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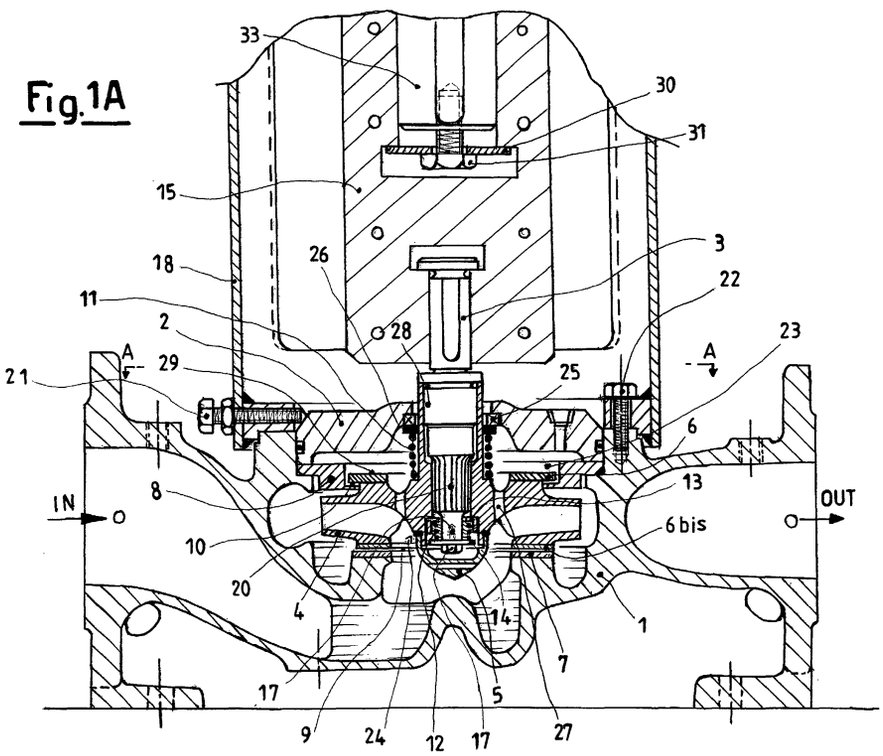
## (54) Centrifugal pump with self-balancing axial drive

(57) A centrifugal pump comprises a pump body or casing (1), a rotor (4) connected to a shaft (3) in turn connected to a drive shaft (33) with a joint (15), a removable cover (2), with the seal between the pump body (1) and the rotor body (4) being ensured by rings (7, 8), attached to the fixed casing (1), facing rings (6, 6bis), attached to the rotor (4), which are made to rotate with it. According to the invention, the rotor (4) is fitted onto a shaft (3) through a grooved profile (20), which does not restrict in the axial direction and allows it to float in the liquid pumped in its rotation. Moreover, in the body of the rotor (4) through-holes (27) are made which put the upper chamber (23), enclosed by the cover (2) and by the ring (8), in communication with the passage zone in which the pumped fluid receives energy and pressure from the rotor which is in relative motion with respect to it.

Fig.1A

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## Description

**[0001]** The present invention refers to centrifugal pumps and in particular to a simplified centrifugal pump structure without sliding or rolling bearings, either for guiding or for driving.

**[0002]** In general, centrifugal pumps are machines in which energy is transferred from the machine to the fluid through a rotor which moves with respect to the fluid. Their structure comprises a static part and a moving part: an outer casing which contains the rotor fitted on a shaft which is moved, by means of a rigid joint, by a motor. In general, between the two parts sealing members are interposed which carry out their function between flat or cylindrical interfacing surfaces, in motion relative to each other. To increase the seal and to reduce the frictions forces present, the pump is generally equipped with auxiliary devices for the lubrication of such surfaces distributing a lubrication fluid in their interstices.

**[0003]** Such lubrication devices are the source of substantial drawbacks, be it of the environmental type due to the losses and disposal of the lubrication fluids, be it of mechanical yield of the machine due to fluid leakages, or be it finally for the complicatedness and the greater size of the machine.

**[0004]** Centrifugal pump structures without lubrication devices and with a seal of the radial type between flat surfaces are known from patents USA 4,242,039, 4,501,530 and 4,913,619. Such centrifugal pump structures are, however, quite complex and have difficulties in their realisation, mounting, maintenance and adjustment.

**[0005]** The present invention refers more precisely to a centrifugal pump with a structure which is a good deal simpler and easier to realise, mount, maintain and adjust. It is, moreover, equipped with a self-balancing system of the axial drive, and corresponds, moreover to requirements of simplicity, lightness and a small size.

**[0006]** The pump according to the invention is defined, with its essential characteristics, in the first claim, whereas the dependent claims define preferred embodiments and improvements of the invention.

**[0007]** To illustrate the characteristics and the advantages of the present invention with greater clarity, it is described with reference to a typical embodiment thereof shown in figures 1, 2 and 3 as an example and not for limiting purposes.

**[0008]** In figure 1 an embodiment is shown with section views according to an axial (figure 1A) and front (figure 1B) plane, respectively, of the pump seen from AA.

**[0009]** The views of figures 2 and 3 show the details of the configurations taken up by the rotor/casing with the pump in rest state and during operation, respectively.

**[0010]** As illustrated in figures 1 to 3, the centrifugal pump according to the invention comprises a pump body 1, which contains a rotor 4 fitted onto a shaft 3 through a grooved profile 20, which does not restrict the rotor in the axial direction. The shaft 3 is connected to its motor - of which only the shaft 33 is shown - with a rigid joint 15, realised in two halves. The casing 1 of the pump foresees from the two sides an intake IN and a discharge OUT of the pumped fluid, on the left and right-hand side in the figures, respectively. In the upper part of the figures a removable cover 2 of the casing 1 is shown, with attachment screws 21 and a support 18 for the motor. Such a support for the motor is connected to the casing with screws 22.

**[0011]** The shaft 3 is connected to a lower washer 14 by means of a screw 17 and through a spring 12, (shock absorber), keeps the rotor 4 raised until a pressure is created in the chamber 23. With the rotor 4 raised the passages 9, 10 are at their maximum as a result of which the pump can also be started up dry without problems of wearing or seizure by friction in zones 9, 10. When pressure is created in the chamber 23, due to the pumped liquid which comes out of the passage 10, the clearances 9, 10 reduce since the pressure acting on the surface 29 pushes the rotor downwards.

**[0012]** The gasket 24 guarantees the sealing of the fluid pumped between hub 5 and rotor 4. The seal between fixed casing 1 and rotor 4 is taken care of by the contact of the punctured disks or rings 7 and 8, attached to the fixed structure, with the punctured disks or rings 6 and 6bis, fixedly attached to the rotor 4. According to a preferred embodiment of the invention the surfaces of the sealing rings are realised with very hard, low-friction materials and finishes in order to obtain a longer lifetime of the members in contact with each other.

**[0013]** The fixed rings 7 and 8 are preferably realised with materials with a high surface hardness, for example stainless steel, bronze, silicon carbide, ceramics and so on.

**[0014]** The rotating rings 6 and 6bis of the rotor 4 can be realised with self-lubrication materials with a low friction coefficient, for example with resins, containing possible additional fillers, silicon carbide, ceramic, metallic alloys. Such sealing rings can also be realised with the criterion of choosing from them a sacrificial part intended to wear away to optimise the clearances of the seals also in the case of small errors in the planarity and/or in the tolerances.

**[0015]** As stated above, the rotor 4 is fitted onto the shaft 3 without restriction in the axial direction; the clearances between the aforementioned sealing rings can thus vary. The mechanical seal on the cover 2 is realised through a fixed ring 25 and a rotating ring 26, pressed together by a spring 11 which in the lower part is rested upon a shoulder of the rotor 4. A cylindrical circular recess 28 with a shape and size which is coherent with the intermediate widening of the shaft 3, functions as a precise guide of the axial sliding of the rotor 4.

**[0016]** In the body of the rotor 4 through-holes 27 are made which place the upper chamber 23, enclosed by the cover 2 and by the disk 8, in communication with the

passage zone in which the pumped fluid receives energy and pressure from the rotor in relative motion with respect to it.

**[0017]** As summarily shown in figure 1A, the rigid half-joint 15 is made integral with the drive shaft 33 with a washer 30 and a screw 31. During assembly and in subsequent adjustments the screw 31, screwed in or unscrewed, with the joint open, allows the clearances 9 and 10, upper and lower respectively, between the fixed part and the rotating part to be set, by axially displacing the rotor 4.

**[0018]** The special characteristics of the centrifugal pump according to the invention shall become clear from its operation which is summarily described hereafter.

**[0019]** Figure 2 shows the rotating part of the pump at rest. In the chamber 23 there is no pressurised liquid, the spring 12 prevails and tends to push the rotor 4 and the hub 5 upwards, in the plane of the drawing. The gasket 24 guarantees the seal, avoiding the leaking of the pumped liquid. With the pump at rest the clearances 10 and 9, between the upper rings 6, 8 and between the lower rings 7 and 6bis, respectively, are at their maximum.

**[0020]** Between intake IN and discharge OUT the pressure is balanced. Also the mechanical seal spring 11 is more compressed and guarantees the better seal against leakages, since the fixed ring 25 and the rotating ring 26 are pressed with greater force against one another. If, by mistake, the pump is started up dry without liquid, its rotating members do not come into contact with the static components and any risk of seizure is avoided.

**[0021]** Figure 3 shows the rotating part of the pump in operation. The rings 6 and 6bis are therefore characterised by rotary motion whereas the rings 7 and 8, facing towards them are static being attached to the casing.

**[0022]** In the chamber 23 a pressure is created due to the liquid which penetrates through the clearance 10.

**[0023]** An increase in the pressure in the chamber 23 corresponds to a lowering of the rotor downwards, in the plane of the drawing of figure 3, to an increase in the distance X, between the shoulder of the shaft 20 and the upper part of the rotor 4 (figure 3), and to a corresponding decrease in the distance Y, between the end of the shaft 3 and the upper face of the hub 5, with the consequent reduction of the clearances 9 and 10.

**[0024]** Indeed, such a pressure is applied on the surface 29 of the body of the rotor 4, that is on the upper face of the ring 6 fixed to it, and pushes it, together with the hub 5 downwards in the plane of the drawing. The lower clearance 9 is reduced and limits the intake return flow losses towards the intake of the pumped fluid, whereas the clearance 10 is balanced due to the discharge of pressure from the chamber 23 by the holes 27 of the rotor 4.

**[0025]** The upper rotating ring 6 facing the static ring 8 thus functions as a hydraulic balancing disk adjusting the pressure in the chamber 23 as the clearance 10 varies. Then axial pushes are borne with the ring 6bis, which transfers them with the meatus of the liquid on the opposite ring 7.

**[0026]** During its operation, the rotor 4, mounted on the shaft 3 with the grooved profile 20, is axially free and floating in the pumped liquid.

**[0027]** Axial sliding is absorbed by the springs 11 and 12 which work against each other; during service the pump finds its equilibrium of the axial position by itself. The sliding of the rotor 4 downwards, still in the plane of the drawing, frees the spring 11 of the mechanical seal; the fixed ring 25 and the rotating ring 26 are pressed against each other with a lesser force, when they move relative to each other. From such a pump structure a lesser wear and a longer lifetime of the mechanical seal are obtained.

**[0028]** As can be seen from the embodiment shown, the centrifugal pump according to the invention gives further substantial improvements and advantages with respect to the prior art. Amongst these, those which are outlined hereafter deserve at least a mention.

**[0029]** The pump according to the invention allows the replacement and maintenance of the inner parts with great ease, since there are no rolling bearings for guide and for thrust. Equally, there is no need for lubrication devices. All of the inner parts can be accessed without removing the motor and the piping. The setting of the clearances 9 and 10 between the radial sealing rings can be carried out from the outside of the cover 2, without opening the pump.

**[0030]** The pump is very light and compact and is very suitable for the naval field, where there are restrictions both in the space available and in the accessibility of the arrangement of pumps and of their motor.

**[0031]** The shaft 3 of the pump does not come into contact with the pumped liquid and therefore is preserved from possible corrosive attacks. The pump can also be made to operate dry and for prolonged periods without damage of any note.

## Claims

1. Centrifugal pump comprising a pump body or casing (1), a rotor (4) connected to a shaft (3) in turn connected to a drive shaft (33) with a joint (15), a removable cover (2), with the seal between the pump body (1) and the rotor body (4) being ensured by rings (7, 8), attached to the fixed casing (1), facing rings (6, 6bis), attached to the rotor (4), which are made to rotate with it, **characterised in that** the rotor (4) is fitted onto a shaft (3) through a grooved profile (20), which does not restrict in the axial direction and allows it to float in the liquid pumped in its rotation and **in that** in the body of the rotor (4) through-holes (27) are made which put the upper chamber (23), enclosed by the cover (2) and by the

ring (8), in communication with the passage zone in which the pumped fluid receives energy and pressure from the rotor which is in relative motion with respect to it.

2. Centrifugal pump according to claim 1, **characterised in that** the shaft (3) at one end is connected to the rotor (4) and at the opposite end to the joint (15).

3. Centrifugal pump according to claim 1, **characterised in that** the axial sliding of the shaft (3) is absorbed by springs (11, 12) which work against each other, the spring (11) being connected to the mechanical seal on the cover (2) through a fixed ring (25) and a rotating ring (26), and the spring (12) being inserted between the rotor (4) and a washer (14) fixed to the end of the shaft (3) opposite the joint (15) through a screw (17).

4. Centrifugal pump according to claim 1, **characterised in that** the means for setting the clearances (9, 10), displacing the rotor (4) axially with respect to the pump body (1), consist of a screw (31) for attaching the shaft (3) to the joint (15).

5. Centrifugal pump according to claim 2, **characterised in that** on the rotor (4) a hub (5) is mounted with the interposition of a gasket (24) for sealing in the pumped fluid.

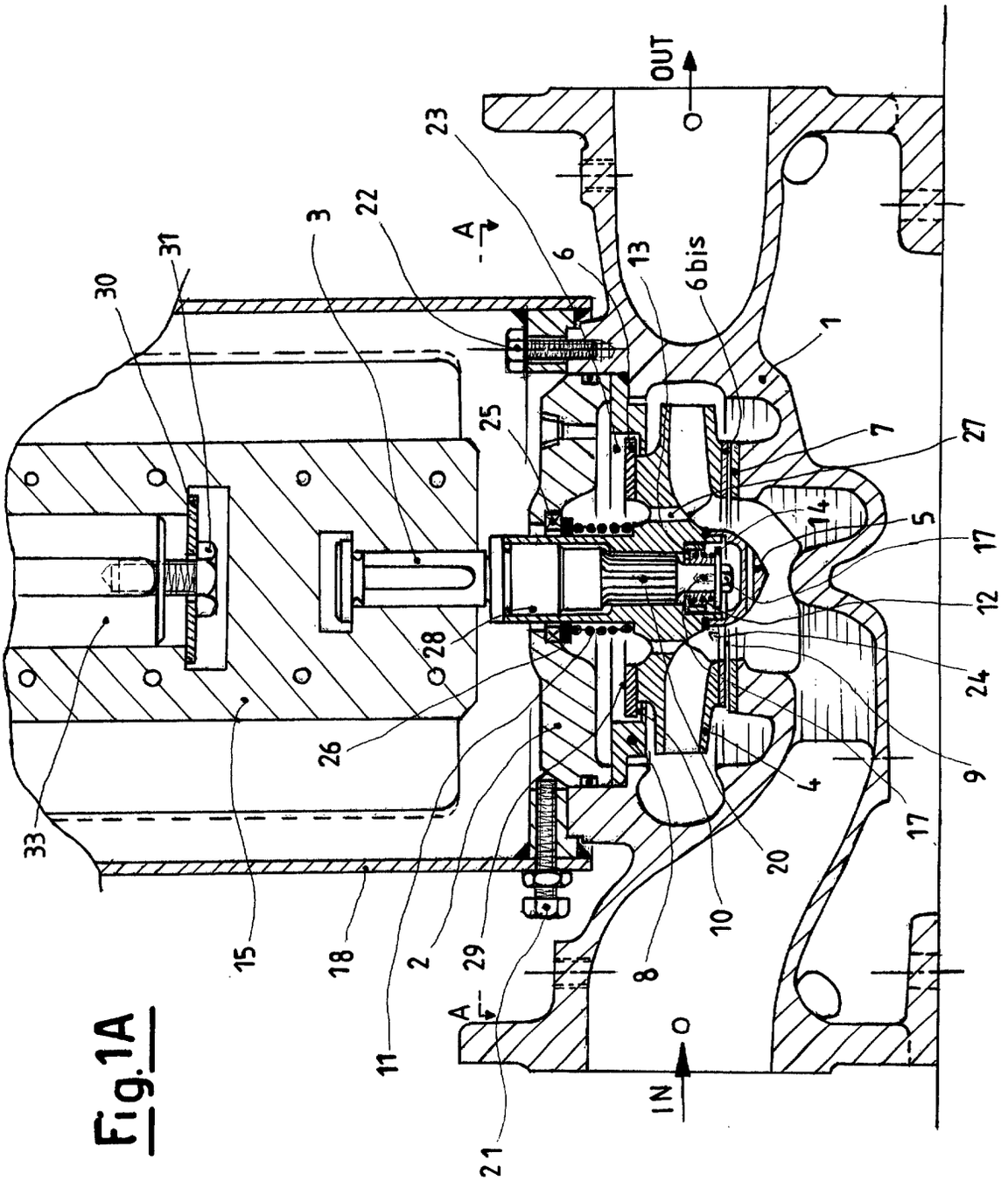
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Fig.1A

Fig.1B

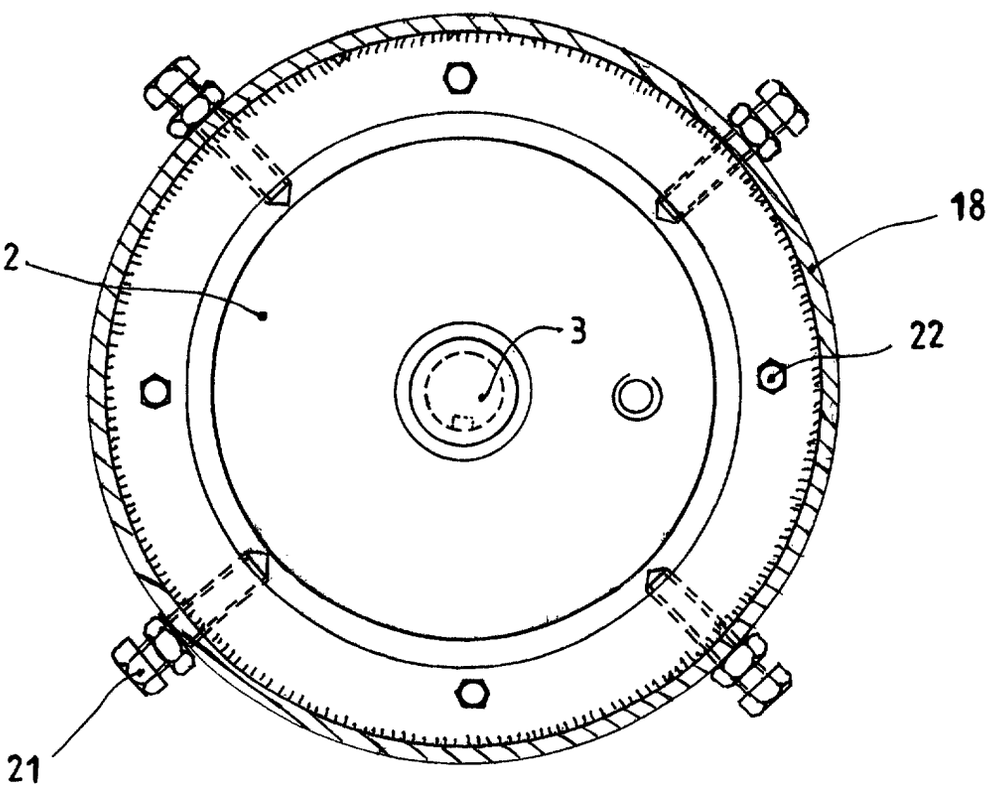


Fig.2

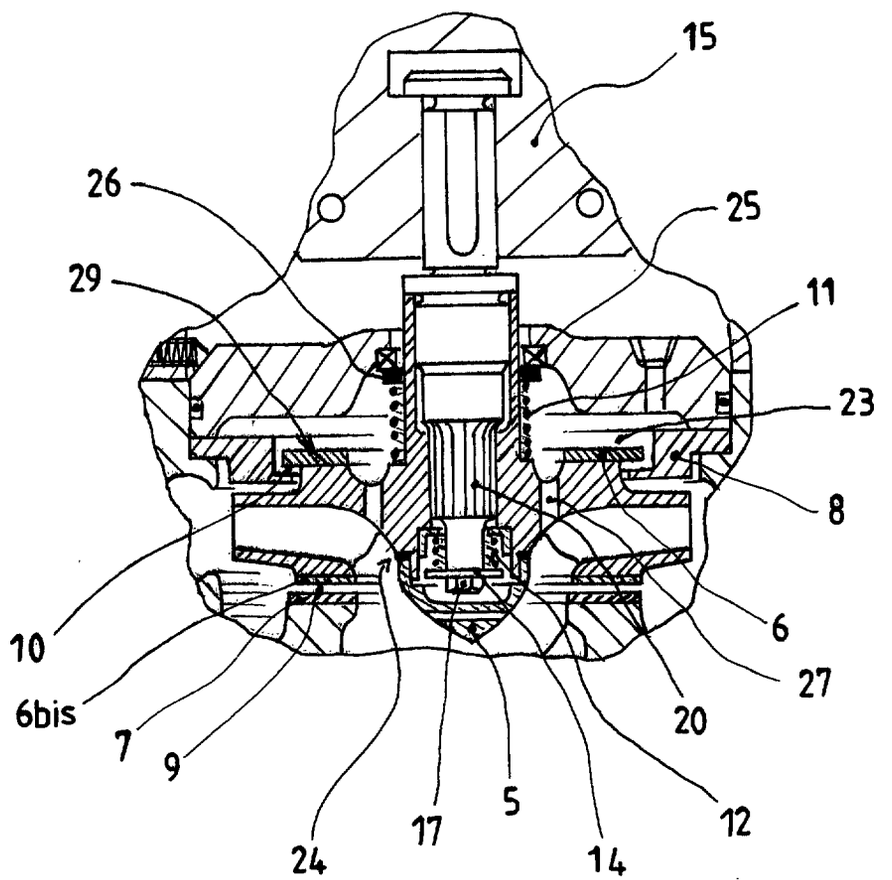
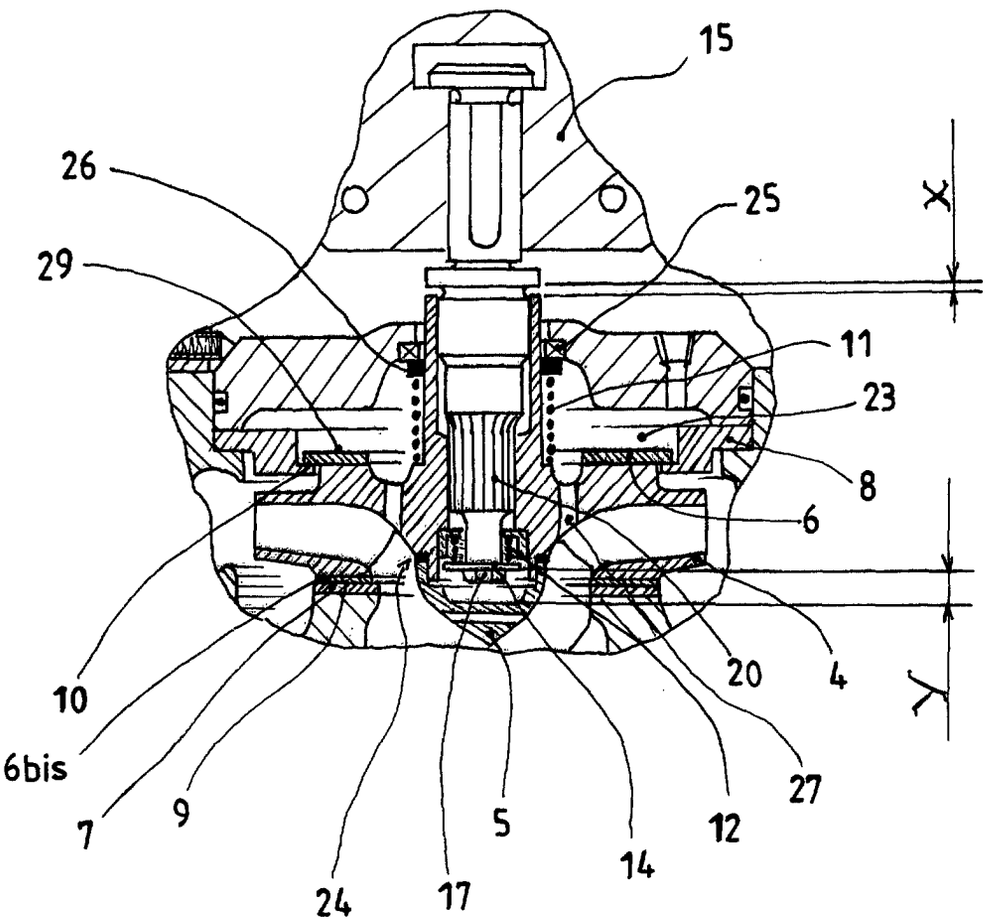


Fig.3



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Application Number
EP 02 07 6078

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| F04D |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| MUNICH | 14 August 2002 | Di Giorgio, F |

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14-08-2002

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