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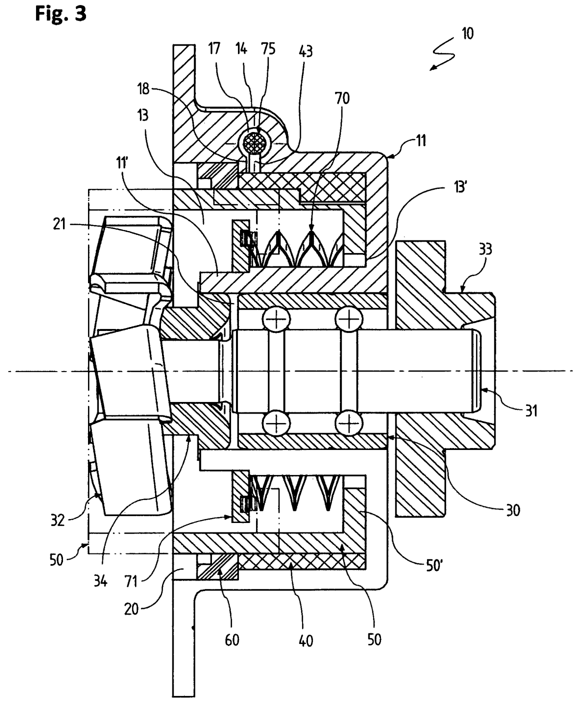
(54) **AN ADJUSTABLE CENTRIFUGAL PUMP WITH SHUTTER ACTUATED BY MEANS OF A ROTO-TRANSLATING SYSTEM OF INCLINED SURFACES**

(57) An adjustable centrifugal pump (10) comprising a flanged body (11) connectable to a volute with an appendage (14) suitable to house an actuator device, a crankshaft, an impeller (32), a cup-shaped shutter (50) suitable to slide axially and position itself on the outer perimeter of the impeller (32); with a rotor (40), rotatably and concentrically housed externally to said shutter (50), having inclined surfaces (42) acting in conjunction with further inclined surfaces (52) of the shutter (50), so that a rotation of said rotor (40), corresponds to a translation of said shutter (50).

Fig. 3




EP 2 902 631 A1

## Description

**[0001]** The present invention relates to an adjustable centrifugal pump with shutter actuated by means of a roto-translating system of inclined surfaces.

**[0002]** More in particular, the present invention relates to a radial, centrifugal turbo pump, applicable to reciprocating internal combustion engines, suitable to make a flow of coolant liquid circulate inside a coolant system and to choke said flow of liquid as far as preventing the circulation of liquid in said system.

**[0003]** It is known, in the sector of reciprocating internal combustion engines, generally for automotive use, that the energy dissipated as heat during combustion must be disposed of and dispersed into the environment in order to avoid extremely harmful consequences for the functioning and integrity of the engine and its relative members. During steady-state operating an internal combustion engine is kept at an ideal temperature, typically by means of a fluid cooling system inside which a coolant liquid circulates which subtracts heat from the engine, dissipating it through a heat exchanger (radiator) into the outside environment.

**[0004]** The circulation of coolant liquid inside the cooling system is generally ensured by a radial, centrifugal turbo pump. In the sector of reciprocating internal combustion engines for automotive applications, the coolant pump receives the motion directly from the engine, usually via a belt/pulley transmission and is thereby always in rotation therewith. During cold starting it is often undesirable for the coolant liquid to circulate in the cooling system since it prevents the engine from rapidly reaching operating temperature, resulting in increased fuel consumption and pollutant emissions, as well as limiting the immediate supply of engine performance.

**[0005]** It is also known in the state of the art to use means of regulating the flow of a pump cooling system, among which that of closing the outer peripheral part of the pump impeller with a cup-shaped shutter sliding in the axial direction, so as to restrict, as far as completely blocking, the flow of liquid in output from the delivery mouth of the pump.

**[0006]** Examples of embodiments of centrifugal turbo pumps adjustable by means of a shutter positioned on the impeller are described in the patent application EP 2 551 484 and in the patents EP 1 963 637**,** DE 10 2010 052996 and DE 10 2008 006451**.**

**[0007]** The patent application EP 2 551 484, in the name of the same applicant describes a radial turbo pump adjustable by means of a circular shutter driven axially by a multiplicity of pistons positioned in respective seats made in the pump casing and connected to a vacuum chamber using the vacuum created by the air intake of the engine. Said pistons use diaphragms as seals to isolate the vacuum part from the hydraulic part of the pump.

**[0008]** The patent EP 1 963 637 on behalf of Geräete & Pumpenbau GmbH [DE] also describes a regulation system for a centrifugal pump that uses a shutter driven by pistons. Said pistons move in respective seats made in the pump casing with sealing gaskets of the traditional type positioned towards the hydraulic part of the pump. Said pistons are driven by a system which uses the vacuum created by the engine.

**[0009]** The patent DE 102010052996, on behalf of BMW AG [DE]/TCG Unitech Systemtechnik GmbH [AT] describes a centrifugal pump adjustable by means of a shutter driven by a thermostatic actuator. The actuator, acting in a radial direction and tangentially to the shutter, gives the latter a rotational moment. The shutter is provided with spiral or ramp surfaces, made on the inner side of said shutter and on a fixed part placed centrally. The shutter is thus forced to rotate and simultaneously move in an axial direction so as to place itself in the working position on the impeller.

**[0010]** The patent DE 102008006451, on behalf of Audi AG [DE], describes a centrifugal pump adjustable by means of a shutter operable axially to the impeller by means of a screw or with spiral or ramp surfaces positioned on the shutter and on the casing of the pump. The shutter is moved by a generic actuator that places it in rotation, while the screw or ramp surfaces simultaneously make it translate.

**[0011]** However these types of centrifugal pumps adjustable by means of a circular shutter have drawbacks and operating limits.

**[0012]** A typical drawback of these adjustable pumps is that the adjustment performed by the actuation of a shutter requires a centrifugal pump with a constructionally more complex casing and with a greater number of components than a conventional centrifugal pump, with stricter dimensional tolerances and hence higher manufacturing costs.

**[0013]** A further drawback of these types of pumps, in particular those where the shutter is moved by pistons, is due to the fact that the multiple components which interact with the shutter must each have sealing means, both on the side of the hydraulic pump, and on the vacuum operation side, to avoid leakage and losses of fluid or air which could jeopardise the operation of the pump.

**[0014]** One drawback of pumps with shutters actuated by a screw or spiral or ramp surfaces system is that the shutter must simultaneously perform the movement of rotation and of advancement, a condition that can easily cause jamming and blockages of said shutter as well as rapid wear, and that the pump requires moving parts with strict dimensional tolerances, contact surfaces with low friction or lubricated.

**[0015]** A further drawback of the types of adjustable pumps mentioned above is that the translatory forward movement of the shutter is constant and cannot be accelerated or delayed as needed between the operating limit positions of the shutter.

**[0016]** The purpose of the present invention is to overcome the drawbacks mentioned above.

**[0017]** More in particular, the purpose of the present invention is to provide an adjustable centrifugal pump with shutter actuated by means of a roto-translating system of inclined surfaces which is simple to construct and composed of a reduced number of components.

**[0018]** A further purpose of the present invention is to provide an adjustable centrifugal pump with shutter actuated by means of a roto-translating system of inclined surfaces with a limited number of gaskets and sealing elements of the fluids.

**[0019]** A further purpose of the present invention is to provide an adjustable centrifugal pump with shutter actuated by means of a roto-translating system of inclined surfaces with smooth, regular functioning, without jamming or blockages and with a reduced implementation force.

**[0020]** A no less important purpose of the invention is to provide a centrifugal pump having a translation movement of said shutter variable according to the position of the shutter during the operating stroke.

**[0021]** Yet a further purpose of the present invention is to provide to users an adjustable centrifugal pump suitable to ensure a high level of resistance and reliability over time and such as to be easy and economical to produce.

**[0022]** These and other purposes are achieved by the adjustable centrifugal pump of the present invention according to the main claim.

**[0023]** The construction and functional characteristics of the adjustable centrifugal pump with shutter actuated by means of a roto-translating system of inclined surfaces will be more clearly comprehensible from the detailed description below in which reference is made to the appended drawings which show a preferred and non-limiting embodiment and wherein:

- figure 1a is an exploded, schematic, axonometric view partially in cross-section of the centrifugal pump which the present invention relates to;
- figure 1b is also an exploded, schematic, axonometric view partially in cross-section of the centrifugal pump which the present invention relates to;
- figure 2a is an exploded, schematic, axonometric view partially in cross-section of the centrifugal pump which the present invention relates to with the shutter in the rest position;
- figure 2b is an exploded, schematic, axonometric view partially in cross-section of the centrifugal pump which the present invention relates to with the shutter in the operating position;
- figure 3 is a schematic view in longitudinal cross-section of the centrifugal pump which the present invention relates to;
- figure 4 is a schematic axonometric view of the shutter;
- figure 5 is a schematic axonometric view of the rotor;

**[0024]** With initial reference to figures 1a to 3, the adjustable centrifugal pump globally denoted by reference numeral 10, comprises a body 11 having a cup shape, provided with a connection flange 12, placed on the open end facing the hydraulic part of the pump not shown, which comprises the volute and the relative suction and delivery mouths.

**[0025]** Said body 11 has a tubular central through portion 11' which, together with the inner cylindrical surface of said body 11, defines a toroidal shape chamber 13 with an open end and a bottom 13'.

**[0026]** With particular reference to figures 1b, 2a and 2b, on the outer diametrical surface of said body 11, a cylindrical, tubular appendage 14 closed at one end, is positioned tangentially and radially relative to the longitudinal direction, formed together with the body 11 and positioned in a tangential direction relative to the outer surface of said body 11. From the open end of said appendage 14 a circular diaphragm seat 15, a gasket seat 16 also circular in shape with relative shoulders and a blind hole 17 extend in order, in a radial direction relative to the body axis 11 and concentrically to one another. Said blind hole 17 has on its surface, in the radial direction towards the centre of the body 11, a slit 18 of a parallelepiped shape and made in said body 11, which connects said hole 17 to the chamber 13. The appendage 14 also has a connection hole 19 between the diaphragm seat 15 and the outside environment situated near the gasket seat 16 and in a radial direction to the axis of said appendage 14.

**[0027]** On the flanged end of the body 11, with reference to figure 3, a counterbore 20 is made concentrically to the chamber 13.

**[0028]** Again with particular reference to figure 3, the inner surface of the central tubular part 11' defines a housing 21 for a support 30, usually consisting of a sliding or rolling bearing, in which a rotary shaft 31 is rotatably positioned to which a bladed impeller 32 is fitted. The bottom 13' of the body 11 is further provided with known means for the stabilisation of a hub 33 for the connection between the shaft 31 and the kinematic transmission with the engine. On the key end of the shaft 31 with the impeller 32 a front insulation seal 34 between the hydraulic part of the pump and the housing 21 of the body 11 of the pump is also positioned and stabilised, in the same housing 21. With reference again to figures 1a to 3, at the outer diametrical surface of the chamber 13 of the body 11, a rotor 40 in contact with the inner surface of the bottom 13' is rotatably inserted. Said rotor 40, as shown in particular in figure 5, is composed of a cylindrical tubular body defining on its inner surface a plurality of equally spaced protrusions 41, generally but not exclusively of a triangular shape, extending for about half the length of the rotor and with a side adjacent to the outer end of the rotor 40 placed towards the bottom 13'. In the preferred embodiment, shown in the figures mentioned, said protrusions 41 have a straight triangular shape in which the sides define the outer walls which extend in a radial direction to the rotor axis 40. The surface defined by the hypotenuse of said triangular protrusion 41 defines an inclined surface 42 or ramp. Said surface decreases until the end of the rotor 40 in the direction of rotation of said rotor. In further embodiments the surface 42 may have a curvilinear extension with a concave or convex profile, involute or defined by a succession of lines or curves forming a cam.

**[0029]** On the outer surface of the rotor 40, near the end facing towards the flange 12, a cylindrical manoeuvring pin 43 is positioned with a hinging hole 43' positioned radially to the diameter of said pin 43 on its free end.

**[0030]** Again with reference to the figures, on the inner diametrical surface of the rotor 40, and concentrically to the chamber 13 of the body 11, a shutter 50 having a cup shape, is slidingly positioned with a perforated bottom 50' inserted at the central tubular part 11' of the body 11 housed inside the chamber 13 with the outer surface of the perforated bottom 50' in contact with the bottom 13'. On the outer diametrical surface of said shutter 50, as shown in particular in figure 4, a plurality of equally spaced out cavities 51 are defined, of a homologous triangular shape and coupled to the protrusions 41 of the rotor 40. Said cavities 51 extend for about a third of the length of the shutter 50 and have an open side on the outer wall of the perforated bottom 50'.

**[0031]** Again with regard to the preferred embodiment, shown in the figures mentioned, the cavities 51 have, similarly to the protrusions 41, a straight triangular shape in which two sides define the inner walls of said cavities 51 which extend in a radial direction to the shutter axis 40. The surface defined by the hypotenuse of said cavity 51 defines an inclined surface 52 or ramp. Said inclined surface 52 decrease until the open end of the cavity 51 along the circumference of rotation of said rotor 40. In further embodiments, similarly to the inclined surfaces 41, the surface 52 may have a concave or convex curvilinear extension, involute or a succession of lines or curves forming a cam. Said cavities 51 of the shutter 50 are arranged so as to contain the protrusions 41 of the rotor 40, with the inclined surfaces 42 in contact and slidingly cooperating with the inclined surfaces 52 of said shutter.

**[0032]** On the outer surface of the shutter 50 a multiplicity of linear guide grooves 53 are also made extending in the axial direction from the open end of the shutter up to about half of its length.

**[0033]** In further embodiments the inclined surfaces 42 and 52, shown in detail in figures 4 and 5, may be made of different materials from those of the rotor 40 and the shutter 50, having a low coefficient of friction, and applied by means of known surface deposition methods or by means of inserts applied by means of attachment elements, braze welding, gluing or co-moulding to said rotor 40 and shutter 50. With particular reference to figure 3, the rotor 40, rotatably positioned in the body 11, is held in position by a locking ring 60 of a cylindrical shape firmly fixed in the body 11, with known locking means such as threads or by mechanical interference, at the counterbore 20.

**[0034]** With particular reference to figure 1b,a plurality of guide pins 61 which extend radially and are suitable to fit into the guide grooves 53 of the shutter 50 are placed on the inner diametrical surface of said locking ring 60.

**[0035]** As shown with reference to figure 3, the shutter 50 is held in the rest position with the perforated bottom 50 'in contact with the bottom 13' of the chamber 13 by a spring 70, inserted in and surrounding the central tubular portion 11' of the body 11. Said spring 70 pushes said shutter 50 towards the bottom 13' of the body 11 at the inner surface of the perforated bottom 50' and is further held in place by a disc-shaped support ring 71, securely attached to the body 11, at the central tubular portion 11', with known attachment means. Said known attachment means, not shown, are generally constituted by threads made on the inner diameter of the support ring 71 and the outside diameter of the central tubular part 11' or may be made through forcing or caulking of the same.

**[0036]** With reference to figures 1b, 2a and 2b, inside the blind hole 17 of the appendage 14, a stem 75 of a cylindrical shape is slidingly inserted with a head 75' acting in conjunction with a diaphragm 76, having the shape of a circular cup open at the bottom with a hole 76' and with an outer circular portion forming an edge 76" generally having a toroidal, *O-ring* shape.

**[0037]** Said diaphragm 76 is inserted inside the diaphragm seat 15 of the appendage 14 with the stem 75 passing through the hole 76' and the head 75' of the stem positioned at the cup-shaped bottom of said diaphragm 76. The stem 75 is connected with a hinge to the manoeuvring pin 43 of the rotor 40 at the hole 43'. Said manoeuvring pin 43 is slidingly inserted inside the slit 18 and engages the stem 75 in the blind hole 17, moving linearly on a section of outer circumference of the chamber 13.

**[0038]** The tightness of the inner part of the pump 10 between the stem 75 and the blind hole 17 is ensured by a ring-shaped gasket 77 positioned in the seal seat 16. The open top of the appendage 14 is closed by a circular cup-shaped cap 78, with a hole 78' for connection to a fluid system, so as to form a chamber 80 defined by the inner surfaces of the diaphragm 76 and the cap 78.

**[0039]** In further embodiments the actuation system of the stem may also be made from a mechanical or electrical or electromechanical device. The functioning of the adjustable centrifugal pump 10 of the invention with a shutter actuated by means of a roto-translating system of inclined surfaces and described below may be inferred from the description of its constituent parts.

**[0040]** With reference to the preferred embodiment shown in figures 1a to 3, the impeller 34 of the pump 10 is always in rotation, as connected to the shaft 31 driven directly by the motor from the connection side of the hub 33.

**[0041]** The body 11 of the pump is connected from the flange side 12 to a volute (not shown) provided with the relative connection outlets to the cooling system of the engine. When starting said motor, as shown in the configuration in figure 2a, a vacuum is created in the chamber 80 through the hole 78', while the air pressure entering from the connection hole 19, pushes the diaphragm 76, and with it the head 75' of the stem 75, making the latter slide in an outgoing direction from the blind hole 17, as shown in Figure 2b.

**[0042]** The stem 75, connected to the manoeuvring pin 43 of the rotor 40, imparts to said rotor 40 a rotational torque that makes it rotate inside the chamber 13 of the body 11. The rotor 40, rotating, engages the protrusions 41 with the cavities 51 of the shutter 50 through the inclined surfaces 42 which co-operate sliding on the inclined surfaces 52 of the shutter 50.

**[0043]** The inclined surfaces 42 of the rotor 40 opposite the inclined surfaces 52 of the shutter tend to pull the shutter 50 in rotation together with the rotor 40. The guide pins 61 of the locking ring 60, being inserted in the grooves 53 of the shutter 50, prevent said shutter 50 from rotating together with the rotor 40, allowing it only the movement of axial translation. The shutter 50, translating, moves into position to cover the outer periphery of the impeller 32 (dotted line in figure 3) restricting the flow of liquid in output from the pump as far as blocking it entirely when the shutter 50 has completely closed the passage in the volute, as shown in the configuration in figure 2b.

**[0044]** During the movement, with reference to figure 3, the shutter 50 compresses the spring 70 pushing it against the support ring 71 at the perforated bottom 50'. When the shutter 50 completes its operative stroke, as far as the limit position on the impeller 32, the spring 70 reaches the maximum state of compression ensuring the return of the shutter to the rest position when the stem 75 is no longer driven by the vacuum of the chamber 80. In this condition the spring 70 pushes the shutter 50 at the perforated bottom 50'. The shutter 50 translates in the opposite direction to the actuation direction guided by the guide pins 61 inserted in the grooves 53, and the inclined surfaces 52, slidingly placed in contrast with the surfaces 42 of the rotor, place said rotor in rotation in the opposite direction to the actuation direction. The pump can resume the configuration of figure 2a, since the roto-translating system of inclined surfaces of the rotor 40 and the shutter 50 is a reversible system.

**[0045]** In further embodiments the stem 75 can be moved by any mechanical, pneumatic, hydraulic, magnetic, electrical or electromechanical device capable of driving said stem in both directions. In the case of the stem 75 being driven in one direction only, the spring 70 creates a "fail safe" safety device so that, where the drive does not return the stem 75 to the rest position, the shutter 50 does not in any case remain positioned on the impeller 32 preventing the circulation of the coolant fluid with consequent damage to the engine.

**[0046]** In further embodiments where the inclined surfaces 42 of the rotor 40 and 52 of the shutter 50 (with particular reference to figures 3 and 4) may have a curvilinear shape with concave or convex, involute or cam extensions, a law of movement of the shutter 50 may be defined depending on its position, with a movement defined by the shape of the inclined surfaces 42 and 52 cooperating with each other. The shutter 50 may thus move more rapidly in the starting phase and more slowly when it is close to the operating position, allowing a regulation of the flow depending on the desired characteristics.

**[0047]** In addition, the inclined surfaces 42 and 52, thanks to the materials with a low coefficient of friction applied to the rotor 40 and the shutter 50, guarantee smooth and regular functioning even with surfaces having a complex shape.

**[0048]** As may be seen from the above, the advantages which the adjustable centrifugal pump with a shutter actuated by means of a roto-translating system of inclined surfaces according to the present invention achieves are evident.

**[0049]** The adjustable centrifugal pump of the present invention is particularly advantageous in that the rotor 40, being positioned outside the shutter 50, allows the actuation device of the stem 75 to have a lever arm of greater length, permitting the movement of said shutter 50 with little force.

**[0050]** A further advantage is that the rotor 40, completely enveloping the outer diametrical surface of the shutter 50 during its rotation, permits a favourable distribution of the rotational torque on the inclined surfaces 52 of the latter, which can slide only in the axial direction with a smooth movement and without jamming or blockages.

**[0051]** Additionally advantageous is the concentric arrangement of the shutter 50 and the rotor 40 in the body 11 which permits the realisation of a pump which is compact in size, easy and cheap to produce, with a limited number of components and with a limited number of seals and insulation gaskets between the hydraulic part of the pump and the outside.

**[0052]** Additionally advantageous is the fact of being able to define a curvilinear or cam conformation of the inclined surfaces 42 and 52 which makes it possible allow to adapt the pump to different cooling systems, allowing the shutter 50 a variable movement along its stroke which permits the regulation of the flow of fluid according to the desired characteristics.

**[0053]** Despite the invention having been described above with particular reference to a preferred embodiment, made solely by way of a non-limiting example, numerous modifications and variants will appear evident to a person skilled in the art in the light of the above description. The present invention therefore sets out to embrace all the modifications and variants which fall within the sphere and scope of the following claims.

## Claims

1. An adjustable centrifugal pump (10) comprising:

    - a body (11) connected by means of a flange (12) to a volute and defining an inner chamber (13) of a toroidal shape and further defining a central tubular portion (11') with a housing (21);
    - an appendage (14) having a cylindrical form closed at one end, radially and tangentially positioned on the outer diametrical surface of said body 11 and suitable to slidingly house in a gasket (77) the stem (75) of an actuation device;
    - a shaft (31) rotatably positioned inside said housing (21) by means of a support (30) of a hub (33) placed on the kinematic connection end and of a front seal (34) placed on the free key end;
    - an impeller (32) cantilever-fitted onto the free end of said shaft (31);
    - a cup-shaped shutter (50) with a perforated bottom (50') slidingly positioned along the rotation axis between the two limit positions and suitable to place itself on the outer periphery of said impeller (32);

    **characterised in that**, between the outer diametrical surface of said chamber (13) of the body (11) and the outer diametrical surface of said shutter (50), a rotor (40) of a cylindrical tubular shape is rotatably positioned, on the inner diametrical surface of which at least one inclined surface (42) is radially positioned, slidingly cooperating on at least one inclined surface (52), radially positioned on the outer diametrical surface of the shutter (50) so that a rotation of said rotor (40), corresponds to a translation of said shutter (50).

2. The adjustable centrifugal pump (10) according to claim 1, **characterised in that** said at least one inclined surface (42) is made on the peripheral wall of a protrusion (41) positioned on the inner diametrical surface of said rotor (40).

3. The adjustable centrifugal pump (10) according to claim 1, **characterised in that** said at least one inclined surface (52) is made on the peripheral wall of a cavity (51) positioned on the outer diametrical surface of said shutter (50).

4. The adjustable centrifugal pump (10) according to claim 3, **characterised in that** said shutter (50) has on its outer diametrical surface at least one longitudinal groove (53), extending in the axial direction to said shutter (50).

5. The adjustable centrifugal pump (10) according to claim 1, **characterised in that** said rotor (40) is rotatably stabilised in the axial direction inside the chamber (13) by a locking ring (60) with at least one guide pin (61) of a cylindrical shape, extending radially on the inner diametrical surface of said locking ring (60), said guide pin (61) being inserted in said at least one groove (53) of the shutter (50).

6. The adjustable centrifugal pump (10) according to claim 5, **characterised in that** said at least one guide pin (61) is positioned on the outer diametrical surface of the chamber (13) or on the diametrical surface of a counterbore (20) made on the body (11).

7. The adjustable centrifugal pump (10) according to claim 1, **characterised in that** said rotor (40) comprises, positioned on its outer diametrical surface in the radial direction, a manoeuvring pin (43) suitable to be hinged to the stem (75) of an actuation device.

8. The adjustable centrifugal pump (10) according to claim 7, **characterised in that** said manoeuvring pin (43) is slidingly manoeuvrable along a portion of circumference external to the chamber (13) by means of a connection slit (18) between said chamber (13) and the outside of the body (11), said pin being rotationally hinged to the stem (75), said stem being slidingly positioned in the radial and tangential direction to said rotor (40).

9. The adjustable centrifugal pump (10) according to claim 1, **characterised in that** said rotor (40) and said shutter (50) are made of metal or plastic polymer.

10. The adjustable centrifugal pump (10) according to claims 2 and 3, **characterised in that** said inclined surfaces (42) and (52), made on the walls of the protrusions (41) and of the cavities (51), are made of material having a different friction coefficient from that of the rotor (40) and the shutter (50).

11. The adjustable centrifugal pump (10) according to claim 10, **characterised in that** said inclined surfaces (42) and (52) are made of material deposited on said protrusions (41) and said cavities (51).

12. The adjustable centrifugal pump (10) according to claim 10, **characterised in that** said inclined surfaces (42) and (52) are made by means of inserts applied to said protrusions (41) and said cavities (51).

13. The adjustable centrifugal pump (10) according to claims 2 and 3, **characterised in that** said inclined surfaces (42) and (52), made on the walls of the protrusions (41) and the cavities (51), have a planar extension.

14. The adjustable centrifugal pump (10) according to

claims 2 and 3, **characterised in that** said inclined surfaces (42) and (52), made on the walls of the protrusions (41) and the cavities (51), have a concave or convex or involute curvilinear extension.

**15.** The adjustable centrifugal pump (10) according to claims 2 and 3, **characterised in that** said inclined surfaces (42) and (52), made on the walls of the protrusions (41) and the cavities (51), have a cam extension.

**16.** The adjustable centrifugal pump (10) according to claim 1, **characterised in that** the stem (75) is actuated by an actuator of the fluidic, mechanical, electromagnetic or electromechanical type.

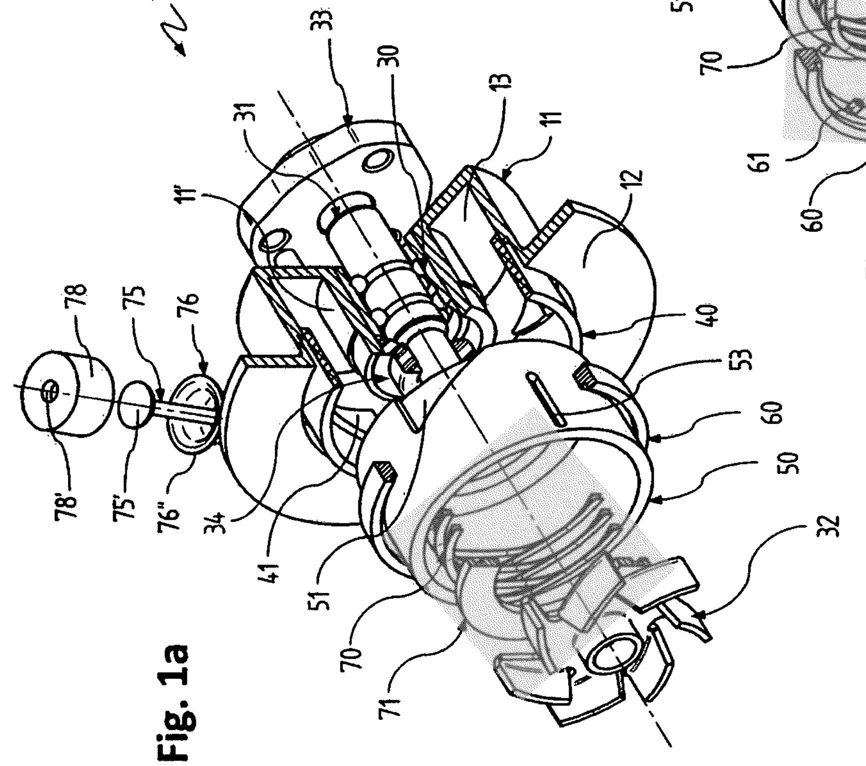

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Fig. 1a

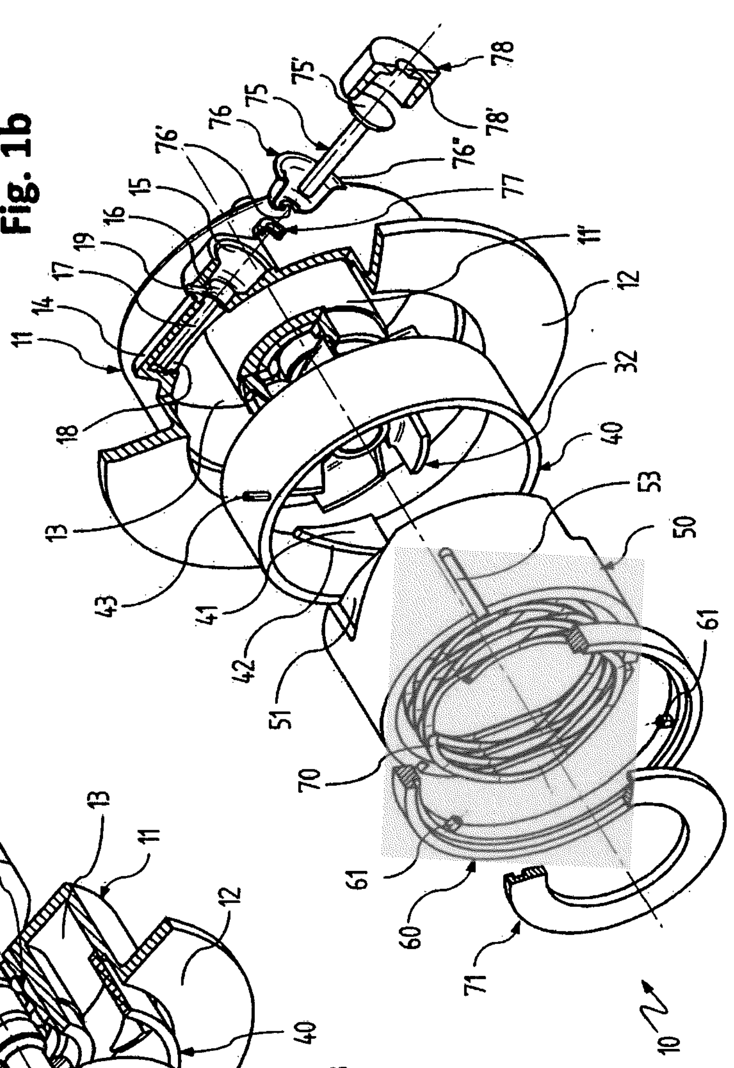
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Fig. 1b

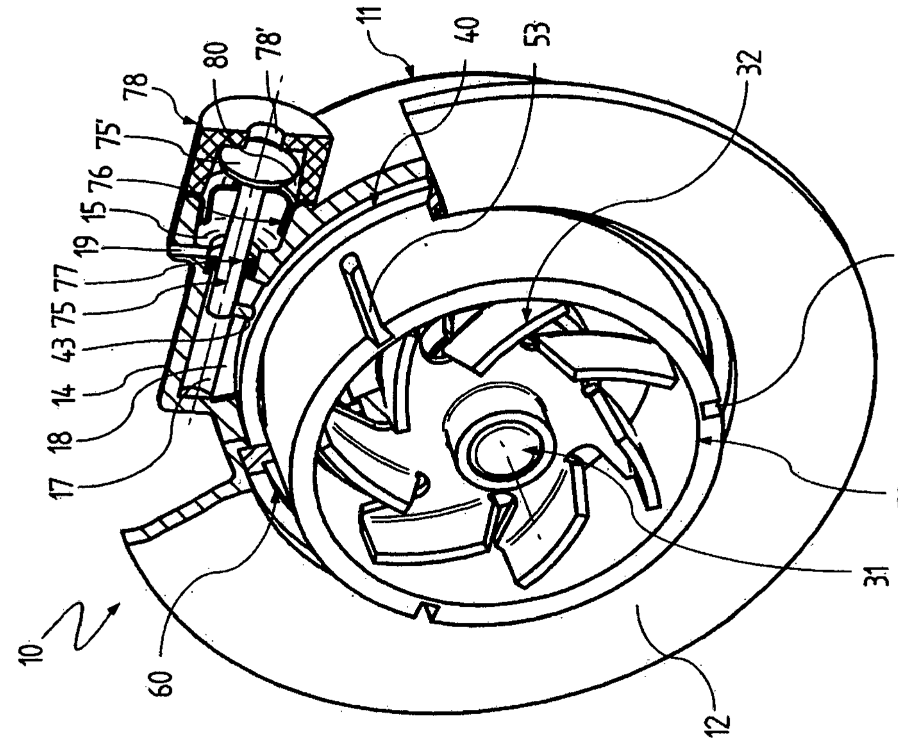
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Fig. 2b

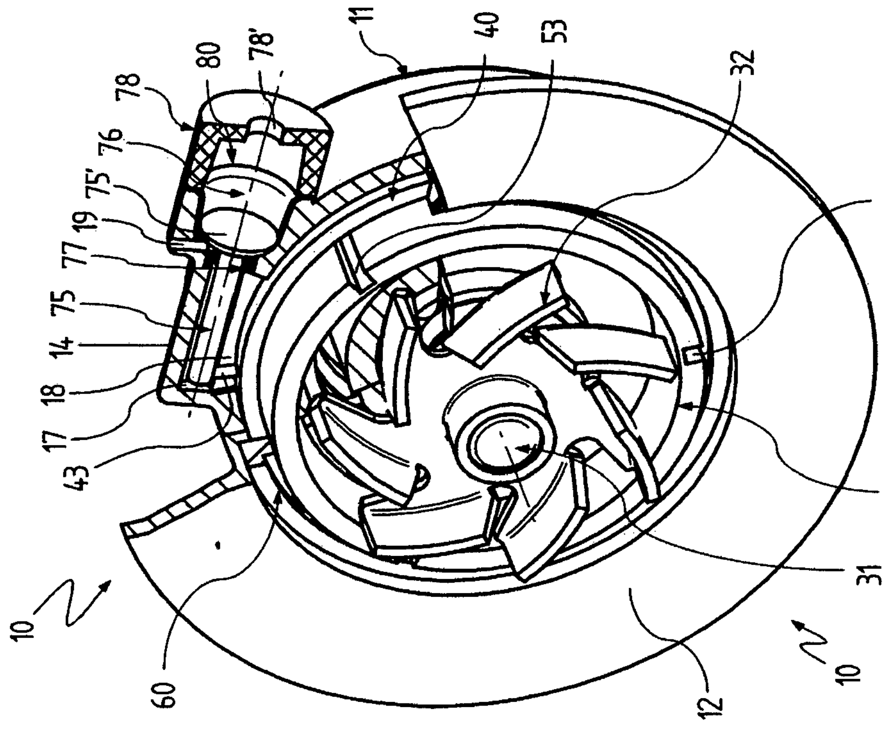
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Fig. 2a

**Fig. 3**

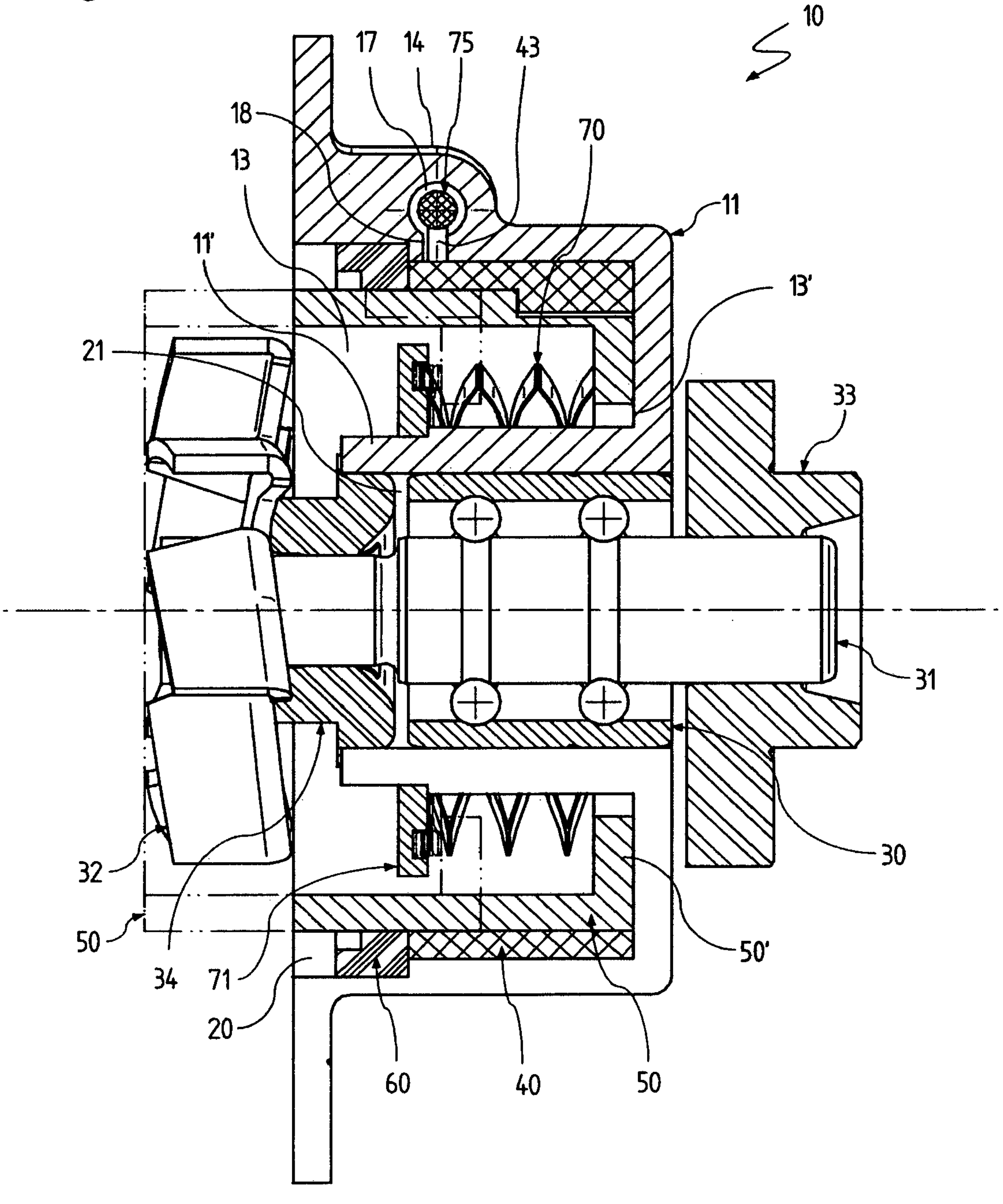

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Fig. 5

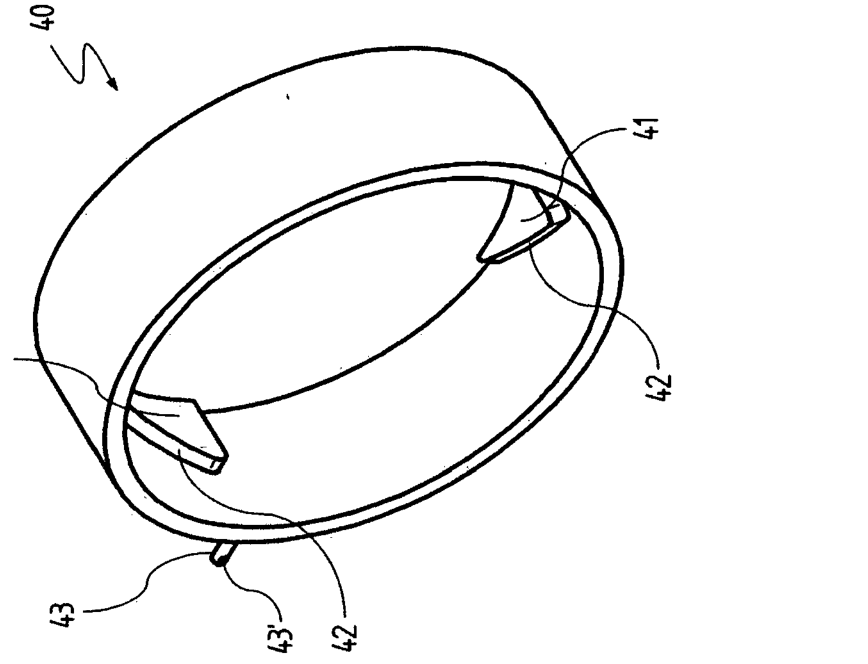
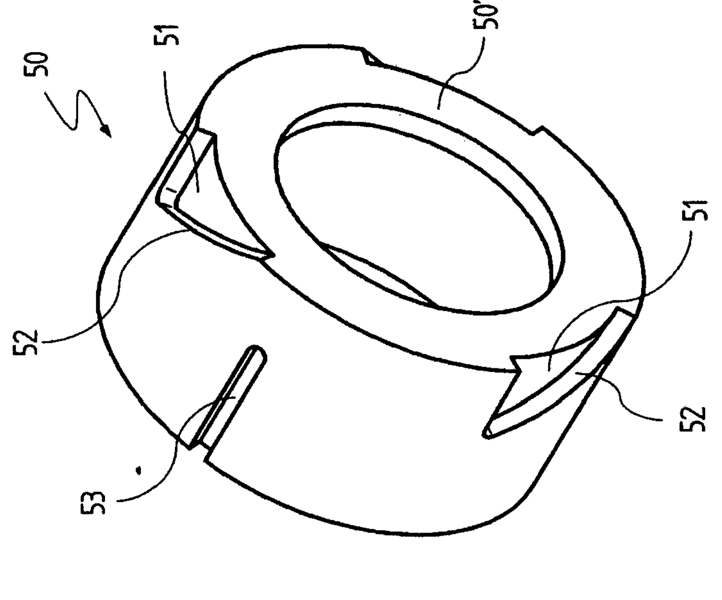



Fig. 4



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# EUROPEAN SEARCH REPORT

Application Number
EP 15 00 0548

## 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 | DE 10 2008 059462 A1 (TCG UNITECH SYSTEMTECHNIK GMBH [AT]) 4 June 2009 (2009-06-04) * the whole document * * figures 1,2 * ----- | 1-16 | INV. F04D15/00 |
| A,D | DE 10 2008 006451 A1 (AUDI NSU AUTO UNION AG [DE]) 30 July 2009 (2009-07-30) * the whole document * * figure 3 * ----- | 1-16 | |

TECHNICAL FIELDS SEARCHED (IPC)
F04D

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 23 June 2015 | Ingelbrecht, Peter |

1

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 00 0548

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23-06-2015

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| DE 102008059462 A1 | 04-06-2009 | AT 506107 A1 | 15-06-2009 |
| | | DE 102008059462 A1 | 04-06-2009 |
| DE 102008006451 A1 | 30-07-2009 | NONE | |

EPO FORM P0459

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### Patent documents cited in the description


- EP 2551484 A **[0006] [0007]**
- EP 1963637 A **[0006] [0008]**
- DE 102010052996 **[0006] [0009]**
- DE 102008006451 **[0006] [0010]**