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(54) **Title**: CONTROL VALVE FOR A COOLING SYSTEM

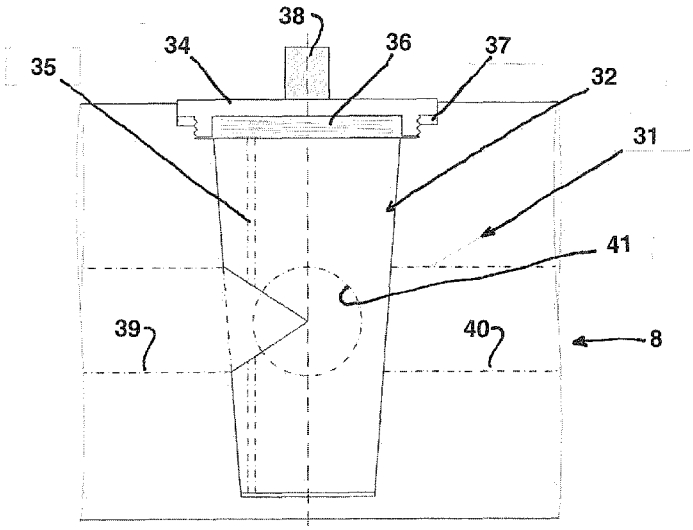

Fig. 1

(57) **Abstract**: Control valve for a cooling system, and of the type comprising a valve member(32), which by means of an electric powered modulating rotary actuator (42) is oscillating with predominantly constant velocity in a valve housing or manifold (31), where said valve housing or manifold (31)comprises a main channel, a control channel and a number of measuring channels, said valve member is constituted by piston like cylindrical member (32) being provided with a side recess(29, 30), the shape of which is ajusted in accordance with the wanted control characteristic of the control valve, and that said electric modulating rotary actuator (42) is adapted to execute oscillating or swinging movements between extreme predetermined angular positions. Hereby it is by means of simple provisions possible to achieve a control valve for use in cooling systems by way of example for hydraulic fluid in hydraulic control systems in wind power turbine or similar control systems, where the importance of precise and reliable temperature control is indeed significant.

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Control valve for a cooling system

Field of the Invention

The present invention relates to a control valve for a cooling system and of the type indicated in the preamble to claim 1.

Background of the Invention

In connection with the temperature control by way of example in cooling systems for hydraulic fluid in hydraulic control systems in wind power turbines it is very important with a precise and reliable temperature control system.

Object of the Invention

The purpose of the present invention is to provide an improved control valve of the introductory mentioned type and by which it by simple provisions is possible to achieve a control valve for use in cooling systems by way of example for use in cooling systems for hydraulic fluid in hydraulic control systems in wind power turbine or similar control systems, where the importance of precise and reliable temperature control is indeed significant.

Description of the Invention

The control valve according to the invention is characterized in that said valve housing or manifold comprise a main channel, a control channel and a number of measuring channels, said valve member is constituted by a piston like cylindrical member being provided with a side recess, the shape of which is adjusted in accordance with the wanted control characteristic of the control valve, and that said electric modulating rotary actuator is adapted to execute oscillating or swinging movements between extreme predetermined angular positions.

By means of simple provisions it becomes hereby possible to achieve a control valve for use in cooling systems by way of example for hydraulic fluid in hydraulic control systems in wind power turbine or similar control systems, where the importance of precise and reliable temperature control is indeed significant.

By its oscillating angular movement the valve actuator mixes the two temperatures of the medias to a certain controlled inlet temperature for by way of example converters, generators and gearboxes for wind turbine generators.

In a preferred embodiment the control valve according to the invention is such provided, that said recess of said cylindrical member has a shape as a lying V with the pointed end positioned in horizontal position approximately along a transverse axis.

By this preferred embodiment the control valve according to the invention may furthermore be such provided, that said cylindrical member is provided with a central longitudinal channel with circular cross section, said central channel is connected with said side recess.

In an alternative embodiment the control valve according to the invention may be provided such, that said recess of said cylindrical member have mutually parallel sides, which in a distance from each other extends perpendicular to a centre plane through said cylindrical member.

The control valve according to the invention may be such provided, that said electric modulating rotary actuator is adapted to perform oscillating or swinging movements between extreme points with a mutual angular difference of abt. 90° - 180°.

In a first embodiment the control valve according to the invention may be such provided, that said electric modulating rotary actuator is adapted to execute oscillating or swinging movements between extreme points with a mutual angular difference of abt. 90°.

Or in another control valve according to the invention may be such provided, that said electric modulating rotary actuator is adapted to execute oscillating or swinging movements between extreme points with a mutual angular difference of abt. 180°.

Description of the Drawing

The invention is described in more detail in the following with reference to the drawing - in which:

Fig. 1 shows a plane view - partly in section - of an embodiment for a control valve according to the invention

Fig. 2 shows a plane sectional view through the channels of valve housing or manifold of the control valve cf. Fig. 1,

Fig. 3 shows in two views cylindrical piston members with a lying V-shaped side recess (to the left hand side of Fig. 3) and with a lying squared side recess (to the right hand side of Fig. 3)

Fig. 4 shows a plane view illustrating comparison graphs illustrating valve members with triangular (V-shaped) recess and squared recess, respectively,

Fig. 5 shows a diagram of a complete liquid cooling system for the hydraulic liquid for a hydraulic control system by way of example for a wind power turbine comprising a control valve according to the invention,

Fig. 6 shows in a side view and a top view an embodiment of an electric modulating rotary actuator used to rotate the piston like valve member of a control valve according to the invention, and

Fig. 7 shows a perspective view of an embodiment of a modified valve member comprising a cylindrical central, longitudinal channel communicating with the lying V-shaped side recess of the valve member.

Detailed Description of the Invention

The control valve according to the invention shown in Figs. 1 and 2 comprises a valve housing or manifold 31 provided with a central conical main channel or bore for a conical cylindrical valve member 32 communicating with manifold ports in the form of an inlet port 39 for cold liquid, a inlet port for 40 for warm liquid and a supply port 41 for mixed liquid. The dotted lines of Fig. 2 define the passage where the fluid flows from the cold inlet port 39 to the supply port 41.

The internal valve cylinder is made conical with the same slope as that of the central, main bore of the valve housing or manifold 31. In this manner is assured that in case of wear, the valve cylinder will still be able to prevent internal leakage in the manifold. This is achieved by inserting a spring 36 in top of the valve cylinder 32, generating a

preloaded downwards force on the valve cylinder in its seat. In case of an internal wear of the valve cylinder 32, the spring 36 on top of the valve cylinder 32 will secure that the cylinder still fits firmly in its seat.

To make sure that the spring 36 always is able to make the valve cylinder fit closely in its seat, even if an internal leakage should occur, the valve cylinder is made with a balancing port 35. This way the flowing fluid will always generate the same forces on the top and the bottom of the valve cylinder 32 in opposite directions.
In the top of the valve housing or manifold 31 a top lid 34 is mounted and tightened by means of a ring-shaped gasket 37 and with said spring 36 positioned between the top of the valve cylinder 32 and the top lid 34.

In order to prevent galvanic corrosion and for obtaining important mechanical advantages such as reduced wear and friction/stick-slip etc. the valve housing or manifold 31 and possible also the top lid 34 can be produced from a suitable durable and wear resistant material such as sea water resistant aluminium, by way of example EN AW 5083. And the valve cylinder 32 may be produced from acid-proof stainless steel, by way of example AISI316, or a suitable durable technical plastic such as PETP TX (polyethylenterephtalat) possibly comprising a small amount of PTFE (Teflon).

The conical valve member 32 is provided with a side recess 29 having a shape as a lying V with the pointed ends of the recess positioned in a horizontal plane along a transverse centre line or axis of the valve member 32. Alternatively, the valve member 32 may be provided with a squared side recess 30. By rotation of the valve member 32 with oscillating forward and backward turns by means of an electric modulating rotary actuator 42 (Fig. 6) it is possible to obtain a precise and reliable control valve by way of example for controlling the temperature of the hydraulic liquid in the hydraulic control systems in wind power turbine or similar control systems, where the importance of precise and reliable temperature control is indeed significant.

The velocity of the turning of the valve member 32 forwards and backwards in said oscillating movement is rather slow as the turning rate of the valve member 32 through 90° is in the order of 90 sec. The leakage from the control valve is very little in the or-

der of 0.2 l/min by a flow in the order of 160 l/min. The overall flow rate of the control valve is between 100 - 250 l/min.

Cooling systems making use of a control valve according to the invention may be used for many different purposes such as cooling systems for frequency converters, electric power generators, gearboxes and other similar cooling systems, where precision, durability and reliability are the key words.

The two main principles regarding the shape of said side recesses of the valve members 32 and 33 are illustrates in Fig. 3, where in the left hand side the lying V-shaped recess 29 is shown, while the squared side recess 30 is shown in the right hand side of Fig. 3.

Fig. 4 shows a comparison of the two types of control valves having triangular (lying V-shaped) side recess and having squared side recess, respectively.

The following conditions are common for the shown graphs or plots:

a) constant turbulent flow [l/min]
b) 52 % v/v antifrogen N-water mixture. Constant temperature of 20° C; density 1085 [kg/m^3]
c) pressure drop across the valve assumed constantly 0.2 [bar]
d) flow discharge coefficient C_d = 0.6 [-].

The two graphs show the function between the Flow [l/min] over the turning angle [°] of the respective valve members.

Fig. 5 illustrates by way of example a diagram of a complete liquid cooling system comprising a 3-way mixing or control valve 8 according to the invention possible with electric modulating rotary actuator 42.

Fig. 6 illustrates in two views the preferred type of electric modulating rotary actuator 42. Of course it would be possible to make use of a similar electric stepping motor for the rotating of the valve member 32.

In Fig. 7 is shown an alternative embodiment of a valve member 33 with a central bore communicating with the lying V-shaped side recess of the valve member 33.

Drawing reference numbers:

1:	Pump (Fig. 5)
2, 5, 9, 12:	Ball valves 1½'' (Fig. 5)
3, 6, 7, 10:	Hoses DN40 (Fig. 5)
4:	Strainer, 50 micron
8:	3-way mixing control valve with actuator (2-10V) (Fig. 5)
11:	Heater (Fig. 5)
13, 19, 21:	Needle valves (Fig. 5)
14:	Pressure gauge (Fig. 5)
15, 20:	Pressure transmitter (4-20mA) (Fig. 5)
16:	Pressure switch (Fig. 5)
17, 24:	Test connections (Fig. 5)
18:	Air vent valve (Fig. 5)
22:	Expansion tank 8 L (Fig. 5)
23:	Temperature transmitter PT100 (Fig. 5)
25:	Safety valve (Fig. 5)
26:	Plastic bottle (Accumulation of coolant from safety valve) (Fig. 5)
27:	Cooler (Fig. 5)
28:	Cylindrical valve member (Figs. 3 and 7)
29:	Lying V-shaped side recess (Figs. 1, 3 and 7)
30:	Squared side recess (Fig. 3)
31:	Valve housing, Manifold (Fig. 1)
32:	Conical cylindrical valve member (Fig. 1)
33:	Cylindrical valve member with central bore (Fig. 7)
34:	Top lid (Fig. 1)
35:	Balance port (Fig. 1)
36:	Spring (Fig. 1)
37:	Gasket (Fig. 1)
38:	Turning tap (squared) (Figs. 1, 3 and 7)
39:	Cold inlet (Fig. 2)
40:	Warm inlet Fig. 2)
41:	Supply outlet (Fig. 2)
42:	Electric modulating rotary actuator (Fig. 6)

CLAIMS

1. Control valve for a cooling system, and of the type comprising a valve member (32), which by means of an electric modulating rotary actuator (42) is oscillating with predominantly constant velocity in a valve housing or manifold (31), **characterized in** that said valve housing or manifold (31) comprise a main channel, a control channel and a number of measuring channels, said valve member is constituted by a piston like cylindrical member (32) being provided with a side recess (29, 30), the shape of which is adjusted in accordance with the wanted control characteristic of the control valve, and that said electric modulating rotary actuator (42) is adapted to execute oscillating or swinging movements between predetermined angular extreme positions.

2. Control valve according to claim 1, **characterized in** that said recess (29) of said cylindrical member has a shape as a lying V with the pointed end positioned in horizontal position approximately along a transverse axis.

3. Control valve according to claim 2, **characterized in** that said cylindrical member (33) is provided with a central longitudinal channel with circular cross section, said central channel is connected to said side recess (29).

4. Control valve according to claim 1, **characterized in** that said recess (30) of said cylindrical member have mutually parallel sides, which in a distance from each other extends perpendicular to a centre plane through said cylindrical member.

5. Control valve according to any of the preceding claims, **characterized in** that said electric modulating rotary actuator (42) is adapted to execute oscillating or swinging movements between extreme points with a mutual angular difference of abt. 90° - 180°.

6. Control valve according to any of the preceding claims, **characterized in** that said electric modulating rotary actuator (42) is adapted to execute oscillating or swinging movements between extreme points with a mutual angular difference of abt. 90°.

7. Control valve according to any of the preceding claims, **characterized in** that said electric modulating rotary actuator (42) is adapted to execute oscillating or swinging movements between extreme points with a mutual angular difference of abt. 180°.

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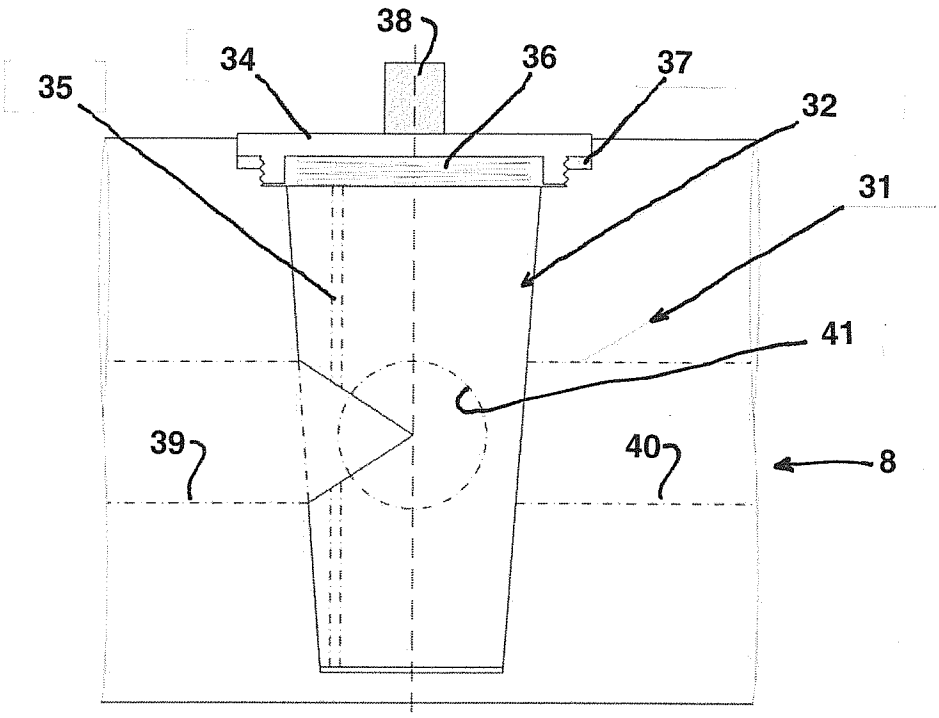

Fig. 1

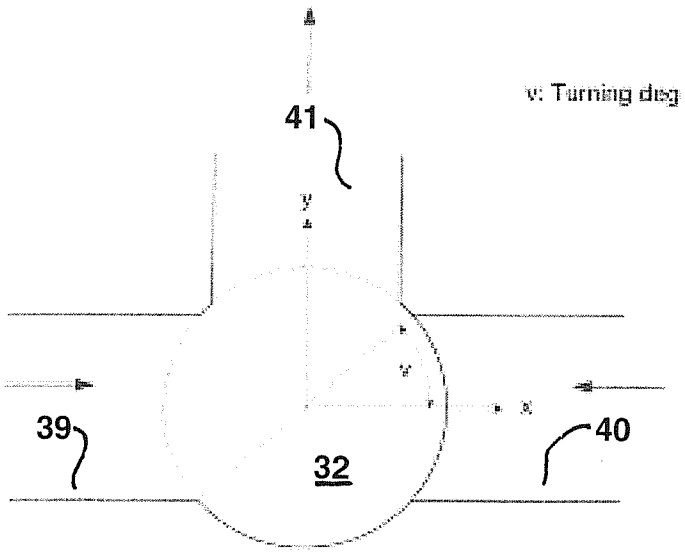

Fig. 2

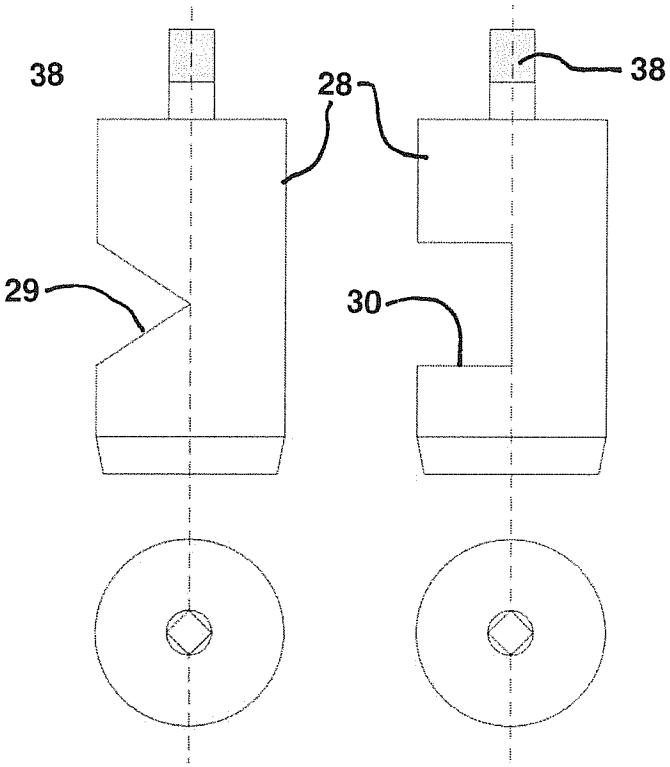
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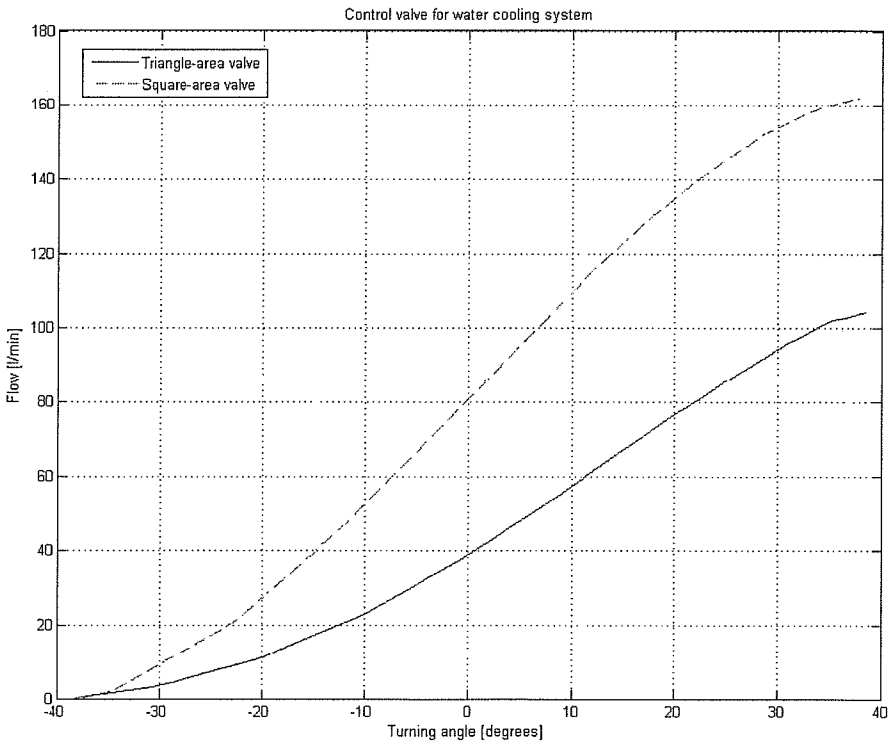
Fig. 3


Control valve for water cooling system
Triangle-area valve
Square-area valve
Flow [l/min]
Turning angle [degrees]
180
160
140
120
100
80
60
40
20
0
-40
-30
-20
-10
0
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30
40

Fig. 4

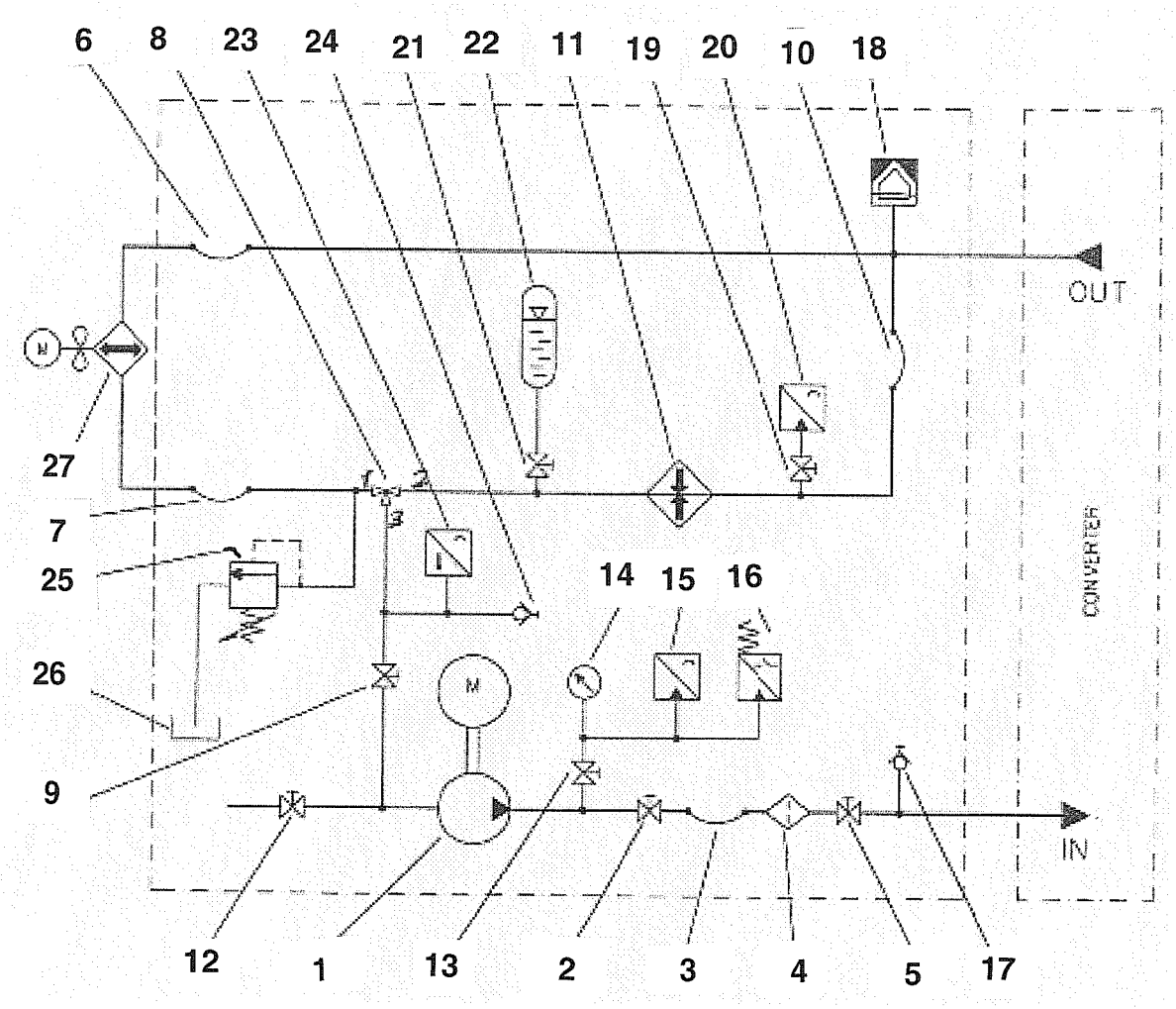
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Fig. 5

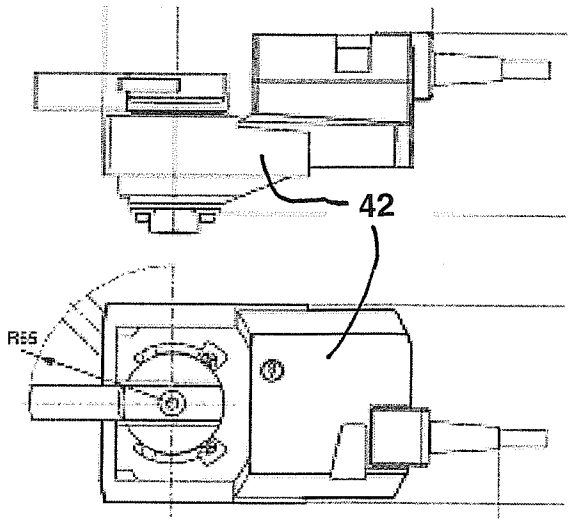
42
RES

Fig. 6

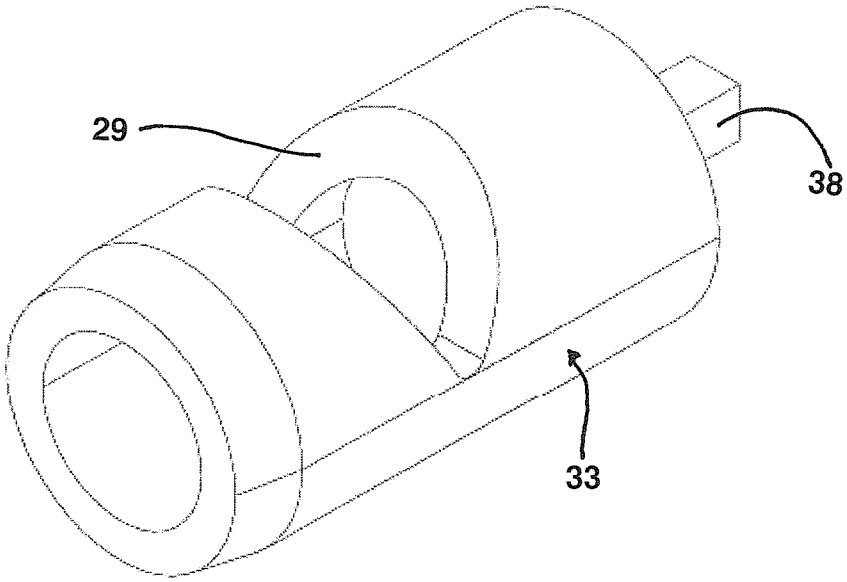

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2009/050206

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: F16K

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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	WO 03100950 A1 (ROBERT BOSCH GMBH), 4 December 2003 (04.12.2003), figure 4, abstract, page 6, paragraph 2	1-7

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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 December 2009	16 -12- 2009
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Andreas Fredriksson / JA A Telephone No. +46 8 782 25 00

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Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/DK2009/050206

WO	03100950	A1	04/12/2003	DE	10223362 A	04/12/2003
				EP	1512213 A	09/03/2005