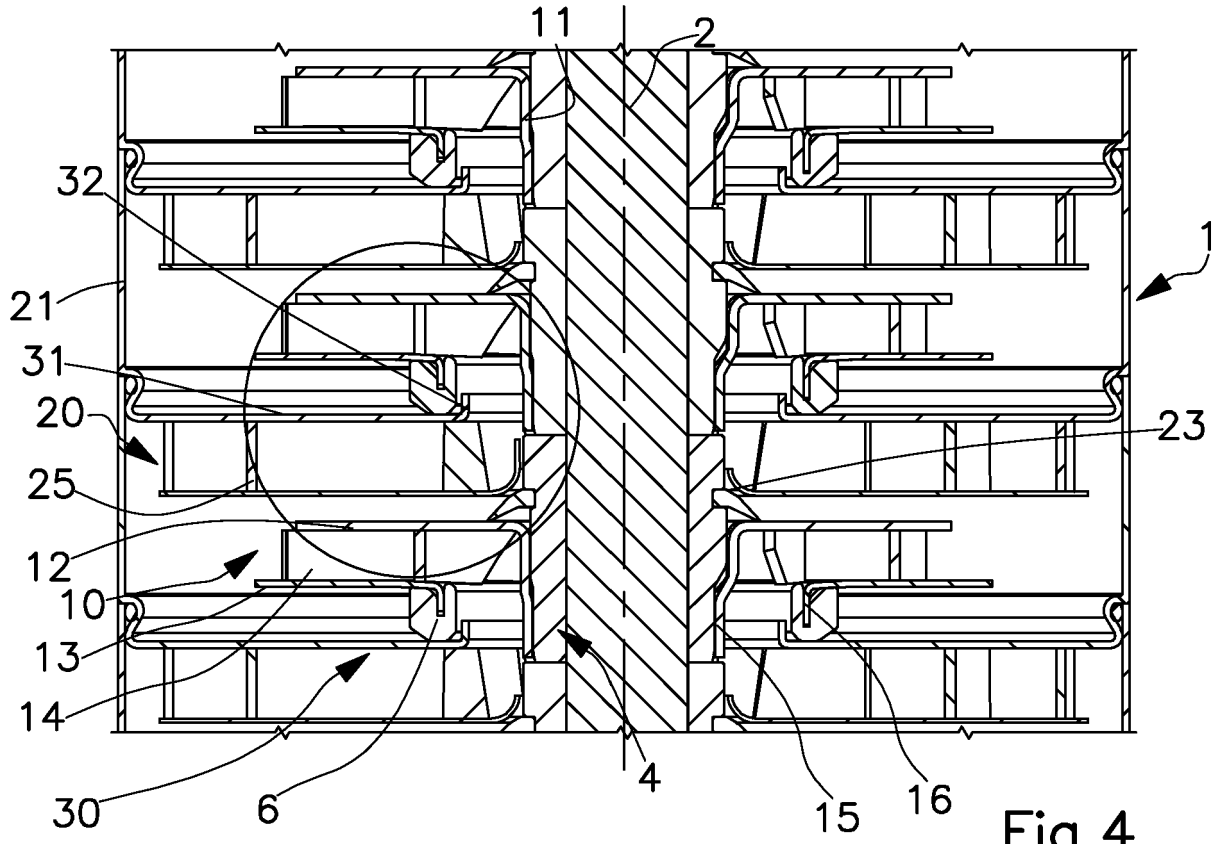
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Fig.4

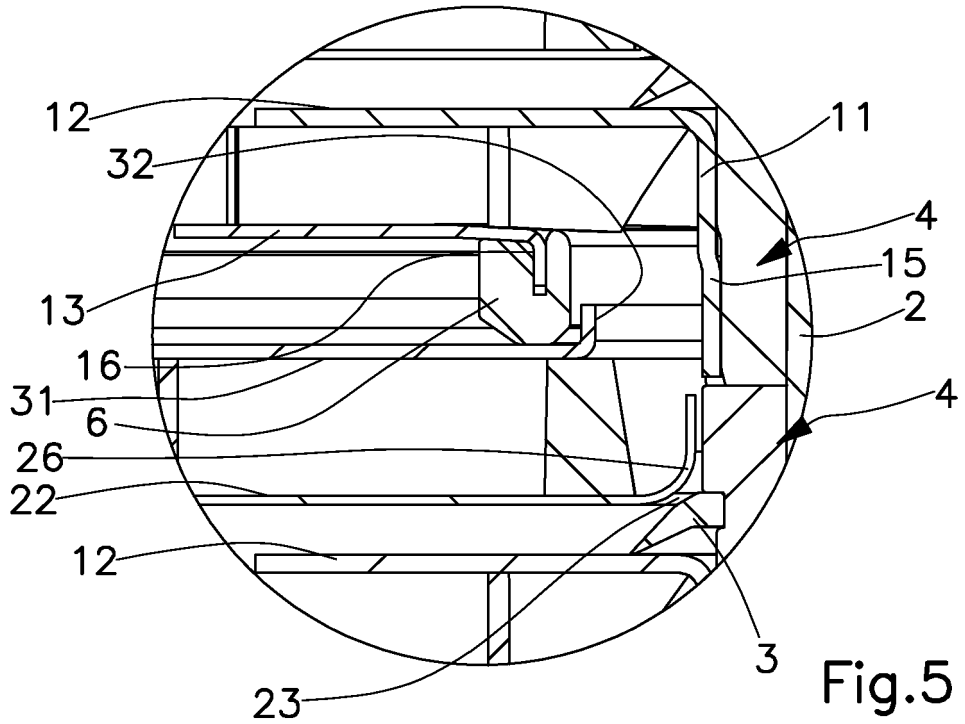
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Fig.5

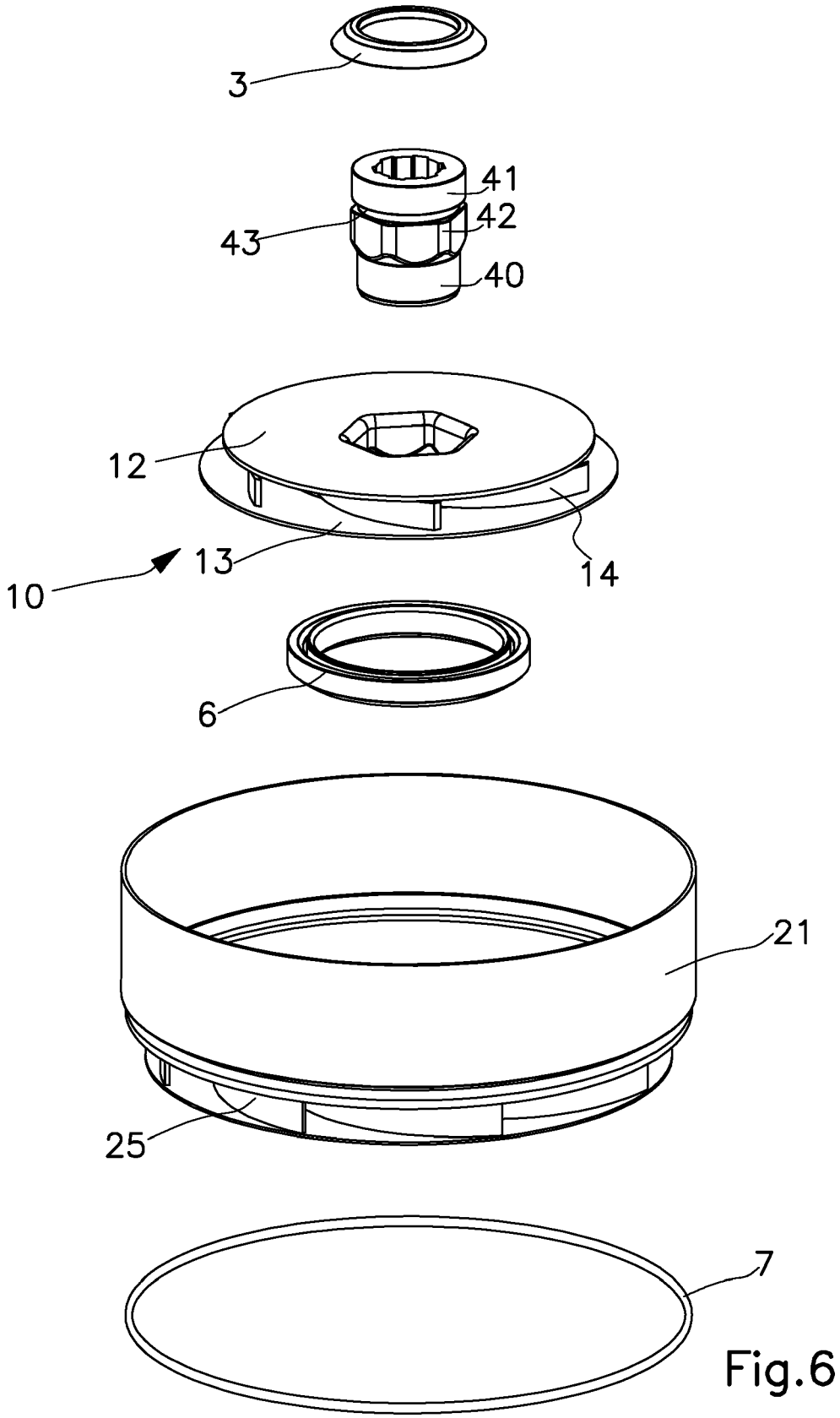

Fig.6

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 15 7493

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 398 493 B1 (CHIEN HUAN-JAN [TW] ET AL) 4 June 2002 (2002-06-04) * column 1, line 4 - line 10 * * column 1, line 49 - column 2, line 26 * * column 2, line 65 - column 3, line 16 * * claims 1-2; figures 1-2,8 *	1-10	INV. F04D1/06 F04D29/16 F04D29/22 ADD. F04D29/20
X A	DE 198 00 617 A1 (KLEIN SCHANZLIN & BECKER AG [DE]) 15 July 1999 (1999-07-15) * column 1, line 3 - line 10 * * column 2, line 23 - line 40 * * column 3, line 58 - column 4, line 46 * * claim 1; figures 1-2 *	1-7,10 9	
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