



(51) International Patent Classification:

F04B 43/14 (2006.01) *F04C 5/00* (2006.01)
F04B 43/00 (2006.01)

(21) International Application Number:

PCT/GB2018/051969

(22) International Filing Date:

11 July 2018 (11.07.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1711608.8 19 July 2017 (19.07.2017) GB

(71) Applicant: **CHARLES AUSTEN PUMPS LTD.**
[GB/GB]; Royston Road, Byfleet, West Byfleet, Surrey
KT14 7NY (GB).

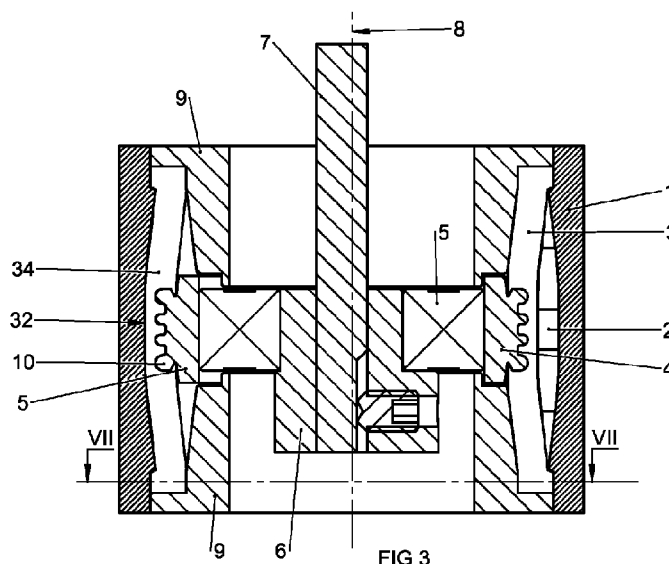
(72) Inventors: **SHEPHERD, William Eric**; 100 Royston
Rd, Byfleet, Surrey KT14 7NY (GB). **FULLER, Robert
David**; 100 Royston Rd, Byfleet, Surrey KT14 7NY (GB).

(74) Agent: **BOULT WADE TENNANT LLP**; Verulam Gar-
dens, 70 Gray's Inn Road, London Greater London, WC1X
8BT (GB).

(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

(54) Title: A ROTARY DIAPHRAGM POSITIVE DISPLACEMENT PUMP



(57) Abstract: A rotary pump comprising a housing (1) defining an annular chamber with inlet and outlet ports (12, 11) spaced apart around the chamber, a flexible annular diaphragm (3) forming one side of the chamber spaced opposite an annular wall of the housing (1) and having two opposed circular ends, the diaphragm (3) being sealed at its edges to the housing (1), a partition (13) extending between the inlet and outlet ports (12, 11) to the diaphragm (3). The diaphragm (3) is configured to be pressed progressively against the housing (1), by a rotating means, to force fluid around the chamber. The rotating means comprises a bearing (5). There is a reinforcement ring (4) surrounding the bearing (5) and connected to a central region of the diaphragm (3), and a pair of annular end caps (9), one in each end of the diaphragm (3). Each end cap (9) is axially spaced less than 0.5 mm from the adjacent bearing (5) or reinforcement ring (4).

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

A ROTARY DIAPHRAGM POSITIVE DISPLACEMENT PUMP

The present invention relates to a rotary diaphragm positive displacement pump.
Such a pump is disclosed in our own earlier EP0819853.

5

Such a rotary pump comprises a housing defining an annular chamber with inlet and outlet ports spaced apart around the chamber, a flexible annular diaphragm forming one side of the chamber spaced opposite an annular wall of the housing, the diaphragm being sealed at its edge to the housing, a partition extending across the chamber from a location
10 between the inlet and outlet ports to the diaphragm; wherein the diaphragm is configured to be pressed progressively against the opposite wall of the housing to force fluid drawn in at the inlet port on one side of the partition around the chamber and to expel it at the outlet port at the other side of the partition.

15 In EP0819853, we added a reinforcement ring to the diaphragm in order to add rigidity to a central portion of the diaphragm so that it can cope with higher loads and to prolong the lifetime of the pump.

The pump has been commercially successful for application such as medical analysis and
20 water dispensing. All of these applications are at a relatively low pressure (typically below 200kPa but more normally below 100kPa). However, at higher pressures, the current design of pump has a more limited life span.

The present invention is directed to modified version of the pump to allow it to operate
25 more reliable at higher pressures over a longer period of time.

According to the present invention there is provided a rotary pump as defined in claim 1.

By bringing the end of the end caps very close to the adjacent bearing or reinforcement
30 ring (as compared to a gap of at least 2mm in our existing pump), the present invention provides an advantage that the annular caps cannot be inserted so far into housing that they overly compress the diaphragm material. Further, both of the end caps can only be inserted to a limited degree and both can be inserted to the same degree. This provides for a more reliable assembly process ensuring alignment between all of the components and
35 reliably forming the seal between the diaphragm and the housing.

The axial spacing is preferably no more than 0.4 mm and more preferably no more than 0.25 mm.

- 5 The second end is preferably formed with a groove at the radially outermost portion into which an inner part of the reinforcement ring can move in use. This allows the pump to accommodate a larger reinforcement ring thereby improving the robustness of the pump and providing an enhanced contact between the bearing and reinforcement ring.
- 10 The bearing may be a plain bearing or bushing. Alternatively, it may be a rolling element bearing such as ball bearing.

The configuration of the rotary pump is preferably such that the diaphragm does not rotate relative to the housing.

15

An example of a pump in accordance with the present invention will now be described with reference to the accompanying drawings, in which:

20

Fig. 1 is a cross section of the pump in a plane perpendicular to the axis of rotation which passes through the inlet and outlet ports;

Fig. 2 is an enlarged portion of Fig.1 showing the region adjacent to the outlet port;

25

Fig. 3 is a cross section in an axial plane shown as III – III in Fig. 1 which includes the line contact between the diaphragm and housing;

Fig 4 shows a detail of the bottom left hand region of Fig 3;

30

Fig 5 is a side view of the diaphragm; and

Fig 6 is an exploded perspective view of the diaphragm.

35

As shown in Figures 1 and 3, a tubular part of a rigid housing 1 has an annular groove 2 running around the inner surface, which acts as the pump chamber. In its relaxed state, a flexible diaphragm 3 lies inside the wall of the housing leaving the groove free to contain

the pumped fluid. A rigid reinforcing ring 4 is moulded into the diaphragm and this ring is at all times in intimate contact with an outer surface of a bearing 5 mounted via an eccentric coupling 6 to a shaft 7 which extends through and is mounted in the housing in bearings (not shown). The shaft 7 is mounted concentrically with the annular groove but eccentrically with regard to the axis 8 of the housing 1 and is powered by a motor (not shown). If the reinforcing ring were not present, the diaphragm would stretch and the performance would be reduced in a similar way to that experienced with peristaltic pumps, when the tubing collapses under vacuum.

As the drive shaft 7 rotates, the bearing 5, reinforcing ring 4 and central portion of the diaphragm 3 all orbit together inside the housing. The two ends of the diaphragm 3 are clamped to the housing 1 by end caps 9, providing an effective and static seal to atmosphere. As the central portion of the diaphragm 3 orbits round inside the groove 2, line contact 10 exists between the diaphragm and the groove providing an abutment which pushes the fluid along towards the outlet port 11 and simultaneously draws fluid in through the inlet port 12. The pump thus provides pressure and suction cycles at the output and intake respectively which are symmetrical and which vary sinusoidally. Since the diaphragm does not rotate relative to the housing, there is minimal sliding action between them and therefore almost no wear.

From Figure 1, it can be seen that another feature of the diaphragm moulding is an elastic partition 13 which prevents communication between the outlet 11 and inlet 12 ports. This is positioned between downwardly depending walls 14, 15 which are part of the housing. Since the partition is elastic, it accommodates the reciprocating movement of the diaphragm whilst maintaining a static pressure seal between both ports and atmosphere. In this way, all compliant sealing functions required by the pump are provided by the diaphragm moulding and since none of these are sliding seals, they are not subject to significant wear.

The above description applies equally to the prior art pump of EP0189853. The modifications to the present pump will now be described.

The end caps 9 are best shown in Fig 4. These have a first end 20 at the outermost face of the end cap and a second end 21 at the opposite innermost face. At the first end 20 is a radially outwardly extending flange 22 which, clamps the diaphragm 3 to the housing 1 with

the cooperation of an annular flange 23 in the housing 1. The flange 22 is then fixed to the housing 1 to hold it in place.

The end cap 9 has a tapered outer face 24 tapering inwardly away from the first end 20.

5 This outer face 24 supports the diaphragm 3 when the diaphragm is in its radially innermost position as shown on the right hand side of Fig 3.

At the radially innermost portion of the second end 21 is an annular projection 25. The presence of this projection 25 forms a recess 26 which provides a step reduction in the
10 outer diameter of the end cap 9 in the region adjacent to the second end 21. As can be seen from Fig 4, the second end 21 is spaced from the bearing 5 by a very small amount creating a first axial gap 27, in this case less than 0.4 mm and preferably 0.25 mm. A second axial gap 28 is present between the recess 26 and the reinforcing ring 4. Again, this is less than 0.4 mm and preferably 0.25 mm.

15

As will be apparent from Fig 4, the end cap 9 is located by engagement with the flange 22 against the flexible diaphragm 3. In view of the very small gap referred to above, the flange 22 cannot over compress the diaphragm 3 otherwise the end cap 9 will abut against the reinforcing ring 4 and bearing 5. This ensures that the end cap 9 at either end of the
20 assembly can be inserted consistently as both end caps will compress the diaphragm 3 to the same limited amount.

The small nature of the second gap 28 also ensures that there is only a very small region of the compressible diaphragm 3 which remains unsupported as the diaphragm 3 is pressed
25 against the end cap 9 (as shown in the right hand side of Fig 3). In this position, the opposite outer face of the diaphragm is receiving the full pressure within the pump chamber and this would tend it extrude the diaphragm material in any unsupported region on the opposite side. The very small nature of this gap 28 significantly limits the potential for extrusion of the diaphragm 3 even when the pressure in the pump chamber is increased.

30

The reinforcement ring 4 has a modified shape as best shown in Figs. 3 and 4.

This comprises an embedded portion 30 forming the radially outermost portion of ring 4 and a support portion 31 forming the radially innermost portion of the ring 4. The embedded
35 portion 30 has a crenulated configuration in this case consisting of four annular ridges

which, in cross section, have a curved configuration which is devoid of sharp corners. This is to avoid any stress concentrations in the ring 4. These crenulations are designed to provide a large surface area within a relatively limited axial region. The diaphragm 3 is formed as an over mould on the ring 4 and the presence of the crenulations maximises the surface area for bonding between the two. The relatively large number of rings 32 combined with their generally curved cross sections effectively spreads the load transmission between the two components thereby avoiding delamination of the two components even under relatively high loads.

10 The support portion 31 of the ring 4 extends axially beyond the crenulations 32 forming diaphragm support portions 34. These have a radially outwardly facing surface 35 which directly faces an inner face of the diaphragm 3. The diaphragm 3 is not bonded to the face 35. However, in the position in which the diaphragm 3 is furthest from the housing 1, the diaphragm is supported in this region by the face 35.

15

This feature provides support for the diaphragm at a time when it is under a relatively high inward pressure from the pressure within the pump chamber. As with the gap 28 mentioned above, this support prevents extrusion of the diaphragm material in this stressed position.

20 As shown in Figs. 1, 2 and 6, the outer face of the diaphragm 3 is provided with a trough 40 extended axially across a substantial portion of the diaphragm in the vicinity of the outlet. A similar trough 41 is provided at the inlet. The trough 40 in each case has a first edge 42 adjacent to the partition 13 and a second edge 43 opposite to the first edge. The troughs 40, 41 are aligned with a respective outlet duct 44 and inlet duct 45 which lead to the outlet port 11 and from the inlet port 12 respectively.

25

In the absence of these troughs 40, 41 when the diaphragm 3 is in the uppermost position, it is possible that while under high pressure, the diaphragm material will extrude into the port to a limited extent thereby causing damage to the diaphragm over time. The presence of the troughs 40, 41 reduces or eliminates this effect. However, trough terminates at edge 43 which is adjacent to the edge of duct 44 so that the full thickness of the diaphragm is available immediately downstream of the edge 43. This means that the diaphragm is able to fully engage with the housing 1 as the diaphragm reaches the top of its travel thereby ensuring that the point contact 10 is maintained up until the outlet duct 44 in order to expel the liquid. A similar geometry is provided for the inlet duct 45.

30

35

Reinforcing members 50 are best shown in Figs. 2, 5 and 6. Although two such reinforcing members 50 are shown in Fig. 6, only one of these need be present in practice. This would depend upon the direction in which the partition 13 is loaded in use.

5

The reinforcing member 50 comprises a frame of material which is harder than the material of the partition and therefore more resistant to deflection under pressure. This is shaped to fit in a shallow recess 51 in the side of the partition. It is preferably a press fit but may be, more securely attached if the application requires it. As shown best in Figure 6, the geometry of the reinforcing member 50 is such that it may be considered as a reinforcing plate, whose thickness is much smaller than its length/width.

10

With reference to Fig. 2, as the diaphragm orbits to pump the fluid around the chamber, the partition 13 deflects to some extent in order to accommodate this orbital movement. In addition, the pressure of the fluid in the inlet 12 or outlet 11 will also act to deflect the partition. Under higher pressure loads, this can cause the softer material of the diaphragm to contact the walls 14, 15 thereby wearing the diaphragm material, particularly at the bottom edge of the walls 14, 15 which can dig into the diaphragm 3 material.

15

As can be seen from Fig. 2, the reinforcing member 50 is positioned in the vicinity of the bottom edge of the walls 14, 15 such that any contact will be between two harder surfaces thereby protecting the diaphragm material from wear.

20

25

CLAIMS

1. A rotary pump comprising:

a housing defining an annular chamber with inlet and outlet ports spaced apart

5 around the chamber, a flexible annular diaphragm forming one side of the chamber spaced opposite an annular wall of the housing and having two opposed circular ends, the diaphragm being sealed at its edges to the housing, a partition extending across the chamber from a location between the inlet and outlet ports to the diaphragm;

10 wherein the diaphragm comprises an outer surface which engages the annular wall of the housing, and an inner surface opposite the first surface, wherein the outer surface is configured to be pressed progressively against the opposite wall of the housing, by a rotating means, to force fluid drawn in at the inlet port on one side of the partition around the chamber and to expel it at the outlet port at the other side of the partition;

the rotating means comprising a bearing;

15 a reinforcement ring surrounding the bearing and connected to a central region of the diaphragm;

a pair of annular end caps, one in each end of the diaphragm,

each end cap having a first end adjacent to a respective end of the diaphragm and a second end axially spaced from the first end adjacent to the bearing, the axial end of the 20 second end being axially spaced less than 0.5 mm from the adjacent bearing or reinforcement ring.

2. A rotary pump according to claim 1, wherein the axial spacing is no more than 0.4mm.

25

3. A rotary pump according to claim 1, wherein the axial spacing is no more than 0.25mm.

4 A rotary pump according to any preceding claim, wherein the second end is formed 30 with a groove at the radially outermost portion into which an inner part of the reinforcement ring can move in use.

1/3

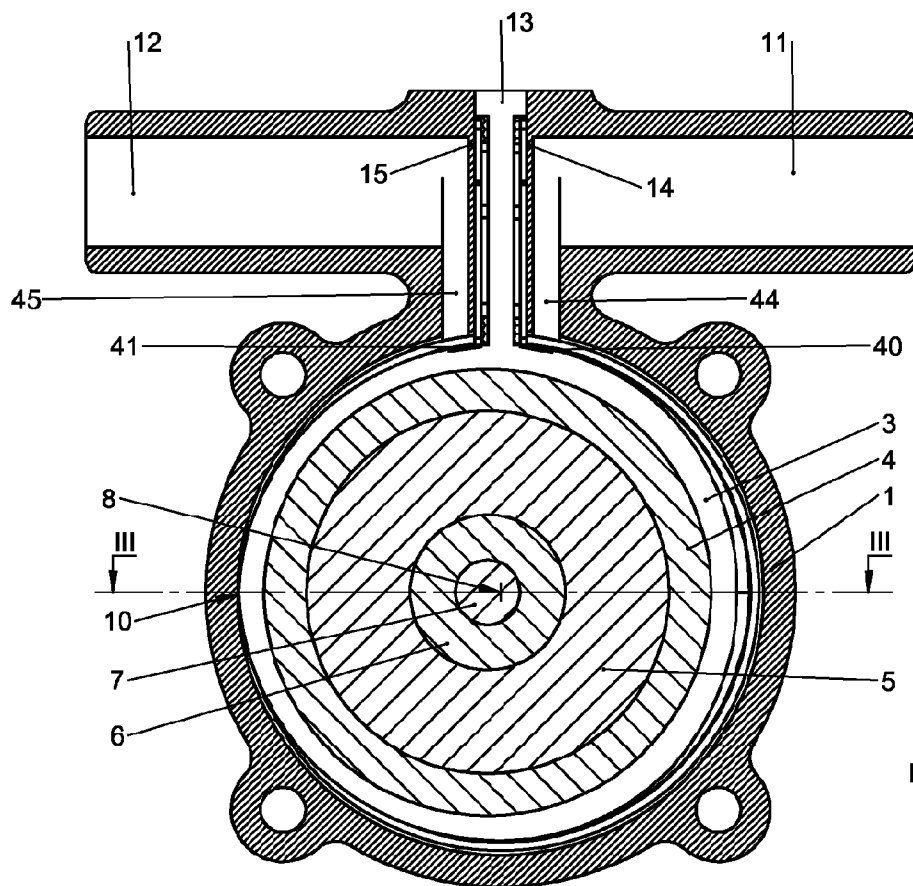


FIG 1

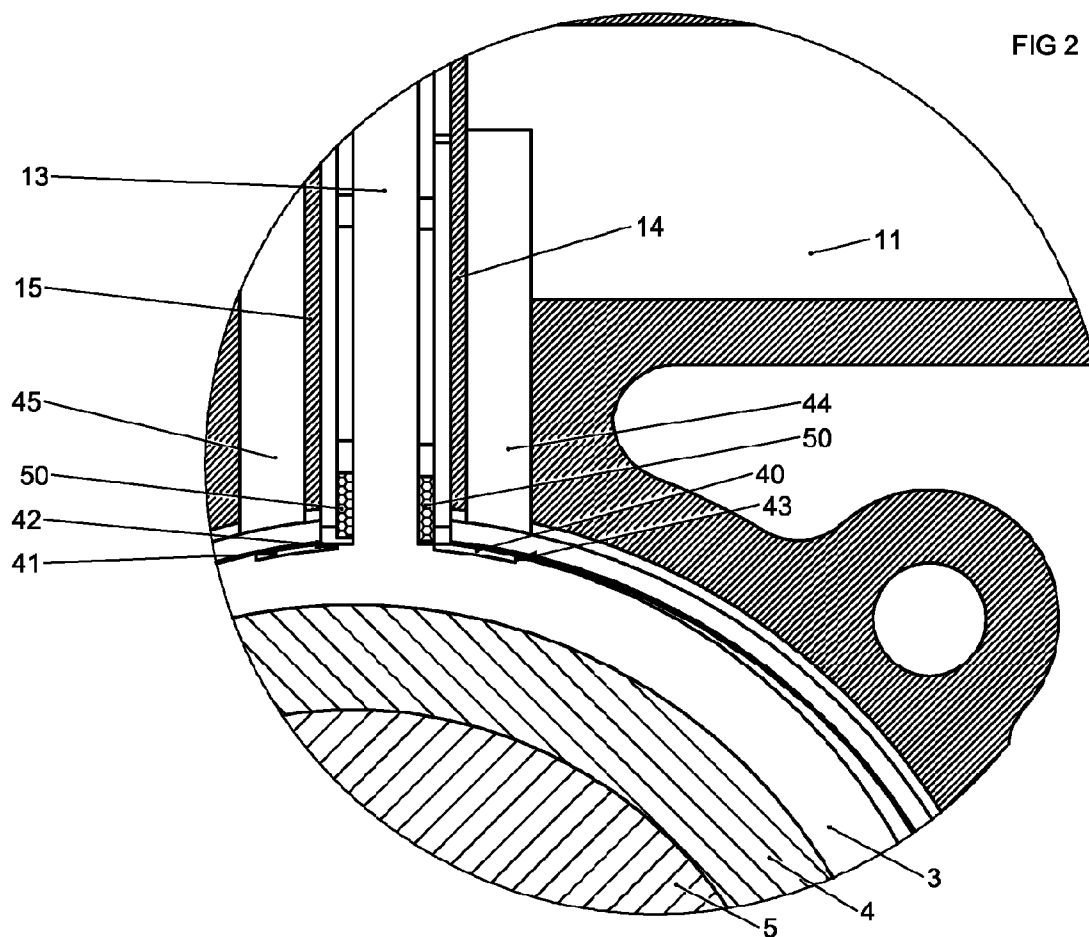
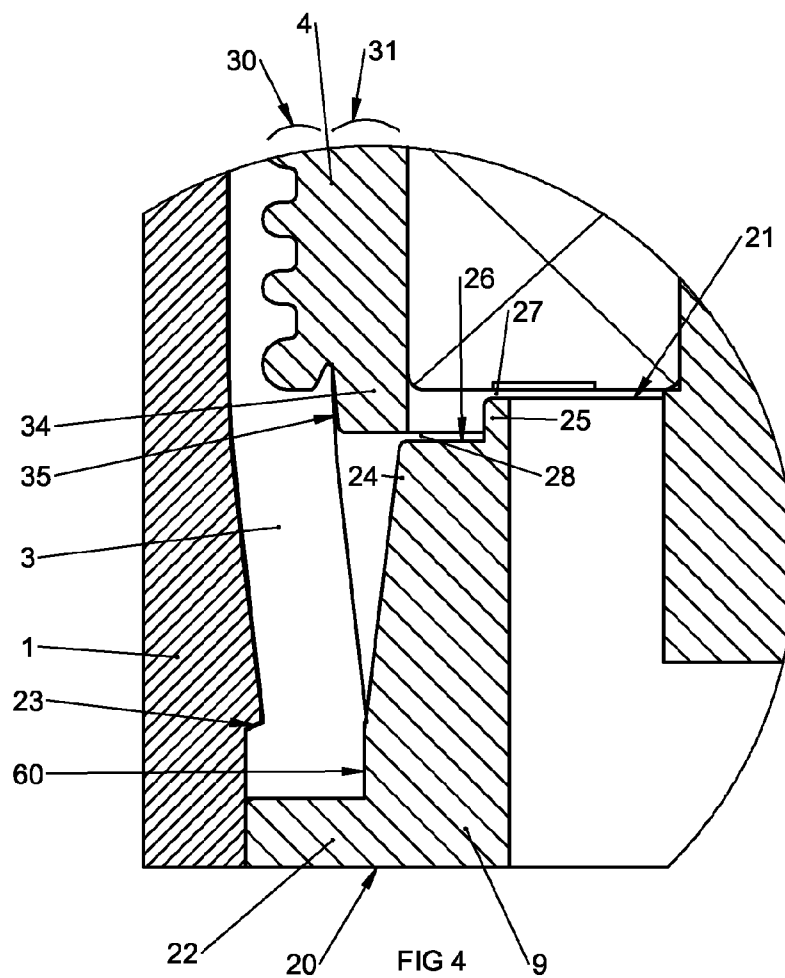
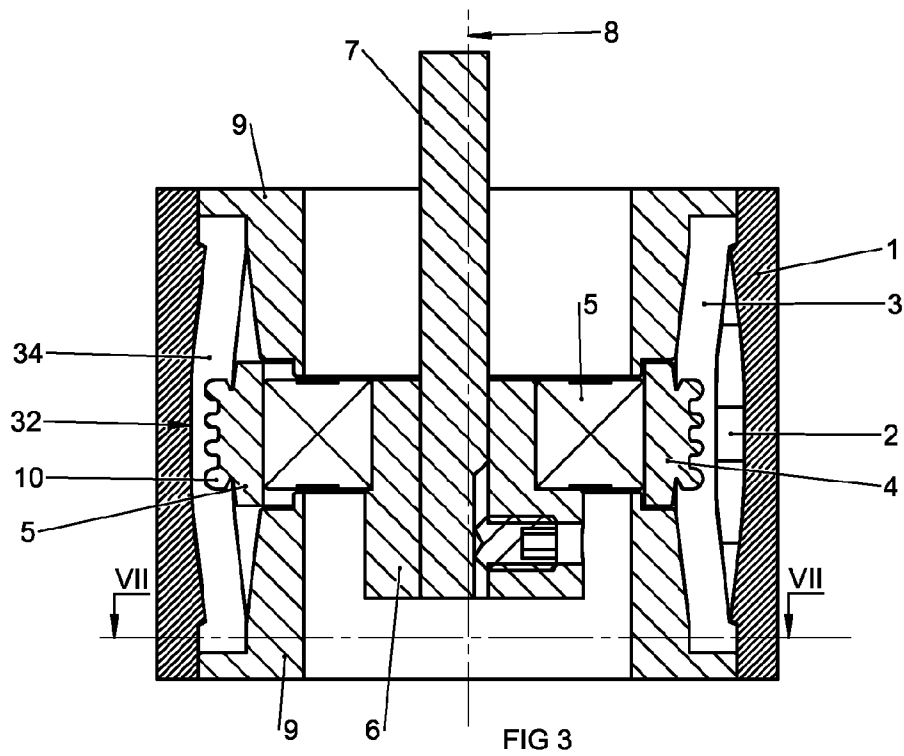


FIG 2



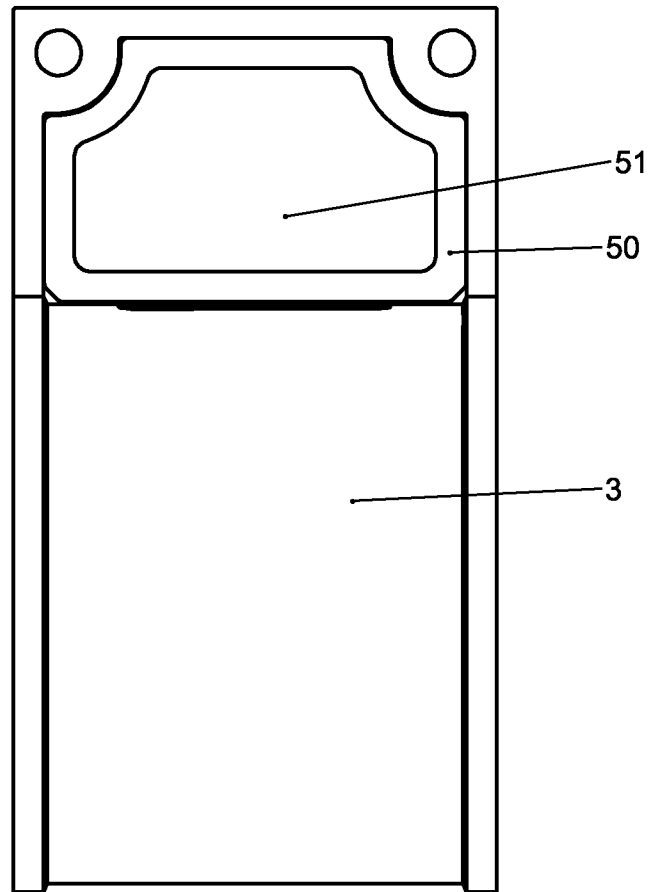


FIG 5

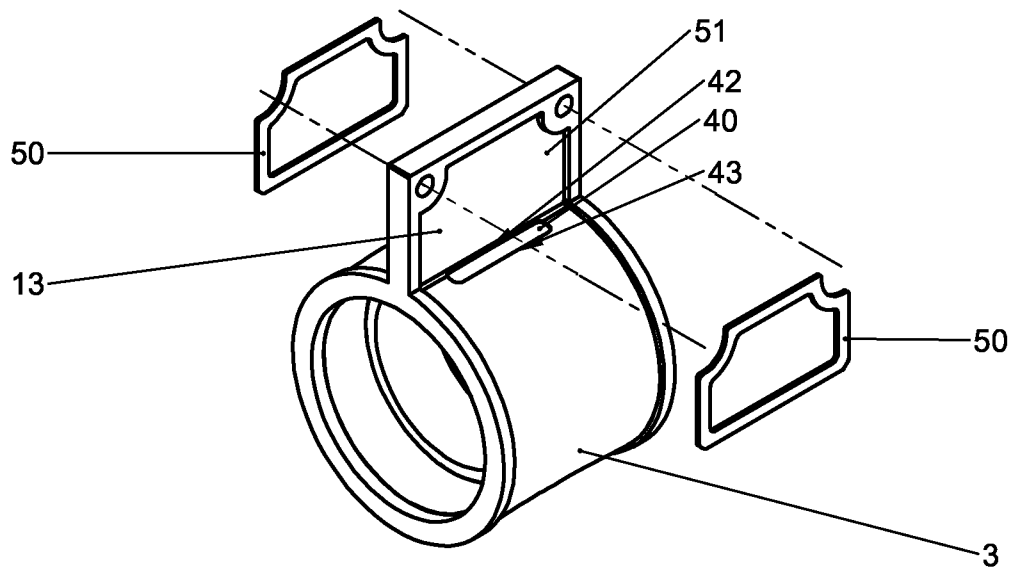


FIG 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2018/051969

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04B43/14 F04B43/00 F04C5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04B F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 280 185 A (STAUBER, S. [CH]) 5 July 1972 (1972-07-05)	1-3
A	figures 1, 2, 3 page 2, line 61 - page 3, line 32 -----	4
X	GB 854 610 A (ROEBIG, A [DE]) 23 November 1960 (1960-11-23)	1-3
A	figures 2, 3 page 1, line 72 - page 2, line 45 -----	4
X	FR 860 457 A (PIQUEREZ, E. [FR]) 16 January 1941 (1941-01-16)	1-3
A	figures 1, 2 page 1, line 51 - page 2, line 72 -----	4
A	US 4 332 534 A (BECKER, E. [DE]) 1 June 1982 (1982-06-01) figures 2-4 column 4, line 13 - column 6, line 61 -----	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 September 2018

Date of mailing of the international search report

24/09/2018

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gnüchtel, Frank

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2018/051969

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1280185	A	05-07-1972	AT 291001 B 25-06-1971
		BE 736863 A 31-12-1969	
		CH 478346 A 15-09-1969	
		DE 1934779 A1 29-01-1970	
		ES 369975 A1 16-07-1971	
		FR 2015343 A1 24-04-1970	
		GB 1280185 A 05-07-1972	
		IL 32709 A 30-01-1973	
		JP S4949126 B1 25-12-1974	
		NL 6911073 A 11-02-1970	
		RO 54847 A 20-08-1973	
		SE 353132 B 22-01-1973	
		US 3583838 A 08-06-1971	

GB 854610	A	23-11-1960	NONE

FR 860457	A	16-01-1941	NONE

US 4332534	A	01-06-1982	FR 2444177 A1 11-07-1980
		GB 2037371 A 09-07-1980	
		US 4332534 A 01-06-1982	
