



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.04.2017 Bulletin 2017/15

(51) Int Cl.:
F04B 7/00 (2006.01) **F04B 39/08 (2006.01)**
F04B 49/03 (2006.01) **F04B 53/10 (2006.01)**
F04B 49/24 (2006.01)

(21) Application number: **16191483.3**

(22) Date of filing: **29.09.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
MA MD

(72) Inventors:
 • **Lilie, Dietmar Erich Bernhard**
89204-060 Joinville (BR)
 • **Lohn, Sérgio Koerich**
88090-221 Florianópolis (BR)

(74) Representative: **Soldatini, Andrea et al**
Società Italiana Brevetti S.p.A.
Corso dei Tintori, 25
50122 Firenze (IT)

(30) Priority: **02.10.2015 BR 102015025294**

(71) Applicant: **Whirlpool S.A.**
04578-000 São Paulo SP (BR)

(54) **INTAKE VALVE ACTUATING SYSTEM, COMPRESSORS STARTING METHOD AND ITS USES**

(57) The present invention relates an intake valve actuating system (13), specially to reciprocating machines, the use of said system in compressors and a compressors starting method, promoting advantages on the compressors starting, minimizing the power needed on said reciprocating machines. Specially, the present invention comprises a controlled actuating mean (1) ac-

tuating an intake valve (13), by a coil (7), while a piston (12) starts its reciprocating movement. The intake valve (13) can be displaced, at the expense of the reciprocating movement of the piston (12), displacing a relief spring (10), avoiding overloading the coil (7). The present invention is situated on field of Mechanical Engineer, more precisely on the area of Flow Machines.

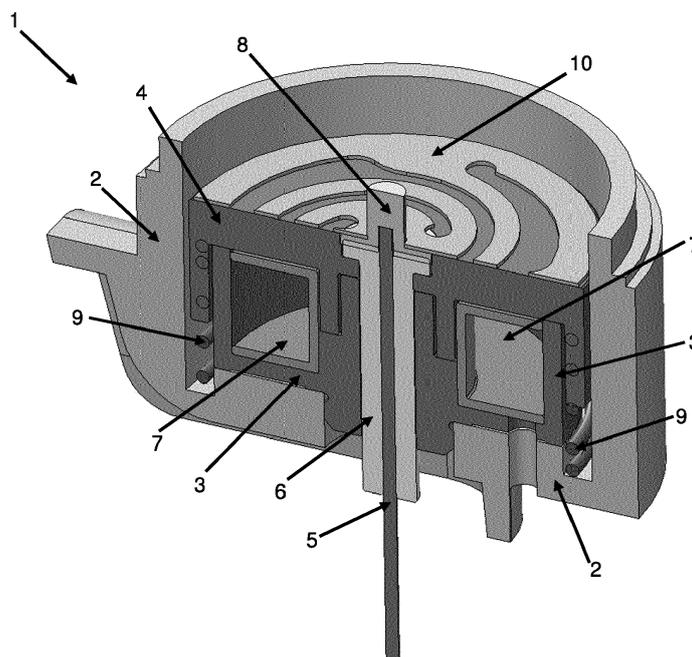


Figure 1

DescriptionField of the Invention

[0001] The present invention describes an intake valve actuating system and a method for starting compressors. In preferred embodiments, the present invention may be used in reciprocating machines such as compressors. The present invention lies in the field of Mechanical Engineering, specifically the flow machines area.

Background of the Invention

[0002] Reciprocating machines are mechanical devices widely used today because they are versatile and have wide applicability in various sectors of industry.

[0003] An example of reciprocating movements is those promoted from a set of mechanisms, commonly known as connecting rod and crank, which transforms the rotation of a shaft into reciprocating motion (to-and-from) which is intended to reciprocatingly displace any device.

[0004] Reciprocating machines enjoy the reciprocating element in a pressurizer, such as a piston to pressurize fluids within a chamber. It is further provided a set of valves for the fluid to be pressurized is directed correctly when leaving the compression chamber. Due to the reciprocating movement of the pressurizer element and the performance of directional valves, is knowledge of the skilled in the art that reciprocating machines need a large initial torque to the starting of the both the inertia of the components and, especially, because the pressurizer element already starts the working cycle by compressing a portion of the fluid to be pressurized.

[0005] It is also the knowledge of ordinary skill in the art, the use of an actuating mechanism in the intake valve of reciprocating machines, which aims to promote the opening of said intake valve during the first instants after the starting of the reciprocating machine, in order to reduce the initial starting torque. After the reciprocating machine supplying the initial inertia and assuming a constant rotation, the valve is closed, and an effective pressurization of the fluid is started.

[0006] For construction and performance issues, current reciprocating machines are built from a pressurizer piston traveling as much as possible course, coming very close to the top of the pressurization chamber, part where commonly the intake valves are housed and discharge. This compact arrangement of the elements makes pressurizer piston to touch the intake valve, which in normal operation, should be closed so that would happen the pressurization of the desired fluid. When this occurs, there is a direct impact on the device which operated the intake valve so that it remained open during the starting. If said device to keep the intake valve open is a solenoid, it will be forced, while magnetized in the opposite direction to the field you are applying, which promotes greater energy consumption.

[0007] In the search for prior art in scientific and patent literature, the following documents related to the matter were found:

The PI0806059 discloses a pressure relief system for gas compressors, so as to reduce the initial starting torque and to avoid "bumps" of the compressor, while in high-load conditions. Among the disclosed embodiments can highlight the use of stems and mechanical devices for actuation of the intake valve in accordance with the rotation imposed to the compressor. It was also revealed magnetic media for this function. However, the document PI0806059, beyond revealing complex mechanisms and susceptible to vibration and balance of the compressor, does not reveal a safe and effective way to not damage the intake valve in case the piston will touch it.

[0008] The US20070272890 discloses a solenoid device used to work in reciprocating compressor intake valves in order to regulate the internal pressure of the pressurizing chamber during periods of time when you want to control said internal pressure in the chamber of said reciprocating compressor. This document discloses several means to be made available to the solenoids used, including a system for compensating the differential pressure. This document, however, does not reveal an effective way to solve the piston contact problem in the intake valve, without the solenoid which acts on said intake valve is damaged.

[0009] Thus, what is clear from the literature, no documents were found suggesting or anticipating the teachings of the present invention, so that the solution proposed here has novelty and inventive activity against the state of the art.

[0010] In view of the above, we see the imminent need for a mechanism of action of valves that is not damaged or increase the power consumption of reciprocating machines, at the beginning of the operation of said reciprocating machine.

Summary of the Invention

[0011] Thus, the present invention solves the constant problems in the prior art, from a system and intake valve actuation (13) of reciprocating machines. More specifically, the present invention discloses a system capable of keeping the intake valve system (13) in a pre-set condition for the time of starting a compressor to the piston and, after stabilization of rotation, according to pre-defined values, the present invention stops acting on said intake valve (13).

[0012] It is, therefore, a first object of the present invention to provide an intake valve opening system (13), comprising:

- a) controlled actuation means (1); and
- b) actuating stem (5) associated to the controlled

actuation means (1),

the system being defined by the fact that the controlled actuation means (1) projecting the actuating stem (5) into an opening direction (OD) sufficient to promote the opening of the intake valve (13), and in that the actuating stem (5), the controlled actuation means (1), or both comprise displacement absorbing means in a sense of relief (RD) opposite the projection imposed by the controlled actuation means and comprises return means of the actuating stem (5) in position enough to promote the reopening of the intake valve (13).

[0013] It is a second object of the present invention to provide a method for starting compressors, defined by the fact that the system is as disclosed by the present invention and said method comprises the actuating steps through controlled actuation means (1) for opening an intake valve (13) according to the displacement movement of a piston (12) in the compression direction.

[0014] It is a third and last object of the present invention to provide the use of intake valve opening system (13), defined by the fact that the system be as disclosed by the present invention and be employed in a compressor.

[0015] Further, the common inventive concept to all the claimed protection context refers to the fact of the present invention to provide an intake valve opening system (13) in pressurization chambers (21) for reciprocating machines, so request a lower torque for the start of this reciprocating machine. Specifically, the present invention acts on the intake valve (13) of a compressor so as to not allow during the first instants of starting the compressor, builds up pressure in the pressurizing chamber. This measure makes the initial torque required for starting said compressor lower, reducing energy consumption and eliminating the need for electrical and electronic components that were used in the prior art to enable the start with higher torques.

[0016] These and other objects of the invention will be immediately appreciated by those versed in the art and by companies with interests in the sector, and will be described in sufficient detail to reproduce in the description below.

Brief Description of the Figures

[0017] In order to better define and clarify the content of this patent application, these figures are presented:

Figure 1 illustrates a cross-sectional view of the present invention, where it is possible to see the inner mechanisms to the outer casing (2) through the controlled actuation (1).

Figure 2 shows a sectional elevation of the present invention, wherein the movable piston (4) is in an upper position and the coil (7) has just been activated.

Figure 3 illustrates the sequence of operation, where

it is perceived that the moving piston (4) is starting its path towards the static element (3).

Figure 4 shows the moving piston (4) in its final position with the stem (5) displaced downwards and acting on the valve element (13).

Figure 5 illustrates the instant when a piston (12) touches the intake valve (13), returning the actuating stem (5) and deforming the relief spring (10).

Figure 6 shows a set of pressurizer element (12) and pressurizing chamber (21) provided with actuation system on the valve element (13).

Figure 7 is similar to Figure 5, but in this image the pressurizer element (12) is in a top position, after having come into contact of said element with the valve element (13) and retracted the valve (13).

Detailed Description of the Invention

[0018] In a first object the present invention provides an intake valve opening system (13) comprising:

- a) controlled actuation means (1); and
- b) actuating stem (5) associated to the controlled actuation means (1),

the system being defined by the fact that the controlled actuation means (1) projects the actuating stem (5) into an opening direction (OD) sufficient to promote the opening of the intake valve (13), and in that the actuating stem (5), the controlled actuation means (1), or both comprise displacement absorbing means in a sense of relief (RD) opposite the projection imposed by the controlled actuation means and comprises return means of the actuating stem (5) in position enough to promote the reopening of the intake valve (13).

[0019] In one embodiment, the controlled environment of action is given by applying electric current.

[0020] In one embodiment, the displacement absorbing means is comprised of at least one of the group defined by: elastic mechanical element; electric current intensity controller; Spring-gas; fluid compression; a calibrated balance masses; or equivalent.

[0021] As springy mechanical element, we can exemplify in a non-limiting manner, the plate springs and compression. As for the embodiment that deals with the calibrated mass use for balance, is it exemplified not restrictively, that the construction of the actuating stem (5) and other peripherals associated with this, must be done accurately, so the actuating stem assembly (5) has total mass such that it is able to overcome the force imposed to open the intake valve (13) when the means of controlled operation (1) is triggered. When the piston (12) comes against the intake valve (13), the actuating stem (5) is pushed in the opposite direction to that which the means for controlled actuation (1) imposed by moving the metered mass and allowing the closure of said intake valve (13). The actuating stem (5) back to open the intake valve so that the piston returns.

[0022] In one embodiment, the intake valve actuation system is defined by the fact that:

- a) actuation means is a solenoid fitted with a magnetizable movable plunger (4) housing the actuating stem (5), the solenoid being able to impose displacement of the moving piston (4) into an opening direction (OD);
- b) means of displacement absorption is a spring (10) associated to the movable piston (4) and actuating stem (5) able to allow, through elastic deformation, the displacement of the actuating stem (5) in a relief direction (RD), otherwise the displacement of the movable piston (4) when magnetized.

[0023] In a second object, the present invention provides a method for starting compressors, defined by the fact that the system is as disclosed by the present invention and said method comprises the medium controlled actuation trigger steps (1) to open an intake valve (13) in accordance with the displacement movement of a piston (12) in the compression direction.

[0024] In one embodiment, the actuating of controlled actuation means (1) takes place during the compressor start.

[0025] In an embodiment of the present invention, the compressor starting method includes the steps of:

- a) activating a controlled actuation means (1) for opening an intake valve (13);
- b) initiating displacement movement of a piston (12) in the compression direction;
- c) absorbing piston displacement movement (12) when in contact with the intake valve (13),

controlled actuation means (1) being held actuated during all steps (a) to (c).

[0026] In a preferred embodiment, the controlled actuation means is disabled when the compressor reaches the pre-defined operating conditions to maintain an operating system.

[0027] In a third and last object of the present invention, the system and method described are employed in a compressor.

[0028] In a preferred embodiment of the present invention, the hermetic type compressor is used to feed cooling cycles.

Example 1. Preferred Embodiment

[0029] The examples shown herein are intended to illustrate only one of many ways of performing the invention, but without limiting the scope thereof.

[0030] Figure 1 illustrates how controlled actuation means (1) of intake valves (13) was achieved. In this picture it is clear that the outer casing (2) is associated with a static element (3) and the coil (7) of the solenoid. Said coil (7) is responsible for inducing magnetic force

moving piston (4) to promote movement of said movable piston (4) towards the static element (3). This movement causes deformation of a return spring (9), which is responsible for returning the movable piston (4) to its original position when the coil (7) do not exert more force on said movable piston (4). The movable plunger (4) is associated with the internal sleeve (6) by interference fitting between them and the actuating stem (5) is fixed to the relief spring (10) the locking element (8). The movement promoted in the movable piston (4) causes the elements associated with it also having said movement, and it is this movement that causes the intake valve (13) present at the inlet of a reciprocating machine, is kept open. During testing, they showed their advantages for the construction of the inner sleeve (6) from a material which is electrically insulating. This prevents the actuating stem (5) to be directly influenced by the magnetic field generated by the coil (7).

[0031] Figures 2, 3 and 4 show a sequence of how the controlled action is taken intake valve (13) in reciprocating compressors.

[0032] Figure 2 illustrates the initial time of operation of the controlled actuation means (1). With the induction of electric current, the coil (7) attracts the movable piston (4) into an opening direction (OD) by moving the actuating stem (5) and compressing the return spring (9). When moving, the movable piston (4) is magnetically attracted by the coil (7) leading from the relieving spring (10) associated with the actuating stem (5) via the locking element (8). Once actuated, the actuating stem (5) opens intake valve (13).

[0033] Figure 3 illustrates the means for controlled actuation (1) at an instant that the movable piston (4) is in an intermediate position of the displacement in opening direction (OD). The return spring (9) remains depressed, the inner stem (5) continues to move in the opening direction (OD), once the locking element (8) associating said inner stem (5) to the relief spring (10) and the inner sleeve (6) mounted with interference on the movable piston (4), also follow the movement in the opening direction (OD).

[0034] Figure 4 illustrates the moment when the piston (4) completes the displacement in opening direction (OD), with the return spring (9) fully compressed and the actuating stem (5), the inner sleeve (6) and the locking element (8) completely displaced to said opening direction (OD). In this position, an intake valve (13) is fully open, depending on displacement of actuating stem (5).

[0035] Figure 5 illustrates the moment when, due to shock from a piston (12) against the intake valve (13), the displacement of the actuating stem (5) and the locking element (8) in a direction relief (RD), tensioning the relief spring (10). The displacement of the actuating stem (5), according to the relief direction (RD), allows the return of the intake valve (13) which is displaced by movement of a piston (12) operating in a reciprocating compressor. The relief spring (10) has calibration such that deformation is promoted with less effort than the supportable by

the magnetic field imposed by the coil (7), this ensures that said relief spring (10) always deform first, avoiding the displacement of the movable plunger (4). When the piston (12) ceases to have contact with the intake valve (13), the relief spring (10) is responsible for displacing the actuating stem (5) and locking element (8) in opening direction (OD). This movement again opens the intake valve (13) so as not to allow pressurization to take place in a chamber (21) of a reciprocating compressor. During the return of the actuating stem (5), as mentioned above, the inner sleeve (6) remains fixed in the movable piston (4). It is an opening and closing cycle of the intake valve (13) in accordance with the teachings of the present invention, and this cycle of opening and closing is responsible for not allowing pressure build-up in the chamber (21), reducing the amount torque required for starting a compressor containing the teachings disclosed herein. Additional embodiments for this concept relief intake valve (13) relate to the use of calibrated weights on the locking element (8) so as to dispense with the relief spring (10). Said calibrated weights are adjusted for moving in the opening direction (OD) when the movable piston (4) moves downwardly, moving the actuating stem (5) so as to open the intake valve (13). Analogously to the operation of the relief spring (10) calibrated weights are adjusted for moving towards relief (RD) when the piston (12) contacting the intake valve (13).

[0036] Figure 6 illustrates a set pressurizer (22) comprised of the pressurizing chamber (21), the piston assembly (12), rod (19) and handle (20), responsible for pressurization of a fluid in a set pressurizer (22). The pressurizer said assembly (22) further comprises intake ducts (17), inlet chamber (15), exhaust ducts (18) and discharge volume (16). In normal operating conditions, the discharge valve (14) operates to transfer pressurized fluid from the pressurizing chamber (21) into the discharge volume (16). The means controlled actuation (1) is also shown acting in the opening of the intake valve (13). In this position, the internal housing elements (2) through the controlled actuation (1) assume a position similar to that shown in Figure (4). The crank (20) actuating the rod (19) performs a movement in the rotation direction (N).

[0037] Figure 7 illustrates the pressurizer assembly (22) at the instant that the piston (12) touches the intake valve (13) actuated by actuation means controlled (1). The moment depicted in figure 7, is analogous to that shown in Figure 5, with the actuating stem (5) and displaced deforming the relief spring (10) in the direction of relief (RD).

[0038] Those skilled in the art will value the knowledge presented herein, and may play the invention shown in the embodiments, and other embodiments which fall within the scope of the appended claims.

Claims

1. Intake valve actuating system, comprising:

- a. controlled actuating mean (1); e
- b. actuating stem (5) associated to the controlled actuating mean (1),

the system **characterized by**:

- the controlled actuating means (1) project the actuating stem (5) in an opening direction (OD) sufficient to promote the opening of the intake valve (13);
- the actuating stem (5), the controlled actuating means (1), or both comprises displacement absorption means in a relief direction (RD) opposite to the projection imposed by the controlled actuating means and comprise actuating stem return (5) in position sufficient to promote the intake valve reopening (13).

2. Intake valve actuating system according to claim 1, **characterized by** the fact that the controlled actuating means happens applying a controlled electrical current.

3. Intake valve actuating system according to any of claims 1 to 2, **characterized by** the displacement absorption mean is comprised by at least one of the comprised on the group defined by: elastic mechanical element; electrical current intensity controller; spring-gas; fluid compression; balance by controlled mass; or similar.

4. Intake valve actuating system according to any of claims 1 to 3, **characterized by**:

- a. the actuating mean being a solenoid having a magnetizable movable plunger (4) housing an actuating stem (5), the solenoid being capable of displace the movable plunger (4) in an opening direction (OD);
- b. the displacement absorption mean being a spring (10) associated to the movable plunger (4) and to the actuating stem, capable of allowing, by means of an elastic deformation, the actuating stem displacement (5) in a direction contrary to the movable plunger displacement (4), when magnetized.

5. Method for starting compressors, in which the compressor uses a reciprocating piston for compressing a fluid and comprises an intake valve actuating system as defined in any of claims 1 to 4, the method being **characterized by** comprising the steps of controlled actuating mean actuation (1) for the opening of an intake valve (13) according to the displacement

movement of a piston (12) on the compression direction.

6. Method for starting compressors, according to claim 5, **characterized by** actuating the controlled actuation mean (1) during the compressor starting. 5
7. Method for starting compressors, according to claim 5, **characterized by** comprising the steps of: 10
- a. activates a controlled actuating mean (1) for opening an intake valve (13);
 - b. start displacement movement of a piston (12) to the compression direction;
 - c. absorb the piston displacement movement (12), when in contact with the intake valve (13), 15
- the controlled actuating mean (1) being held actuated during all steps (a) to (c). 20
8. Method for starting compressors, according to any of claims 5 to 7, **characterized by** the fact that controlled actuating mean (1) is disabled when the compressor reaches pre-defined operation conditions for maintenance of an operation regimen. 25
9. Use of the intake valve actuating system, **characterized by** the system being as defined in any of claims 1 to 4 and for being used in a compressor. 30
10. Use of the intake valve actuating system according to claim 9, **characterized by** the compressor being of hermetic type for feeding cooling cycles. 35

35

40

45

50

55

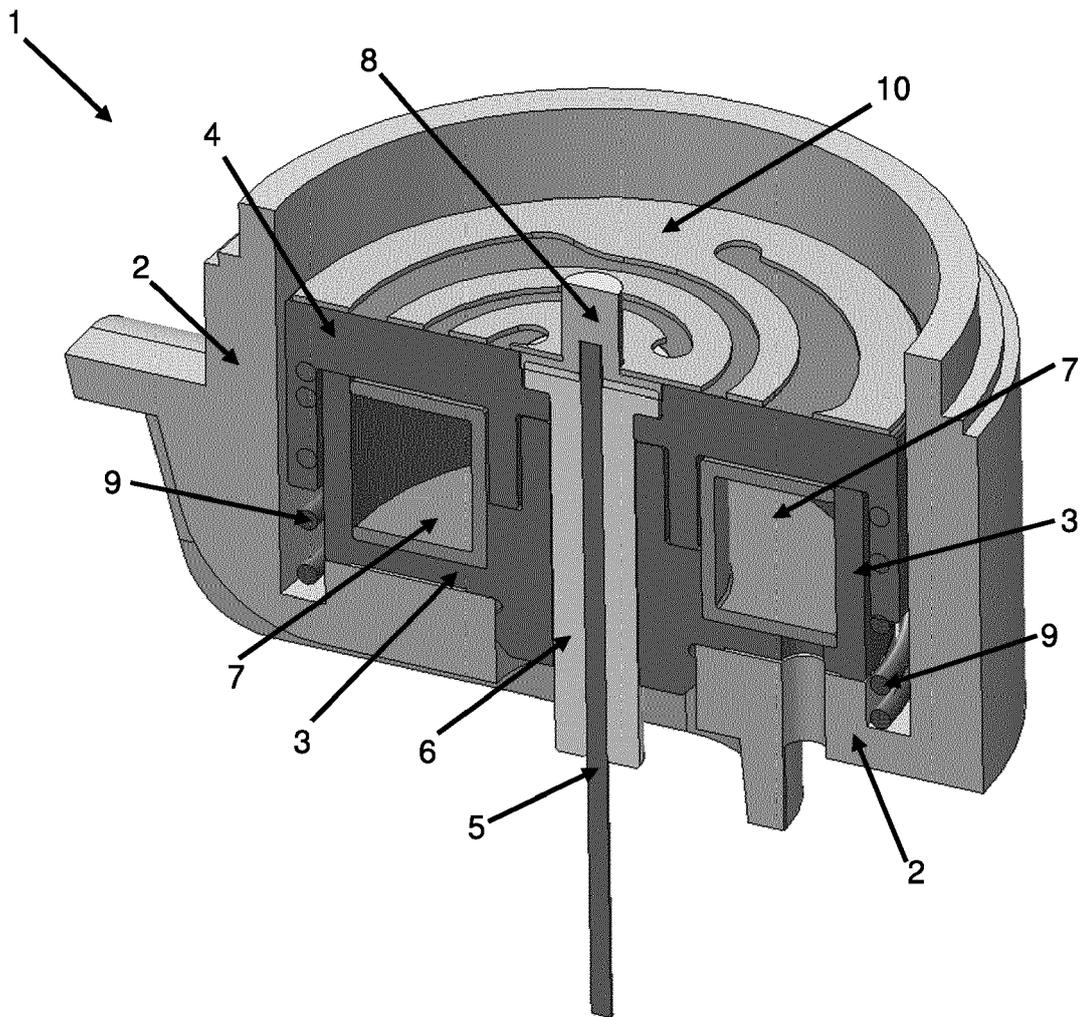


Figure 1

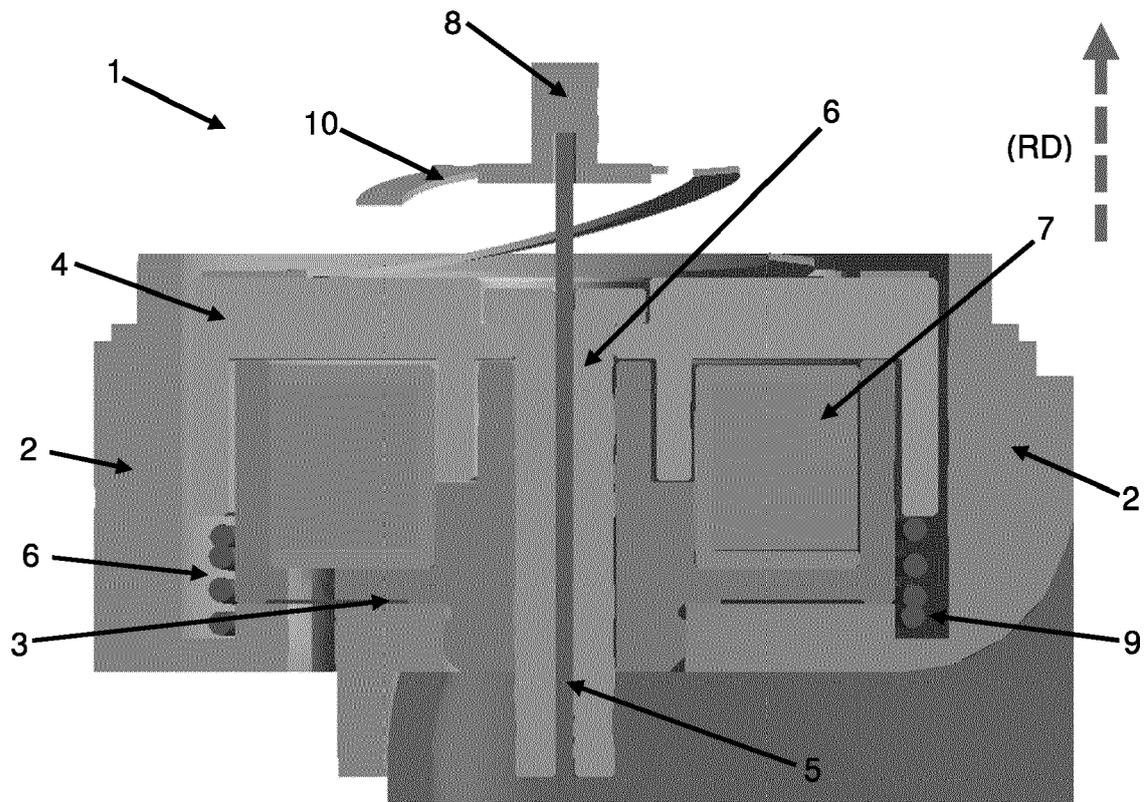


Figure 5

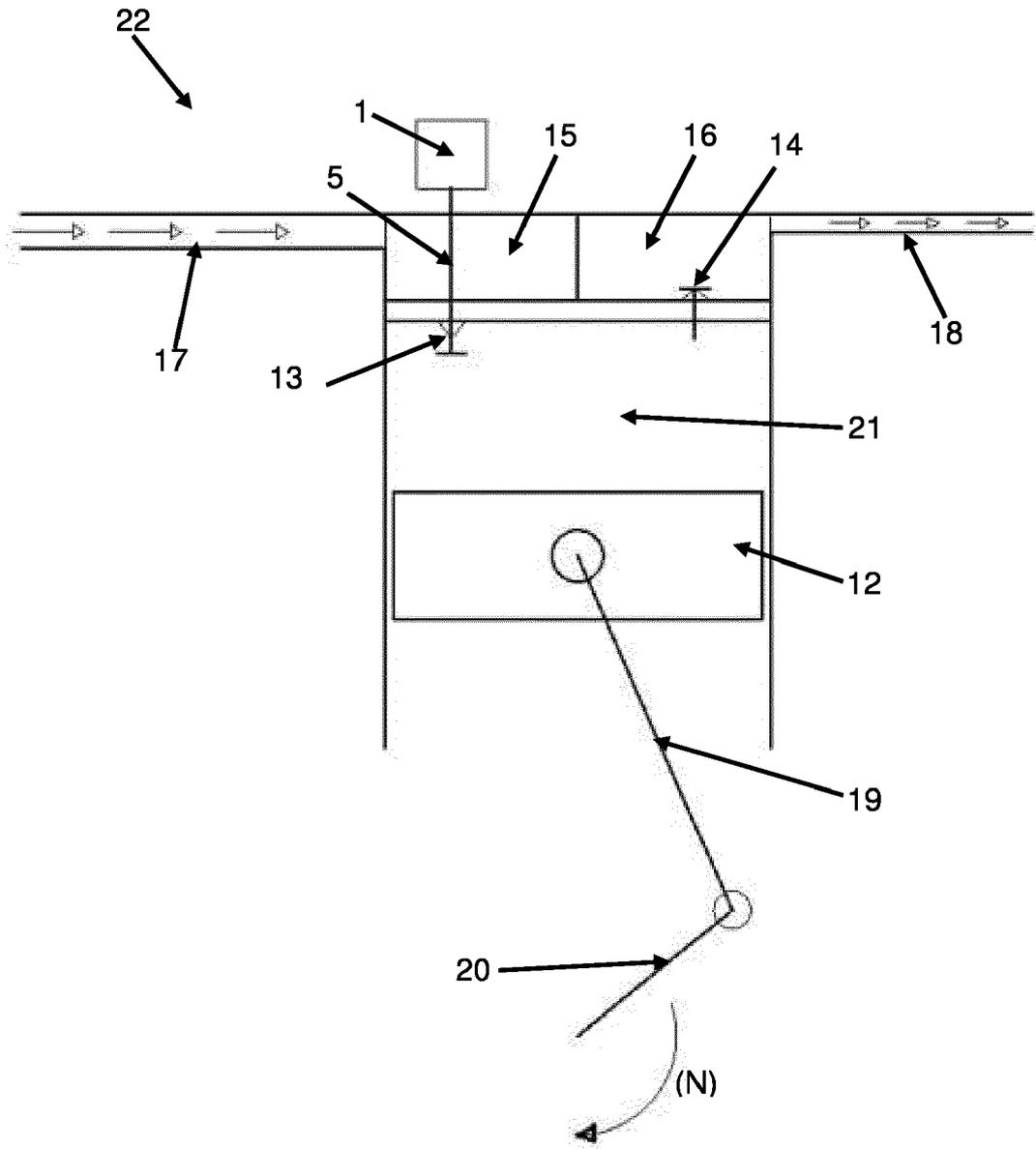


Figure 6

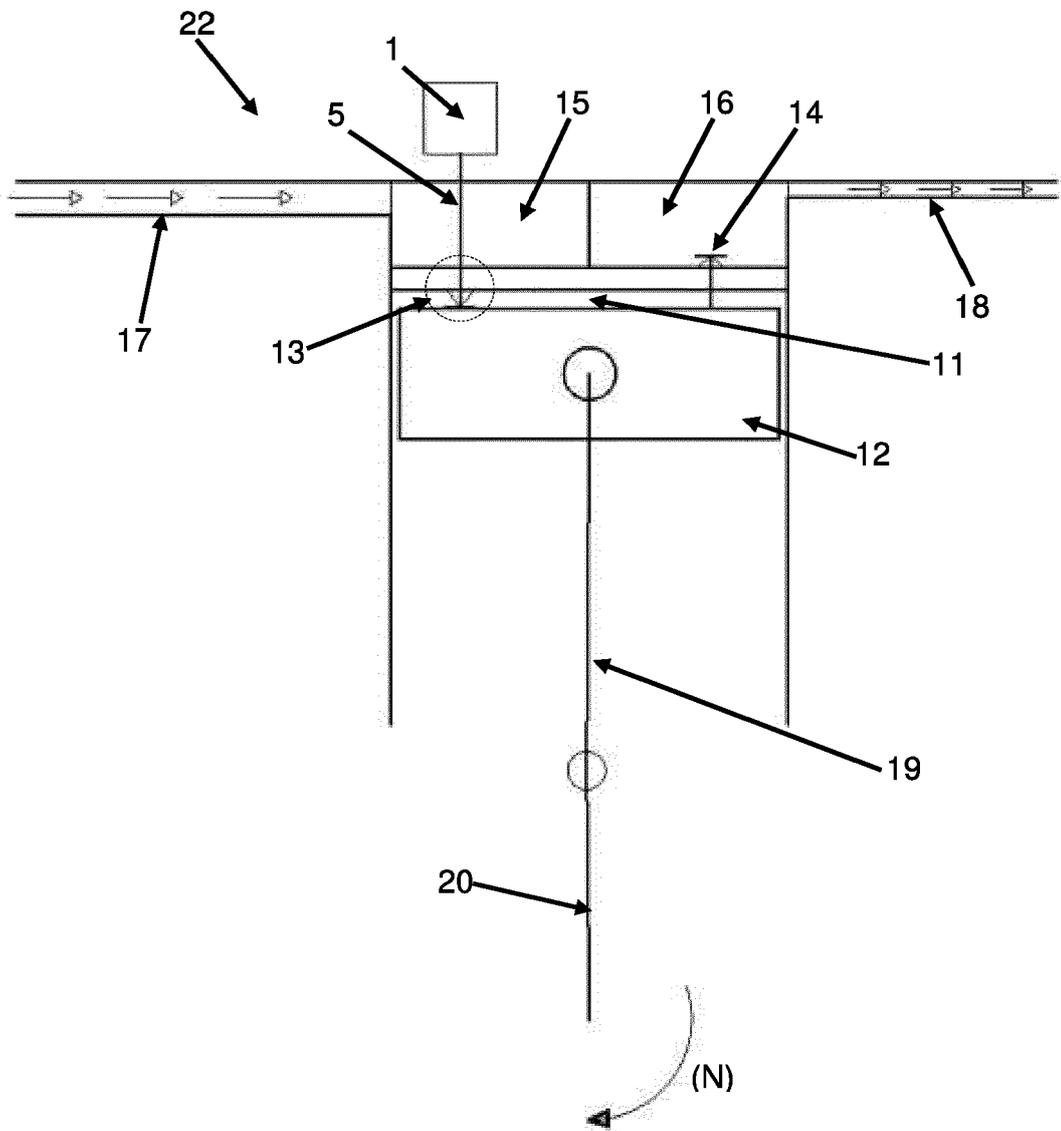


Figure 7



EUROPEAN SEARCH REPORT

Application Number
EP 16 19 1483

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 373 891 B1 (WHIRLPOOL SA [BR]) 31 October 2012 (2012-10-31) * abstract *; figures 2-12 * * paragraphs [0007] - [0010], [0038], [0062] - [0066] * -----	1-10	INV. F04B7/00 F04B39/08 F04B49/03 F04B53/10 F04B49/24
X	DE 100 57 831 A1 (KNF FLODOS AG SURSEE [CH]) 23 May 2002 (2002-05-23) * abstract *; figure * * paragraphs [0002] - [0018], [0023] - [0032] * -----	1-10	
X,D	US 2007/272890 A1 (KOPECEK HERBERT [DE] ET AL) 29 November 2007 (2007-11-29) * abstract *paragraph 28-38; figures * -----	1-10	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F04B
Place of search		Date of completion of the search	Examiner
Munich		24 February 2017	Pinna, Stefano
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.02 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 16 19 1483

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-02-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2373891	B1	31-10-2012	
		BR PI0806059 A2	21-09-2010
		CN 102301137 A	28-12-2011
		EP 2373891 A1	12-10-2011
		ES 2398414 T3	19-03-2013
		JP 5596698 B2	24-09-2014
		JP 2012510022 A	26-04-2012
		KR 20110093911 A	18-08-2011
		SG 171830 A1	28-07-2011
		SI 2373891 T1	30-04-2013
		US 2011311382 A1	22-12-2011
		WO 2010060169 A1	03-06-2010

DE 10057831	A1	23-05-2002	NONE

US 2007272890	A1	29-11-2007	NONE

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US PI0806059 A [0007]
- US 20070272890 A [0008]