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(71) Applicant: **Nylænde, Harald**  
**1702 Sarpsborg (NO)**

(72) Inventor: **Nylænde, Harald**  
**1702 Sarpsborg (NO)**

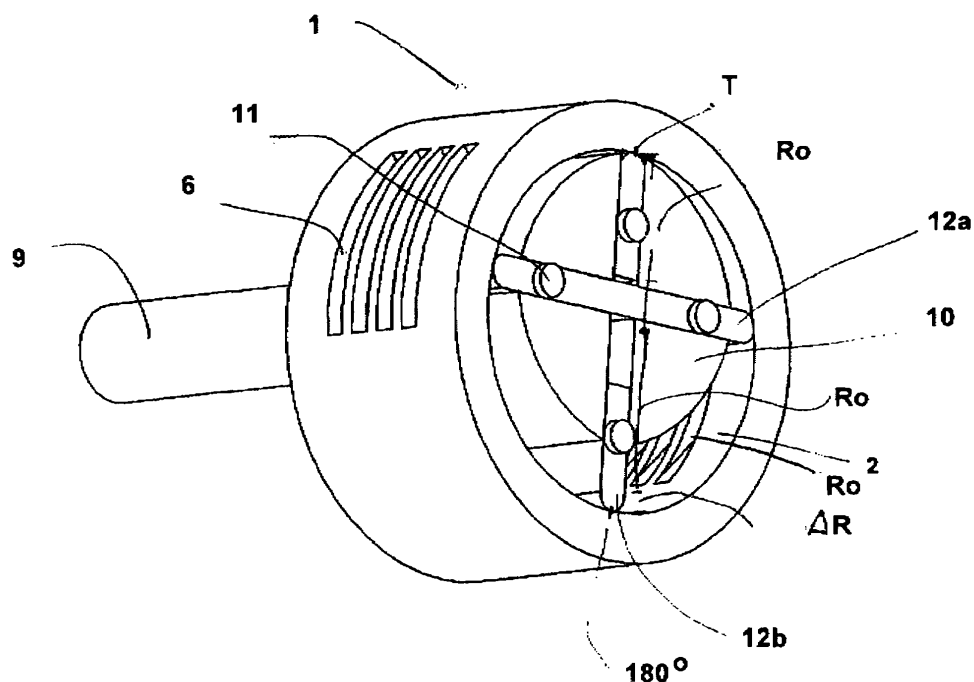
(74) Representative: **Fluge, Per Roald**  
**c/o Fluges patent as,**  
**Postboks 27**  
**1629 Gamle Fredrikstad (NO)**

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(54) **Vane pump**

(57) Pump with a rotor (10) comprising one or more vanes (12a, 12b, ...), wherein each vane (12a, 12b, ...) is arranged to run each in a corresponding diametrical slot (141, 142 ...) in the rotor (10), each vane (12a, 12b, ...) extends from an end edge (17a1, 17b1, ...) to the opposite end edge (17a2, 17b2 ...) substantially across the entire inner diameter ( $\emptyset$ ) of the rotor housing, between two opposite sides of the inner wall surface (2)

for all rotation angles of the rotor (10), and wherein the cross-section of the cylindrical rotor housing (1) is non circular with a radius (R) from the center of the rotor (10) to the inner wall surface (2), increasing from a base radius ( $R_0$ ) with a given rate ( $\Delta R$ ) per arclength counted from a top point (T) to 180 degrees-from the top point (T), and decreases with an equivalent rate continuously for the increasing arclength further to the top point (T).



**Fig. 1**

## Description

**[0001]** The invention relates to a pump for pumping of the majority of pumpable substances/medium by the use of rotatable vanes in a pump housing. The medium to be pumped may be in pure state or in a mix of more substances and more aggregate phases such as solids particles, liquids and gaseous matter.

**[0002]** Known problems related to pumps are abrasion and cavity inside the pump housing as well as loss of pump efficiency if an interruption in the supply of the pumped matter should occur.

## Prior art

**[0003]** WO90/14518A1 relates to a rotary machine with wings extending from a rotor. The pump housing is shaped as half of a cylinder and the rotor is eccentric mounted with its axis outside the center of the pump housing. A number of wings extend from an axle in the rotor towards the inner wall surface of the housing. To force the motion of the wings the wings have guiding pins fitting in guiding slots in the end wall of the rotary machine. US2443994A cover a rotary machine as well, with wings with guiding pins. The pump housing is circular and the rotor is mounted with its axis outside the center of the pump housing. The wings extend from an axis core to the inner wall surface of the pump housing. The forced motion of the wings results in continuous contact with the pump housing.

DE3108819A1 cover a similar rotary machine with a circular housing, wings which have a minor extend than the radius of the pump housing, forced motioned by guiding grooves or magnetism. GB262344A relates to a rotary machine comprising a circular or oval shaped pump housing and a number of wings forced motioned by a piston- or a spring arrangement in such way that continuous contact to the pump housing is achieved.

**[0004]** Common to all off those are that they comprise pump vanes or wings that have an extend minor to the radius of the pump housing. The pumps also consist of numerous amounts of movable components.

**[0005]** GB1013801A shows a rotary pump with at least two vanes with limited movement in an axle with a slot. In addition the pump is provided with a rotating sleeve with apertures.

US2495771A describes a rotary pump with vanes in pump housing, shaped out of roundness with four different radii. The vanes are installed in a way that they may oscillate in a rotor which is eccentric placed. The extent of the vanes is minor to the largest diameter inside the pump housing. The radius of the rotor body is identical to one of the radii in one of the sectors of the pump housing and so forming a sealing zone with a rather long contact area. Parting in such sectors as described in US2495771A may induce undesired high noise and wear inside the pump as well as an uneven flow of the pumped medium. The pressure rise at the discharge side of the

pump will lead to a slight movement of the rotor, and wear damages at diametrical opposite side of the pump housing will occur. The rotor may be slowed down and heat will be generated, and in worst case the rotor will stop completely. US2352941A and GB534510 describes a rotary pump with vanes in an pump housing out of roundness. The vanes are arranged to oscillate in an eccentric installed rotor. The radius of the rotor body is in at least a sector of the pump housing identical to the radius of the pump housing and forms a sealing zone. The pump housing may have different embodiments with different unround forms, formed by two different radii, or by varying radii as in an Archimedes spiral. Within a sector of the pump housing the radius of the rotor body is identical to the radius of the housing and thus forms a sealing zone by the contact area between the rotor and the inner wall surface in the housing.

The rotary pumps described in US2352941A and GB534510 are improvements of the pump described in US2495771A in such a way that the transition points between two radii which could cause noise and uneven flow of the pumped matter are reduced, but the design with the contact between the rotor and the housing in a specific sector will still give the same risk as above. The pressure rise at the discharge side of the pump will lead to a slight movement of the rotor and wear damages at diametrical opposite side of the pump housing will occur. The rotor may be slowed down and heat will be generated, and in a worst case the rotor will stop completely. WO97/04216A1 describes a rotary machine for a motor or a pump with two vanes which extend fully across the diameter of a uncircular pump housing. The internal form of the housing is formed by to sectors with constant radius connected by two sectors with varying radius the. The sector with the minor radius, has the same radius as the radius of the axle body, and forms a sealing zone.

The rotary machine described in WO97/04216A1 may cause undesired noise and abrasion in the rotary machine, and uneven flow of the pumped/driving matter. The pressure rise at the discharge side of the pump will lead to a slight movement of the rotor and wear damages at diametrical opposite side of the pump housing will occur. The rotor may be slowed down and heat will be generated, and in a worst case the rotor will stop completely.

## Short summary

**[0006]** The present invention is a pump with a rotor (10) comprising one or more vanes (12a, 12b, ...) arranged for running with edges (17a1, 17a2, 17b1, 17b2, ...) against a plain inner wall surface (2) in their full axial extent in a rotor housing (1) with a bottom wall (15) and a cap (16) and further arranged with an inlet (7) and an outlet (6), wherein the rotor (10) is arranged on an axle (9) mainly eccentrically placed related to the inner wall surface (2) of the rotor housing (1), wherein each vane (12a, 12b, ...) is arranged to run each in a corresponding diametrical slot (141, 142 ...) in the rotor (10),

that each vane (12a, 12b, ...) extend from an end's edge (17a1, 17b1, ...) to the opposite end's edge (17a2, 17b2 ...) substantially across the whole inner diameter ( $\emptyset$ ) of the rotor housing, between two opposite sides of the inner wall surface (2) for all rotation angles of the rotor (10), and wherein the cross-section of the cylindrical rotor housing (1) is non circular with a radius (R) from the center of the rotor (10) to the inner wall surface (2) increasing from a base radius ( $R_0$ ) with a given rate ( $\Delta R$ ) per arclength counted from a top point (T) to 180 degrees from the top point (T), and decreases with an equivalent rate continuously for the increasing arclength further to the top point (T). Advantageous embodiments of the invention are shown by the dependent claims.

#### Short figure caption

#### [0007]

Fig. 1 shows in a perspective view a sketch of a pump housing according to the invention with a shaft and slots for vanes and two vanes.

Fig. 2a is a frontal view of a vane with guiding pins and recesses.

Fig. 2b shows a vane in perspective view.

Fig. 2c shows two vanes in internal engagement.

Fig. 2d shows two vanes internal engaged within the slots in the rotor.

Fig. 3 is an end view of the rotor housing according to the invention, with guiding tracks for the guiding fins and hole for the shaft, and a perspective view of an empty housing without any rotor, shaft nor vanes.

Fig. 4a is an end view of a rotor according to the invention with diametric slots for the vanes.

Fig. 4b is a side elevation view of the rotor with a shaft and a diametrically arranged slot.

Fig. 4c is a perspective view of the rotor with a shaft and diametrically slots.

Fig. 5 is a perspective view of a cap according to the invention with guiding tracks.

Fig. 6 is a longitudinal section view of an embodiment of the invention, cut through the rotor shaft, the housing and the vane connected in the guiding tracks. Note that the cap is not shown.

Fig. 7 is a perspective view of manifolds for inlet and outlet for an embodiment of the invention.

#### Componentslist

#### [0008]

- |    |                                                                                             |
|----|---------------------------------------------------------------------------------------------|
| 5  | 1- Housing                                                                                  |
|    | 2- Inner surface wall                                                                       |
|    | 3- Outer surface of guiding track                                                           |
|    | 4- Inner surface of guiding track                                                           |
|    | 5- Hole for the rotor shaft (9)                                                             |
| 10 | 6- Outlet for the pumped medium                                                             |
|    | 7- Inlet for the pumped medium                                                              |
|    | 8- Guiding tracks in the bottom (15) and the cap (16) wherein the vanes are forced motioned |
|    | 9- Rotor shaft                                                                              |
| 15 | 10- Rotor with slots (14a, 14b...)                                                          |
|    | 11- Guiding pins at the vanes                                                               |
|    | 12a, 12b... Vanes                                                                           |
|    | 13a, 13b... Recess                                                                          |
|    | 141, 142... Slots for the vanes in the rotor                                                |
| 20 | 15- Bottom plate                                                                            |
|    | 16- Cap                                                                                     |
|    | 17a1, 17a2, 17b1, 17b2 ... End's edge                                                       |

#### Embodiments of the invention

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[0009] An embodiment of the invention comprise a pump with a rotor (10) comprising one or more vanes (12a, 12b, ...) arranged for running with edges (17a1, 17a2, 17b1, 17b2, ...) against a plain inner wall surface (2) in their full axial extent in a rotor housing, (1) with a bottom wall (15) and a cap (16) and further arranged with an inlet (7) and an outlet (6), wherein the rotor (10) is arranged on an axle (9) mainly eccentrically placed related to the inner wall surface (2) of the rotor housing (1), wherein the new and characteristic features are that each vane (12a, 12b, ...) is arranged to run each in a corresponding diametrical slot (141, 142 ...) in the rotor (10), that each vane (12a, 12b, ...) extend from an end's edge (17a1, 17b1, ...) to the opposite end's edge (17a2, 17b2 ...) substantially across the entire inner diameter ( $\emptyset$ ) of the rotor housing, between two opposite sides of the inner wall surface (2) for all rotation angles of the rotor (10), and wherein the cross-section of the cylindrical rotor housing (1) is non circular with a radius (R) from the center of the rotor (10) to the inner wall surface (2), increasing from a base radius ( $R_0$ ) with a given rate ( $\Delta R$ ) per arclength counted from a top point (T) to 180 degrees from the top point (T), and decreases with an equivalent rate continuously for the increasing arclength further to the top point (T). There might be one, two or more vanes. In the figures there are illustrated two vane plates in the rotor. The vanes are preferably stiff plates. An advantage with this design of a rotary pump is that the vanes, which are the pumping vanes, extend over approximately the entire diameter of the pump housing, regardless of the rotary position of the vanes. For the pump according to the invention the vanes provide for the necessary sealing to prevent backflow of the pumped

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medium, see Fig. 1. Due to the design of the pump according to the invention one will have few movable parts, few components that may fail and low risk of wear. A large diameter of the rotor combined with a vane that extend over the entire diameter in the pump housing gives a large contact area between the rotor and the vane, in contrast to pumps wherein the vane only extend from a place between the rotor center and the outer diameter of the rotor, and to the inner surface of the pump housing as shown in e.g. WO9014518 and GB262344. The large contact area results in reduced local compressive force compared to prior art. Due to the fact that the vanes extend over the entire diameter of the pump housing, it is possible to use the pump without force motioning the vanes. The diameter of the rotor is less than the cylinder diameter of the pump housing. The different is the length of the stroke with addition of a necessary allowance. For example, in an embodiment of the invention, the rotor diameter may be 100 mm and the cylinder diameter then will measure 120 mm. The maximum stroke length will then be 20 mm. The pump as a rotary machine may be used as a compressor, an extractor, a vacuum pump and a combustion motor among other range of use.

**[0010]** In an embodiment of the invention the bearing of the axle is a shaft bearing which form an asymmetric extension of the pump housing (1) and formed as one component.

**[0011]** A major advantage of the pump is that it is so simple to produce and uncomplicated to assemble. The pump comprises in an embodiment mainly of five components, of which three are movable. In an embodiment of the invention with detachable end cap the maintenance will be very easy. It will be easy to access the components exposed to wear, such as vanes.

**[0012]** In an embodiment of the invention the rotor housing (1) is cylindrical and the one or more vanes (12a, 12b,...) are rectangular. Such an embodiment of the housing is easy to mill and makes the assembling very easy. One may also imagine that the rotor housing is more or less drum shaped and that the vanes are formed to fit and fill the drum shape of the rotor housing.

**[0013]** The components of the pump may be manufactured of for instance metal or ceramic material depending of the range of use.

On pump geometry

**[0014]** In an embodiment of the invention the radius (R), counted from the center of the rotor (10) to the inner wall surface (2), from a base radius ( $R_0$ ) with a given rate (DeltaR) per arch length, counted from a top point (T) to 180 degrees from the top point (T), and decrease with a equivalent rate further for the increasing arc length back to the top point (T), in a way that even though the rotor axis is out of center of the pump housing the a whole vane plate with center in the rotor may rotate in and extend over the entire diameter of the pump housing. In this way it will not be required with other means to press the

vanes out and towards the walls surfaces inside the pump housing to maintain the pump efficiency. The cross section of the so formed cylindrical pump housing will not have a real mathematic center point. The housing, the cylinder, will in this embodiment be egg- or heart- shaped. At 0 and 180 degrees the transitions may be smoothened to prevent strokes to the vanes at those points.

**[0015]** In an embodiment of the invention the rate, Delta R, is 1/10 mm per degree and  $R_0$  is 50 mm. In another embodiment  $R_0$  is 920 mm and the rate 80/180 mm. Please see the example in the below table. The radius and the gradient may be adjusted according to the use. The cross section of the rotor housing does not have a real center. The geometry of the inner walls will be defined as e.g. described in claim 2.

| $\varnothing_{\text{rotor}}$ | $\varnothing_{\text{housing}}$ | Delta R         |
|------------------------------|--------------------------------|-----------------|
| 50                           | 59                             | 1/20 mm         |
| 100mm                        | 118mm                          | 1/10 mm per deg |
| 920                          | 1000                           | 80/180 mm       |

**[0016]** In an embodiment of the invention the vanes (12a, 12b,...) are provided with corresponding recesses (13a, 13b, ...) arranged for mutual translational motion within the slots (141, 142) of the rotor (10). This allows the use of more vanes which extend over the entire pump housing diameter and are arranged in the rotor that are located outside the approximate center point of the center of the pump housing. The cylindrical pump housing has no real axis of revolution but only an approximate circular form of the cross section. The rotor has in an embodiment a minor radius to the smallest diameter of the pump housing. In such an embodiment the rotor will not form a sealing zone to the cylindrical inner wall in the pump housing. The rotor is in this embodiment arranged with an allowance to the housing, see Fig. 1, where the vane bears against the top point (T) in the cylinder wall and at the same time has some extend outside the rotor. An advantage by this embodiment is that the rotor may have some movement caused by generated pressure without inflict any wear at neither the housing nor the rotor.

The vanes will travel independent of each other trailing the inner wall of the pump housing. In an embodiment comprising two vane plates the vanes will be identical and arranged 180 degrees to each other and crossing inside the rotor slots.

**[0017]** In an embodiment of the invention a conduit internally in the slots in the rotor allows transport of fluid across the vanes so as for the vanes to slide easily and prevent mechanical locking or jamming by the liquid pressure when moving the vanes. This may be done by not letting the recesses tighten onto each other.

**[0018]** In an embodiment of the invention the vanes are arranged with guiding pins (11) arranged for running in guiding tracks (8) in at least the bottom wall (15) or the

cap (16) in the rotor housing (1), wherein the guiding slots (8) are arranged to guide the vanes (12a, 12b, ...) to run near the cylindrical inner wall surface (2). The guiding arrangement comprising guiding pins and guiding slots may be arranged as e.g. ball-bearing to reduce the risk of wear. Oil or another type of lubricant may also be used to the risk of wear. Such force motioning will guide the vanes to trail the cylinder wall.

**[0019]** In an embodiment of the invention the inlet (7) is arranged radial. In another embodiment of the invention the inlet (7) is arranged parallel with the axle. In an embodiment of the invention the outlet (6) is radial. In another embodiment of the invention the outlet (6) is parallel with the axle. The inlet and outlet may be arranged and vary depending on the desired pressure conditions and range of use. Outside the outlet (6) and inlet (7) there will be pipe fittings or connections to a pipe manifold according to the requirements. It is important that at least one of the vanes always work as a sealing between the inlet and the outlet as shown in Fig. 1. Therefore, in a preferred embodiment there will be two or more vane plates.

**[0020]** In an embodiment of the invention the pump housing comprise a cap. The cap may have a hole for a guiding pin at the top to secure the correct positioning of the guiding slots in the bottom and the cap during assembling, so as for correct guiding of the rotation of the vanes.

**[0021]** In an embodiment of the invention the cap may have a hole near the center of the rotor so as for connecting two pumps to e.g. a combustion engine or other ranges of use.

## Claims

1. A pump with a rotor (10) comprising one or more vanes (12a, 12b, ...) arranged for running with edges (17a1, 17a2, 17b1, 17b2, ...) against a plain inner wall surface (2) in their full axial extent in a rotor housing (1) with a bottom wall (15) and a cap (16) and further arranged with an inlet (7) and an outlet (6), wherein the rotor (10) is arranged on an axle (9) mainly eccentrically placed related to the mainly cylindrical inner wall surface (2) of the rotor housing (1), **characterized in**

- **that** each vane (12a, 12b, ...) is arranged to run each in a corresponding diametrical slot (141, 142 ...) in the rotor (10),
- **that** each vane (12a, 12b, ...) extend from an end's edge (17a1, 17b1, ...) to the opposite end's edge (17a2, 17b2 ...) substantially across the whole inner diameter ( $\emptyset$ ) of the rotor housing, between two opposite sides of the inner wall surface (2) for all rotation angles of the rotor (10), and
- wherein the cross-section of the cylindrical ro-

tor housing (1) is non circular with a radius (R) from the center of the rotor (10) to the inner wall surface (2) increasing from a base radius ( $R_0$ ) with a given rate ( $\Delta R$ ) per arclength counted from a top point (T) to 180 degrees from the top point (T), and decreases with an equivalent rate continuously for the increasing arclength further to the top point (T).

2. The pump according to claim 1, wherein the rotor housing (1) is cylindrical and the one or more vanes (12a, 12b, ...) are rectangular.
3. The pump according to any of the preceding claims, wherein the number of vanes are two or more.
4. The pump according to any of the preceding claims, wherein the vanes (12a, 12b, ...) are provided with corresponding recesses (13a, 13b, ...) arranged for mutual translational motion within the slots (141, 142) of the rotor (10).
5. The pump according to any of the preceding claims, wherein a conduit internally in the slots in the rotor allows transport of fluid across the vanes.
6. The pump according to any of the preceding claims, wherein the vanes are arranged with guiding pins (11) arranged for running in guiding tracks (8) in at least the bottom wall (15) or the cap (16) in the rotor housing (1), wherein the guiding slots (8) are arranged to guide the vanes (12a, 12b, ...) to run near the cylindrical inner wall surface (2).
7. The pump according to any of the preceding claims, wherein the inlet (7) is arranged radial.
8. The pump according to any of the preceding claims, wherein the outlet (6) is radial.
9. The pump according to any of the preceding claims, wherein the inlet (7) is axial.
10. The pump according to any of the preceding claims, wherein the outlet (6) is axial.
11. The pump according to any of the preceding claims, wherein the radius of the rotor (10) is less than the minor radius ( $R_0$ ) of the rotor housing (1).
12. The pump according to any of the preceding claims, wherein there is an allowance between the rotor (10) and the inner wall surface (2) of the rotor housing (1).
13. The pump according to any of the preceding claims, wherein the vanes (12a, 12b, ...) forms the required sealing between the inlet (7) and the outlet (6).

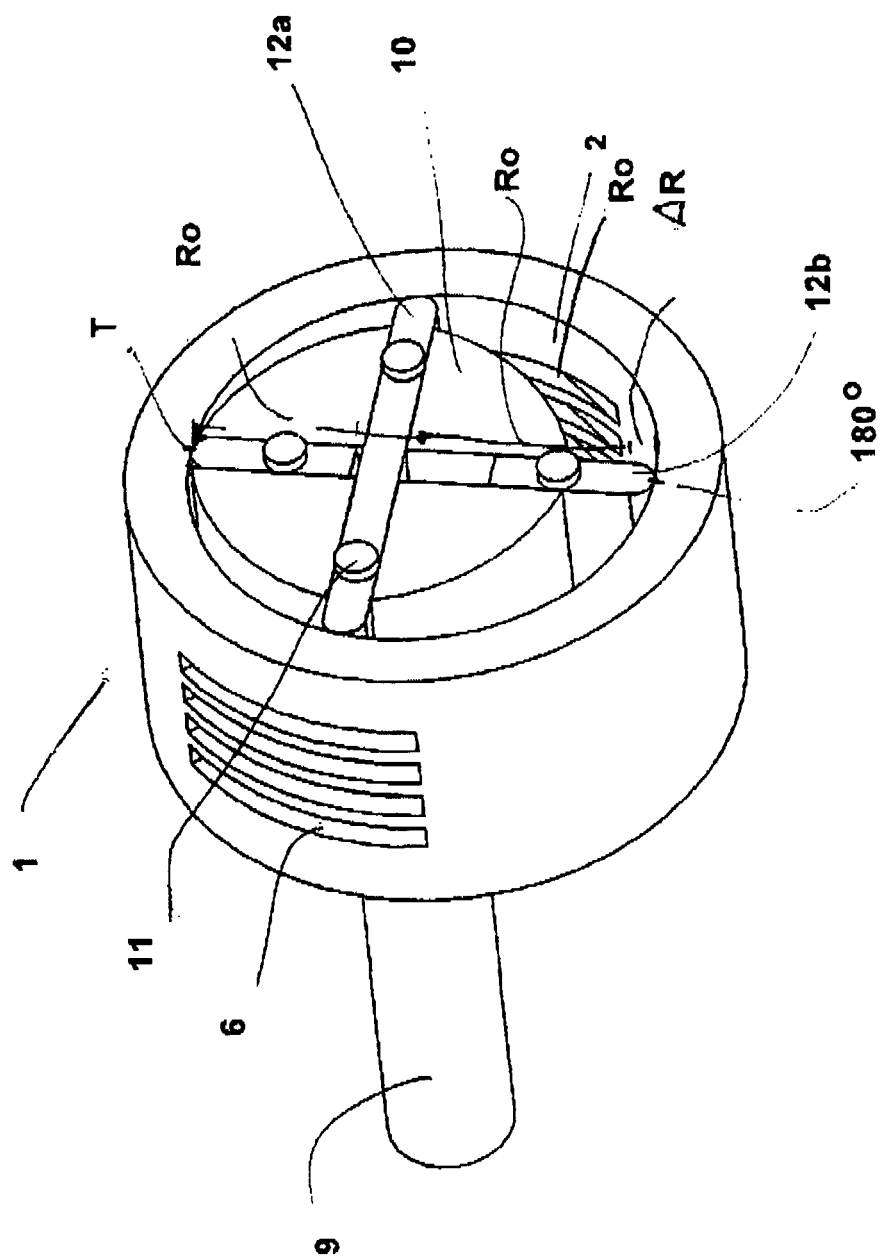
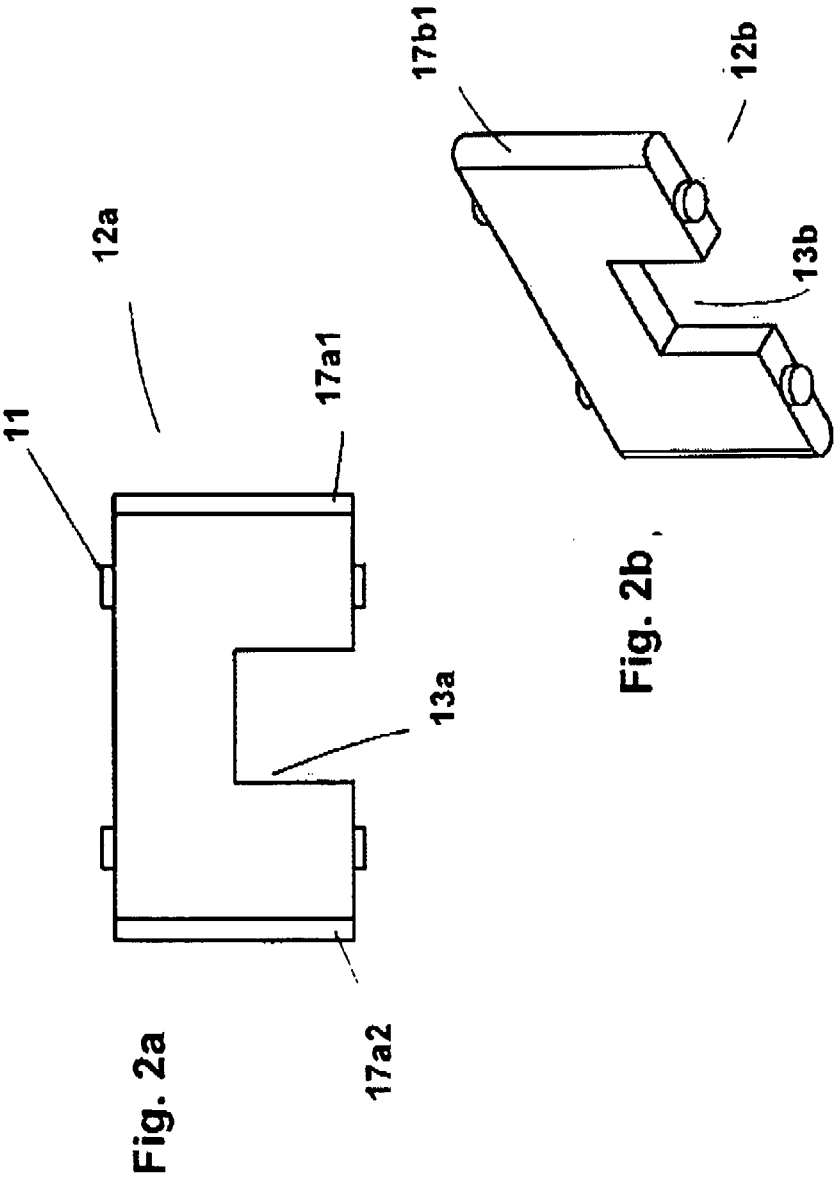


Fig. 1



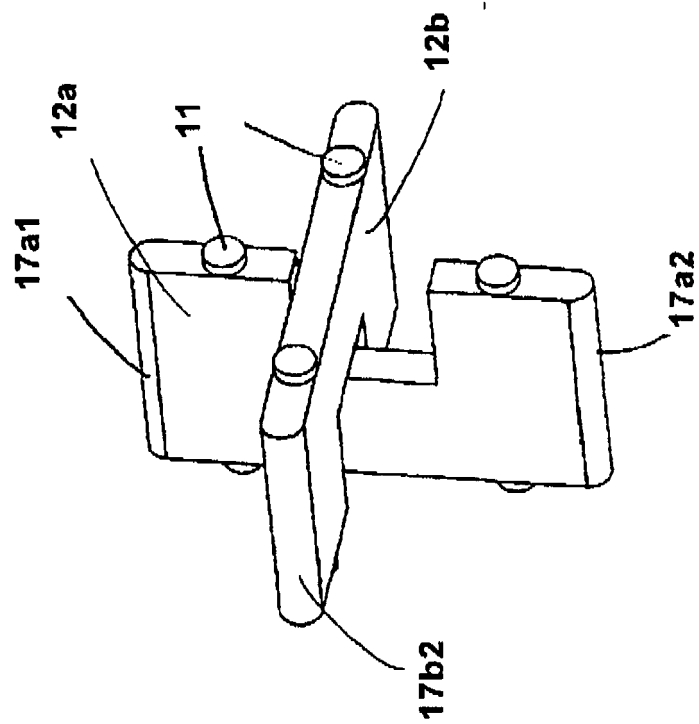


Fig. 2c



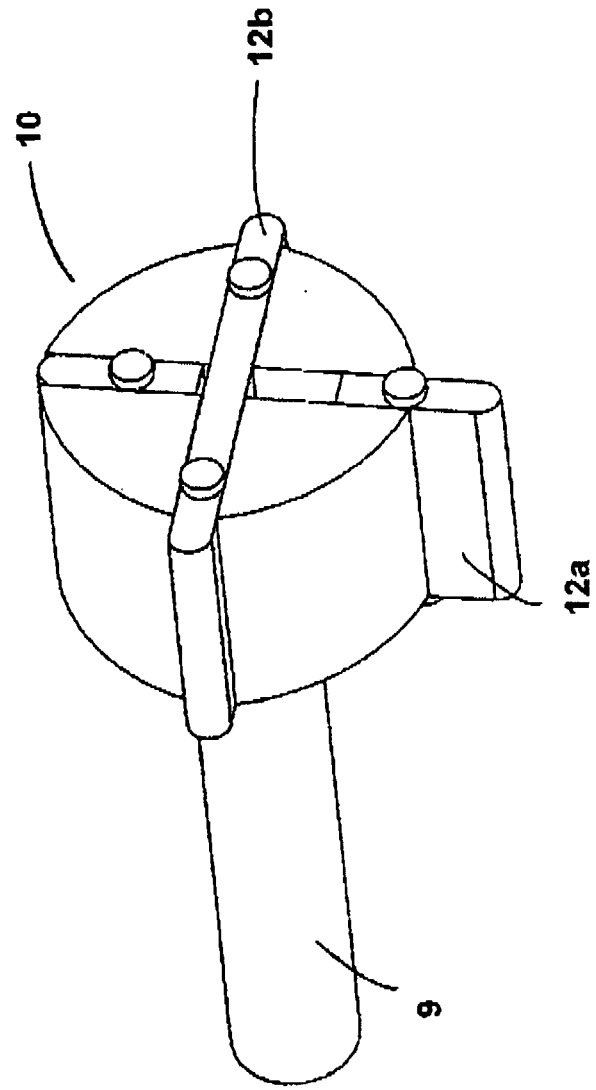


Fig. 2d

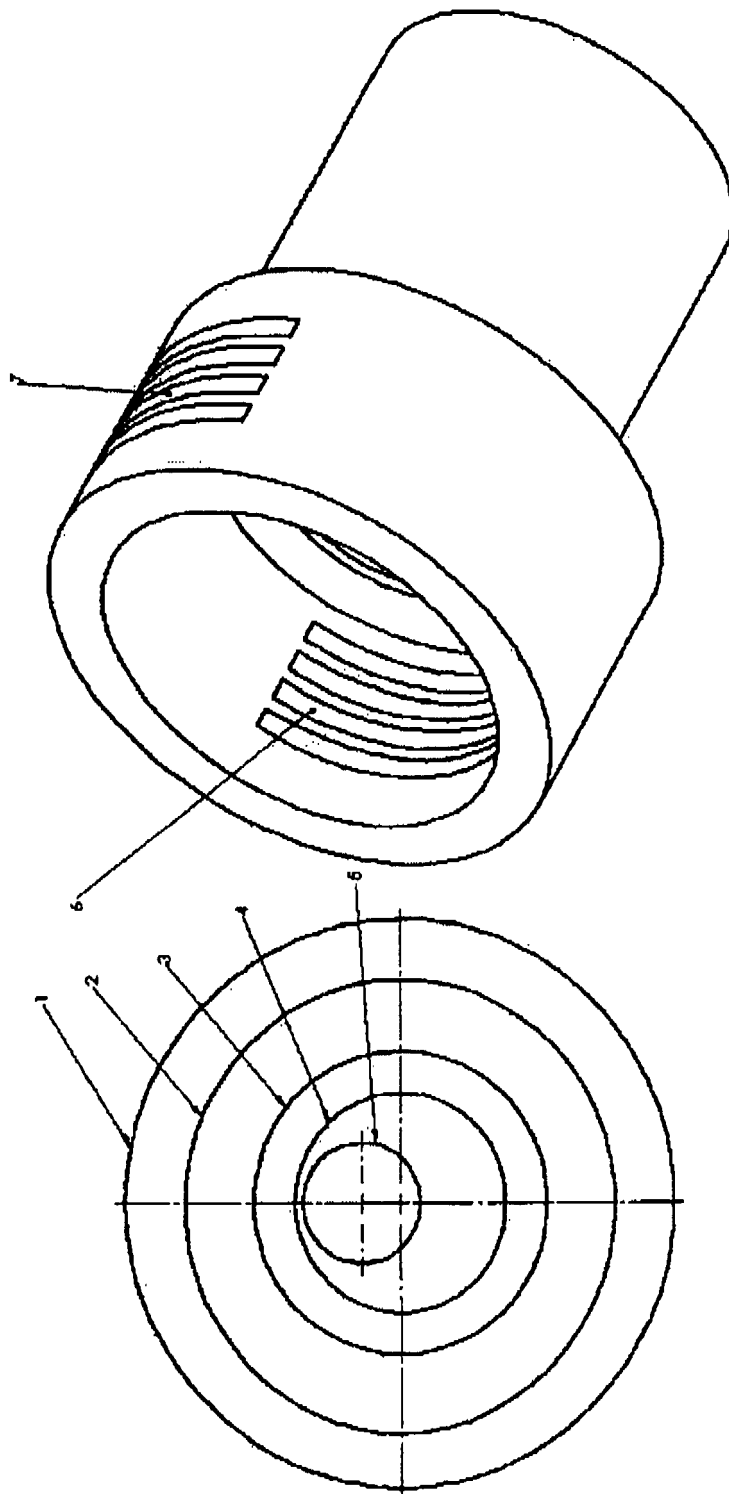
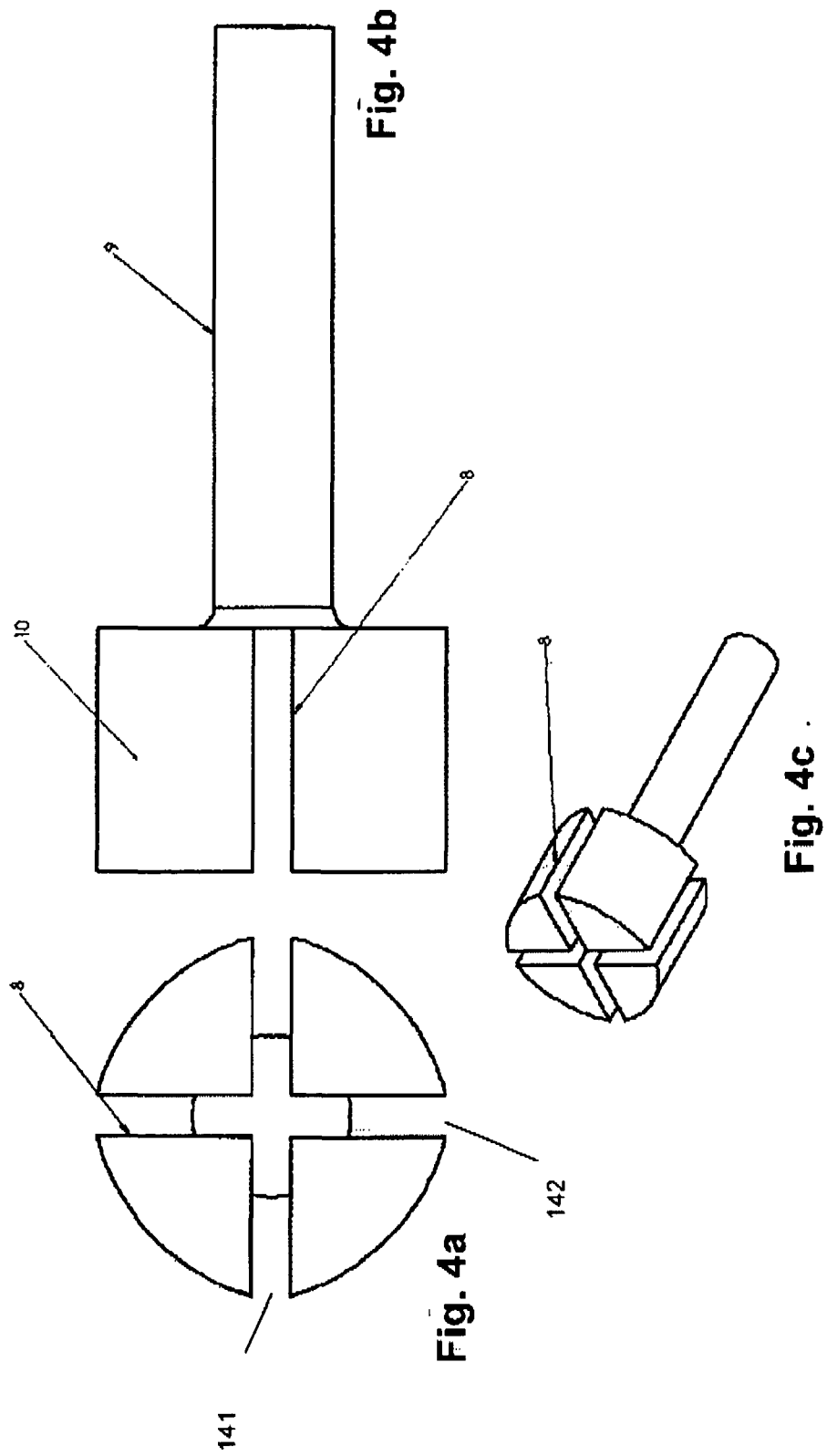
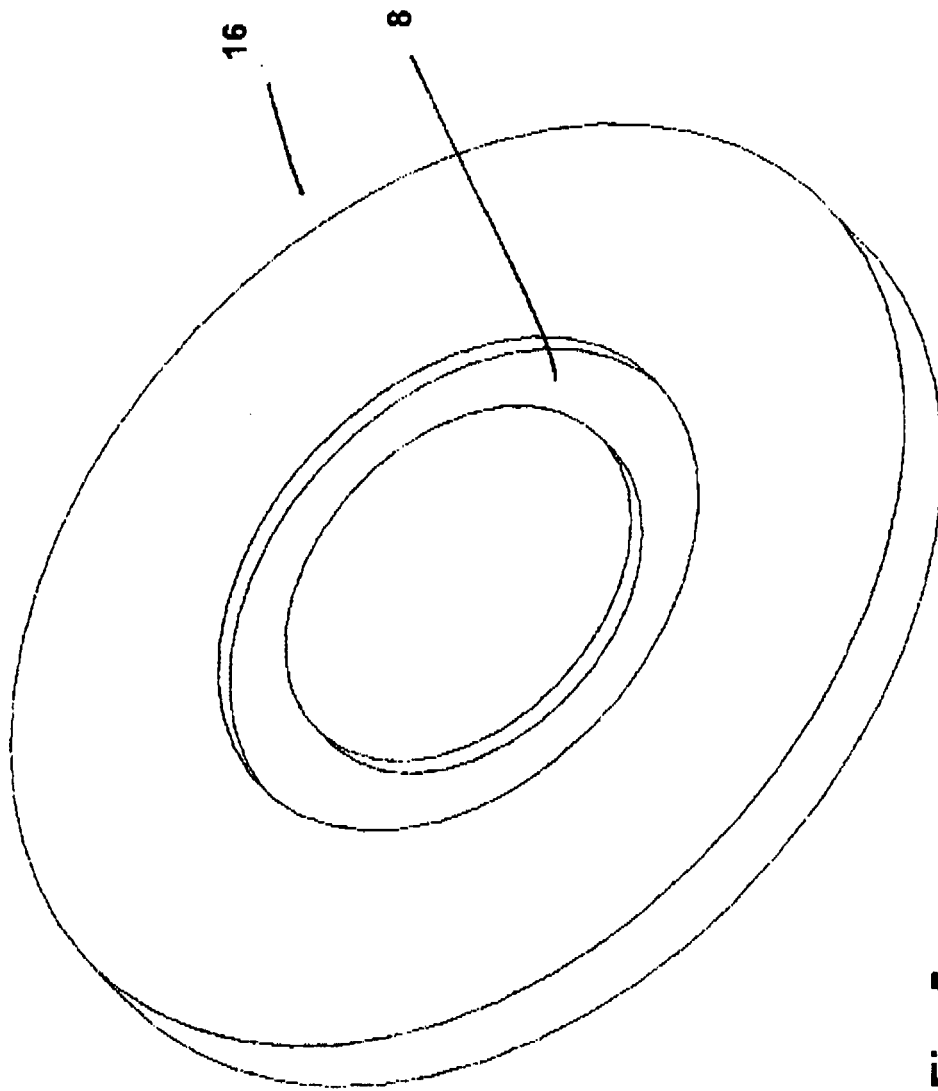


Fig. 3





**Fig. 5**

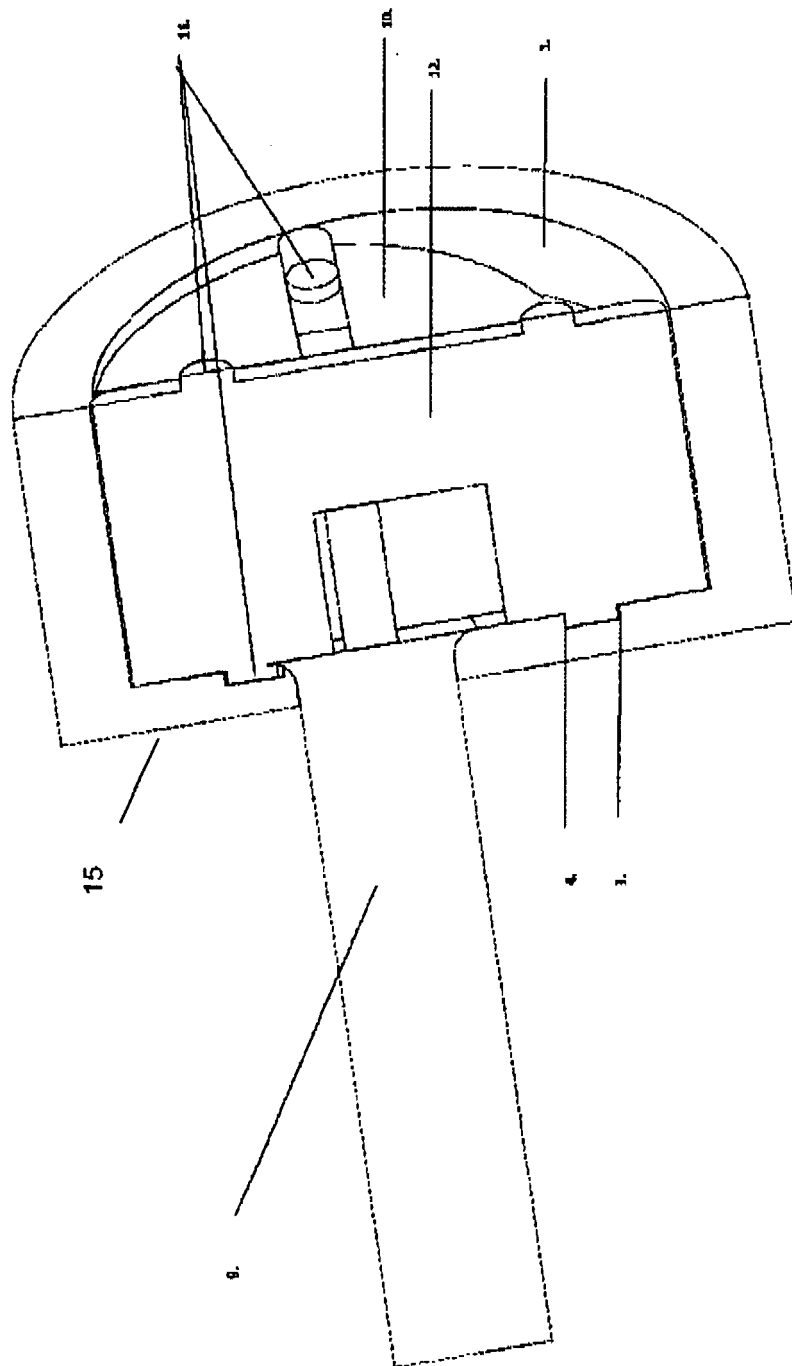


Fig. 6

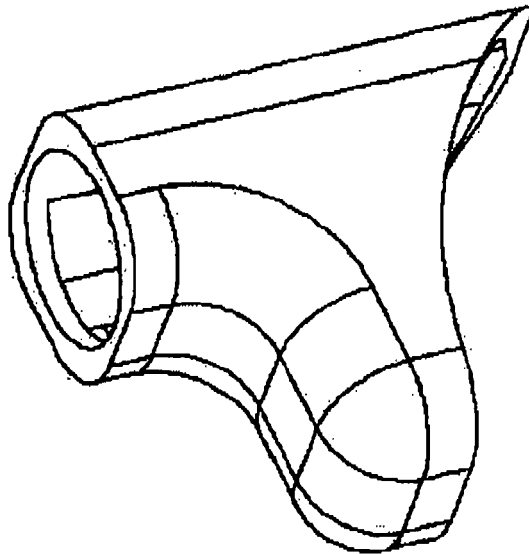
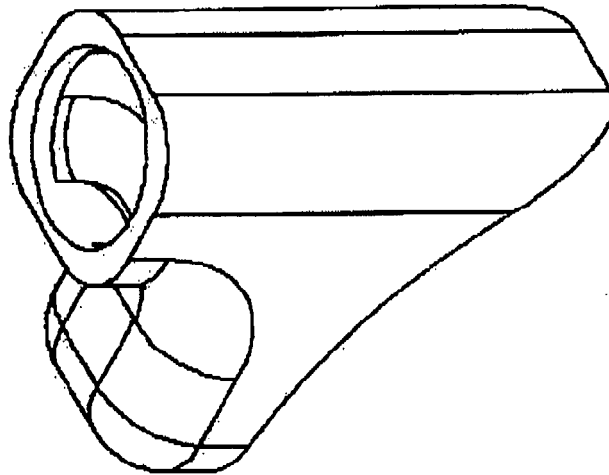


Fig. 7

**REFERENCES CITED IN THE DESCRIPTION**

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