

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
29 March 2007 (29.03.2007)

PCT

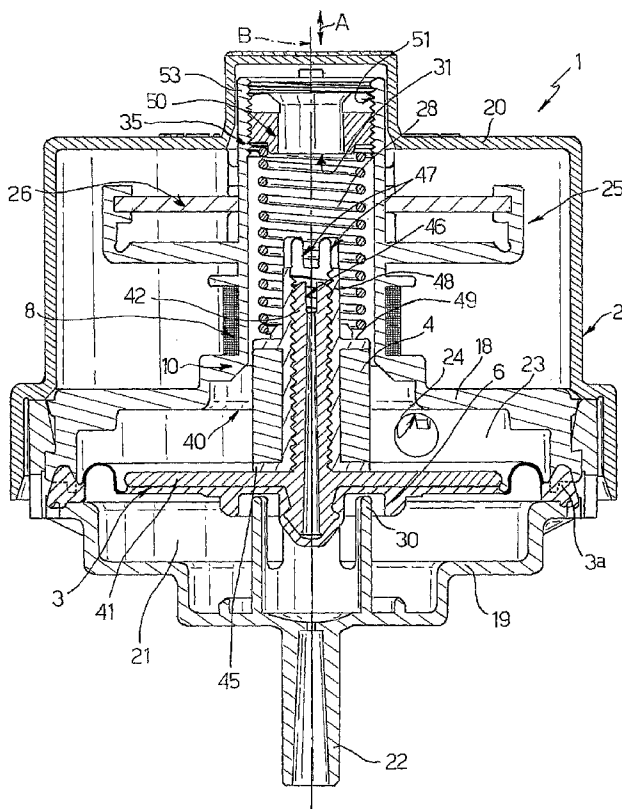
(10) International Publication Number  
WO 2007/034294 A1

- (51) International Patent Classification:  
G01L 9/00 (2006.01)
- (21) International Application Number:  
PCT/IB2006/002596
- (22) International Filing Date:  
19 September 2006 (19.09.2006)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
TO2005A000643  
20 September 2005 (20.09.2005) IT
- (71) Applicant (for all designated States except US): ITW METALFLEX, DRUZBA ZA PROIZVODNJO DE-LOV ZA GOSPODINJSKE APARATE, D.O.O. [SI/SI]; Poljubinj 89e, 5220 Tolmin (SI).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): GIORDANO, Sergio [IT/IT]; Via Cena 19, I-10078 Caselle Torinese (IT).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: MECHANICALLY CALIBRATED ANALOG TRANSDUCER FOR POSITION OR A RELATED PHYSICAL QUANTITY



(57) Abstract: An analogue position transducer (1), usable for example as a pressure switch in a household appliance, including a rigid casing (2) accommodating a deformable membrane (3) sensitive to hydraulic pressure, a first element (4) engaged to the membrane so as to be mobile along with at least one portion of membrane in a predetermined direction (A) and a second element (8) fixed to the casing and operatively coupled with the first element to provide a signal variable according to the relative position of the first element with respect to the second; in which between said first element and a portion (6) of membrane there are interposed means (40) for varying, along said predetermined direction, the relative position of said first element (4) with respect to the portion (6) of the membrane; the transducer also includes a contrast spring (28) for the membrane fitted and preloaded between the casing and the membrane itself and means (35) for adjusting the preload of the contrast spring.

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**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*

**Published:**

- *with international search report*

- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**MECHANICALLY CALIBRATED ANALOG TRANSDUCER FOR POSITION OR  
A RELATED PHYSICAL QUANTITY**

TECHNICAL FIELD

5           The present invention relates to an analogue position or correlated physical quantity transducer, usable for example as a pressure switch in a household appliance, provided with mechanical calibration.

10           BACKGROUND ART

          An electrical-dynamic position or correlated physical quantity transducer, which may be used as a pressure switch in a household appliance and which comprises a rigid casing accommodating within a  
15 deformable membrane sensitive to hydraulic pressure is known from Italian patent application n. 2002A000245; a first element consisting of a ferromagnetic core is engaged to the membrane so as to be mobile in a predetermined direction; and a second element consisting  
20 of an electrical winding forming an inductor, fixed to the casing, is operatively coupled with the first element to provide a signal variable according to the relative position of the first element with respect to the second.

          For example, a relative motion of the core with  
25 respect to the inductor along the winding axis produces a variation of resonance frequency of the inductor, which may be detected and processed by a specific electronic circuit carried by the transducer casing, for example to

provide a signal proportional to the differential hydraulic pressure exerted in use on the membrane, which, in the case of a washing machine or dryer, is subject on one side to atmospheric pressure and on the opposite side  
5 to a hydraulic pressure determined by the level of water present in the tank of the household appliance.

According to the contents of the aforesaid Italian patent application, the transducers of the described type require initial calibration of their transduction  
10 feature. Such calibration may be performed by mechanical means, as for example described in DE4444167 B4, or by means of an additional electronic circuit including a non-volatile memory unit for a series of corrective values to be applied to the values processed by the  
15 transducer, possibly provided with microprocessor.

However, the known mechanical calibration systems are large in size, present low reliability, are complex to make and assemble and are relatively difficult to use; and the electronic calibration system proposed by the  
20 aforesaid Italian patent application is costly and specialised personnel is required for correct use.

#### DISCLOSURE OF INVENTION

It is the object of the present invention to avoid  
25 the drawbacks of the known transducers, by providing a analogue position or correlated physical quantity transducer, usable for example as a pressure switch in a household appliance, free from the described drawbacks

and, in particular, which ensures at the same time limited electrical consumption, low production and assembly costs, small size, high reliability, great manufacturing and assembly ease and which finally allows  
5 to be calibrated also by personnel not trained in the use of electronic apparatuses.

The present invention therefore relates to an analogue position or correlated physical quantity transducer, in particular usable as pressure switch in a  
10 household appliance, typically a washing machine or dryer, as defined in claim 1.

In particular, the transducer according to the invention comprises a rigid casing accommodating a deformable membrane sensitive to hydraulic pressure; a  
15 first element engaged to the membrane so as to be mobile with at least one portion of membrane in a predetermined direction; and a second element fixed to the casing and operatively coupled with the first element to provide a signal variable according to the relative position of the  
20 first element with respect to the second. Between the first element and the membrane portion are interposed means for varying, along said predetermined direction, the relative position of the first element with respect to the membrane portion.

25 According to an aspect of the invention, the membrane portion is coupled adjacent with an essentially rigid cap carrying a threaded stem which extends along said predetermined direction; while the first element is

integrally carried by a threaded bushing which meshes with the stem; the mechanical calibration system is completed by means (for example screwdriver cuts and/or gripping elements adapted to allow the application of a torque, either manually or with tools) for determining a relative rotation between bushing and stem.

Such rotation means are envisaged on a end of the bushing and/or on a corresponding end of the stem. The latter may be then integrally made with the cap, or removably carried by the cap, relatively mobile along said predetermined direction by means of adjustment means interposed between stem and cap.

Finally, the transducer according to the invention comprises, in combination with the description above, a membrane contrast spring preloaded and fitted between the casing and the membrane itself and means for adjusting the preload of the contrast spring.

In this way, it is possible to integrally make, for example by co-moulding, the first element, preferably consisting of a sintered ferromagnetic core, with the bushing, and the cap with the stem and then coupling the two components simply by screwing; furthermore, the transducer requires only one spring, while the previously known transducers, provided with mechanical calibration, required two springs operating at the same time and on opposite sides of the membrane.

This allows to obtain a compact dimension and makes production and assembly very easy. At the same time, the

transducer according to the invention is very reliable and may be calibrated by non-specialised personnel, for example by connecting the transducer to a known hydraulic pressure source and a display, and then by turning the  
5 bushing until the value read on the display through detection made by the transducer is the same as that of the known hydraulic pressure.

Finally, the transducer according to the invention allows to obtain high cost reductions.

10

#### BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present invention will be apparent in the description of the following two non-limitative examples, with reference to  
15 the accompanying drawings, in which

- figure 1 is a cross-sectional and elevated view of an analogue transducer made according to the invention; and
- figure 2 is a perspective and elevated view  
20 with parts removed of a possible variant of the transducer in figure 1.

#### BEST MODE FOR CARRYING OUT THE INVENTION

With reference to figure 1, number 1 indicates as a  
25 whole an analogue position or correlated physical quantity transducer, in particular usable as pressure switch in a household appliance, known and not shown, for example a washing machine or a dryer.

Transducer 1 comprises a rigid casing 2 accommodating deformable membrane 3 sensitive to hydraulic pressure; within casing 1 are also present a first element 4 engaged to membrane 3 so as to be mobile  
5 along with at least one portion 6 (in the case in point, a middle portion) of membrane 3 in a predetermined direction, indicated by letter A in figure 1; and a second element 8, fixed to the casing 2 and operatively coupled with the first element 4 to provide in use, in  
10 the known way, a signal, preferably an electrical signal (but the signal could also be of different nature, for example optical) variable with the relative position of the first element 4 with respect to the second element 8 along direction A.

15 In the non-limitative illustrated case, first element 4 consists of a ferromagnetic material core 4 engaged rigid on membrane 3; and the second element 8 consists of an electrical winding fixed to the casing 2 and operatively coupled with core 4 to form a variable  
20 inductance electrical inductor 10; predetermined direction A also coincides with a symmetry axis B of electrical winding 8, which is also the symmetry axis of casing 2 and of the entire transducer 1.

Casing 2 is made of magnetically neutral material,  
25 preferably synthetic plastic material, and is obtained by moulding, split into at least two half shells 18,19 and a cup-shaped cover 20, which are reciprocally snappingly coupled in use. Between half shells 18 and 19 is fluid-



tightly packed a peripheral edge 3a of membrane 3, whose plan shape is generally circular, so that the membrane 3 divides the inside of casing 2 into a chamber 21 connected hydraulically to the outside through a nipple 22, and a chamber 23 maintained at atmospheric pressure (for example, through a hole 24 made through half shell 18); over chamber 23, cover 20 defines a closed compartment 25 accommodating inside an electronic board 26 to which the opposite ends of winding 8 are connected in a known way and not shown for the sake of simplicity.

Transducer 1 finally comprises a fixed abutting element 30 of membrane 3, integral with casing 11 (for example being an integral part of half shell 19), against which abutting element 30 membrane 3 rests when transducer 1 is in zero condition, in which membrane 3 is undeformed, because the same pressure is exerted on the opposite sides of the same, respectively facing chambers 21 and 23. A contrast spring 28 for membrane 3 is arranged on the opposite side of the fixed abutting element 30, arranged between membrane 3 and a second abutting element 31 of casing 2, facing and opposite to element 30, with a predetermined preload.

Such second abutting element 31 is, as will be shown more in detail below, provided with adjustment means 35, to vary the preload of contrast spring 28.

According to a first aspect of the invention, between first element 4 and membrane portion 6 are interposed means, indicated as a whole by number 40, to

vary, along direction A, the relative position of element 4 with respect to portion 6 of membrane 3; since the latter, in the mentioned zero position, rests against abutting element 30, which is placed at a fixed distance from element (winding) 8, being both integral with casing 2, it results that element 4 is relatively mobile along direction A, also with respect to element 8; furthermore, means 40 are adapted to selectively lock element 4 with respect to portion 6 of membrane 3 in a plurality of different axial positions along axis B; in this way, the relative position along direction A of element 4 with respect to element 8 is selectively variable by means 40 when membrane 3 is resting against abutting element 30, i.e. in zero position of transducer 1.

According to the invention, membrane portion 6 is coupled adjacent to, and closely in contact with, an essentially rigid cap 41 carrying a threaded stem 42 which extends along direction A. Cap 41 and stem 42 are preferably integral and moulded in synthetic plastic resin.

In combination, first element 4 is integrally carried by a threaded bushing 45, which meshes with stem 42; on corresponding ends of bushing 45 and/or stem 42 (in the case in point shown on both) are also envisaged means for determining a relative rotation between bushing 45 and stem 42.

Such rotation means consist in a screwdriver cut 46 made through the end of the stem 42 opposite to cap 41

and facing in use cover 20; and in a series of radial through compartments 47 made through the free end of a tubular shank 48 of bushing 45, integral with the same, and which overhangingly extends from bushing 42 towards  
5 cover 20, for a length longer than that of stem 42.

Shank 48 is internally threaded, as the rest of bushing 45, and meshes with the latter on an external threading of stem 42.

According to this embodiment, bushing 42, on the  
10 side of shank 48 (i.e. on side opposite to cap 41) presents a shoulder 49 against which one of the ends of contrast spring 28 rests, which is a helical spring, the other end of spring 28 resting against abutting element 31, so that spring 28 is sandwiched between bushing 45  
15 and abutting element 31, which, in this embodiment, is carried relatively mobile to direction A by casing 2.

In particular, according to that shown in figure 1, the mentioned means 35 for adjusting the preload of contrast spring 28 comprising a threaded dowel 50 meshing  
20 with a threaded seat 51 of casing 2, in the case in point made in a tubular open end 53 of half shell 18 coaxial with winding 8. Abutting element 31 is defined by a shoulder or frontal surface of threaded dowel 50 facing in use on a side opposite to cover 20 and facing bushing  
25 45. Cover 20 is coupled with half casing 18 regardless of half casing 19.

In this way, threaded dowel 50, and with this, abutting element 31, are selectively mobile along

predetermined direction A and capable of determining, with membrane 3 in zero position, a required variation (adjustment) of the preload of spring 28, i.e. of the contrast force which this applies in use to the mobile  
5 equipment constituted by ferromagnetic core 4 with bushing 45, as well as by cap 41 with stem 42, the latter being held axially integral with bushing 45 by the meshing of the respective threadings.

Furthermore, according to the invention, such  
10 selective displacement motion of the abutting element 31 is adjustable independently of the relative axial position of bushing 45 along the stem and, consequently, by the selective determination of the axial position of the magnetic coupling of ferromagnetic core 4 within  
15 winding 8.

In figure 2, number 100 indicates a transducer similar to transducer 1 of which it is a possible variant; details either similar or equal to those previously described for transducer 1 will be indicated  
20 for the sake of simplicity using the same reference numbers.

Contrast spring 28 in this case is sandwiched between an abutting element 310 fixed to and carried by casing 2 and therefore integral with second element  
25 (winding) 8, and an internally threaded sleeve 320 meshing with an externally threaded stem 420, which, like stem 42, is integrally carried by a cap 41 engaged to the central portion 6 of membrane 3, which is fitted between

half shells 18,19 like in transducer 1.

In this embodiment, stem 420 is removably carried by cap 41, with respect to which it is selectively mobile along a predetermined direction A thanks to adjustment means 400 of the relative position of stem 420 with respect to cap 41 along the predetermined direction A, which are interposed between stem 420 and cap 41 and which consist in a threaded blank seat 410 centrally made in cap 41, in axis with winding 8, and in a threaded end 430, of wider diameter, of stem 420; on the rest of stem 420 is fastened bushing 45 carrying co-moulded ferromagnetic core 4, and which is identical to that previously described, except for the fact that shank 48 is missing.

Sleeve 320, thanks to the threaded coupling with stem 420, is axially integral with the same, but at the same time, by being screwed or unscrewed on stem 420, is also relatively mobile with respect to abutting element 310 along the predetermined direction A, regardless of the movements of the mobile equipment defined by membrane 3, by stem 420 and by bushing 45, so as to be selectively positioned in a plurality of different axial positions with respect to abutting element 310 and thus allowing to adjust the force exerted by spring 28 on membrane 3 in zero position; threaded sleeve 320 is for this purpose also provided, towards bushing 45, with a flange 321 adapted to form a resting shoulder for contrast spring 28 towards said mobile equipment; sleeve 320 is also

provided with gripping means (for example radial ridges) 322 adapted to allow a user to exert on the same a torque sufficient to determine its screwing or unscrewing on stem 420, for example by means of a tool, through an end 5 passage 180 in a sleeve seat 181 of half shell 18 in which are housed spring 28, sleeve 320 and, in part, bushing 45 with respective stem 420, and externally to which winding 8 is fitted on half shell 18; such passage 180 is closed and covered in use by cover 20.

10 In use, in both embodiments, nipple 22 is connected for example to a tank of a washing machine or dryer, carrying in chamber 21 a hydraulic pressure, for example corresponding to the level of water in the tank. Membrane 3 is consequently deformed by the pressure difference 15 (chamber 23 always remains at atmospheric pressure) proportionally displacing the axial overlapping of core 4 in winding 8 and thus generating an electrical signal which is processed. The possibility of intervening during calibration, independently, on the preload of the spring 20 28 and on the relative zero position of the core 4 with respect to winding 8 allows a precise and simple calibration of the transducer. The embodiment shown in figure 2 allows to obtain more independent movements.

## CLAIMS

1. An analogue position or correlated physical quantity transducer (1;100), usable for example as a pressure  
5 switch in a household appliance, comprising a rigid casing (2) accommodating a deformable membrane (3) sensitive to hydraulic pressure; a first element (4) engaged to the membrane so as to be mobile with at least one portion (6) of membrane in a predetermined direction  
10 (A); and a second element (8) fixed to the casing and operatively coupled with the first element to provide a signal variable according to the relative position of the first element with respect to the second; **characterised in that** between said first element and said portion of  
15 membrane there are interposed means (40) for varying, along said predetermined direction, the relative position of said first element (4) with respect to the portion of membrane (6).

20 2. A transducer according to claim 1, characterised in that said first element consists of a ferromagnetic material core (4) rigidly engaged on the membrane; and said second element consists of an electrical winding (8) fixed to the casing and operatively coupled with the core  
25 to form a variable inductance electrical inductor (10); said predetermined direction (A) coinciding with a symmetry axis (B) of said electrical winding.

3. A transducer according to claim 2, characterised in that said casing (2) is made of a synthetic plastic material.

5 4. A transducer according to any of the preceding claims, characterised in that said membrane portion (6) is adjacently coupled with an essentially rigid cap (41) carrying a threaded stem (42;420) which extends along said prefixed direction (A).

10

5. A transducer according to claim 4, characterised in that said first element (4) is integrally carried by a threaded bushing (45), which meshes with said stem; means (46,47;322) for determining a relative rotation between  
15 said bushing and said stem being provided on one end of said bushing (45) and/or on a corresponding end of said stem (42;420).

6. A transducer according to claim 5, characterised in  
20 that said stem (42) is obtained integrally with said cap (41).

7. A transducer according to claim 5, characterised in that said stem (420) is removeably carried by said cap  
25 (41), and relatively mobile along said predetermined direction.

8. A transducer according to claim 7, characterised in



that adjustment means (400) of the relative position of the stem (420) with respect to the cap (41) along said predetermined direction (A) are interposed between stem and cap.

5

9. A transducer according to any of the claims from 4 to 8, characterised in that it further comprises a contrast spring (28) for the membrane preloadedly fitted between the casing (2) and the membrane itself and means  
10 (35;320) for adjusting the contrast spring preload.

10. A transducer according to claim 9, characterised in that said contrast spring (28) is sandwiched between said bushing (45) and an abutting element (31) carried in a  
15 relatively mobile fashion by the casing (2); said means (35) for adjusting the contrast spring preload including a threaded dowel (50) meshing with a threaded seat (51) of the casing so as to be selectively mobile along said predetermined direction (A) and provided towards the  
20 contrast spring with a shoulder forming said abutting element (31).

11. A transducer according to claim 9, characterised in that said contrast spring (28) is tightly secured between  
25 an abutting element (310) fixedly carried by the casing, integral with said second element (8), and a threaded sleeve (320) meshing with said stem (420) so as to be relatively mobile with respect to the abutting element

along said predetermined direction (A); said threaded sleeve (320) being provided, towards said bushing, of a flange (321) adapted to form a resting shoulder for said contrast spring.

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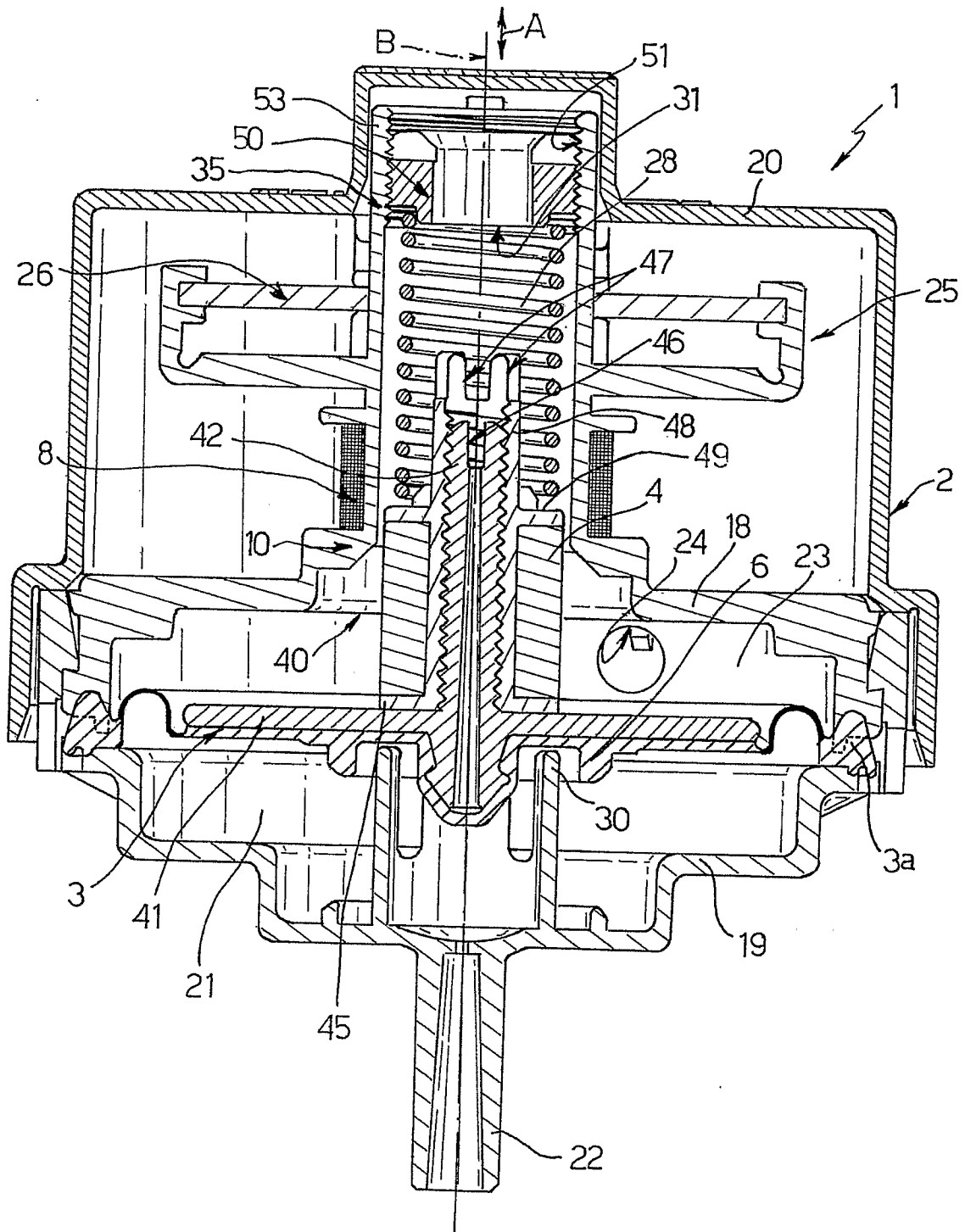


Fig. 1

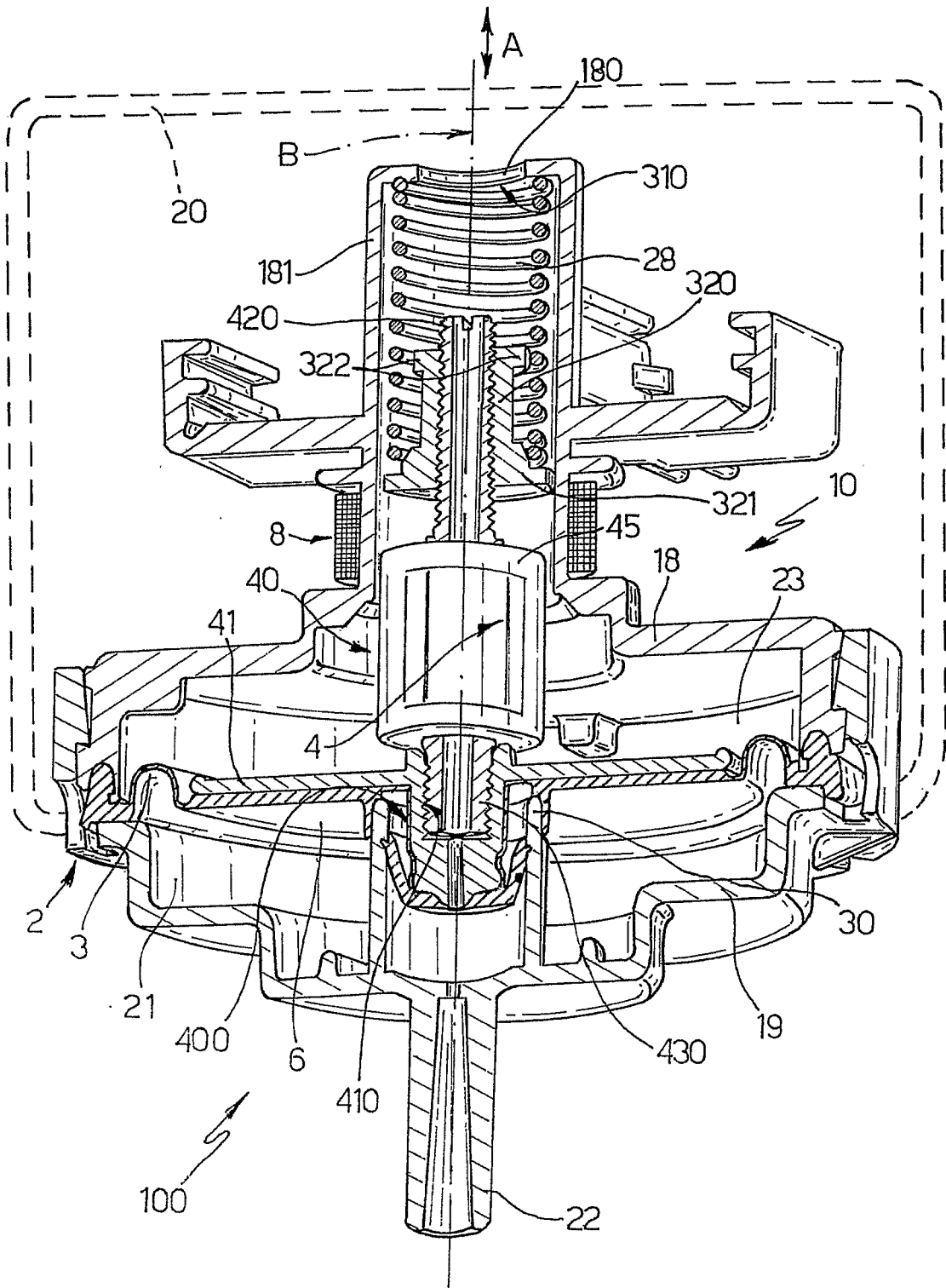


Fig. 2

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2006/002596

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. G01L9/00

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)  
G01L

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 practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 006 402 A (MINCUZZI ANTONIO) 1 February 1977 (1977-02-01) column 2, line 47 - column 4, line 48; figure 1	1,4,6
X	US 3 967 504 A (AKELEY LLOYD T) 6 July 1976 (1976-07-06) column 3, line 38 - column 4, line 25; figure 1 column 5, line 63 - column 6, line 7	1
X	US 4 165 653 A (MOREHOUSE THOMAS P [US]) 28 August 1979 (1979-08-28) column 4, line 4 - line 38; figure 1	1
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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 document but published on or after the international filing date

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"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

11 January 2007

Date of mailing of the international search report

19/01/2007

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Trique, Michael

## INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2006/002596

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 03/078951 A (ELBI INTERNAT S P A [IT]; BINDOCCI SABRINA [IT]; DA PONT PAOLO [IT]; S) 25 September 2003 (2003-09-25) cited in the application abstract; figure 1 -----	1
A	DE 44 44 167 A1 (ELBI INT SPA [IT] ELBI INTERNAT S P A [IT]) 6 July 1995 (1995-07-06) cited in the application abstract; figure 3 -----	1

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Information on patent family members

International application No PCT/IB2006/002596
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