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(54) Title: A SELF REGULATING AIR THROTTLE VALVE, METHOD OF REGULATING AIR, AND METHOD OF ASSEMBLING THEREOF

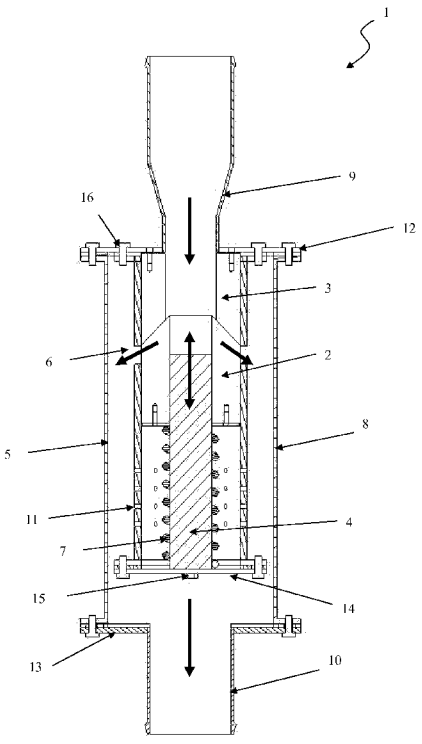

FIG. 1

(57) Abstract: Embodiments of disclosure relate to self regulating air throttle valve comprising male plunger (2) and female plunger (3); helical spring (7) supporting the male plunger at one end and other end is fixed to flange (14); a plunger guide (4) passing through the helical spring and attached to the flange at one end using fasteners and other end is passed through the male plunger; a manifold (5) comprising one or more breathing ports (6) on its surface, said manifold is configured to house said male and said female plungers; and an outer cover (8), housing the manifold, and is attached to an inlet manifold (9) at top of the outer cover and an outlet manifold (10) at bottom of the outer cover; wherein said male plunger is regulated by force of compressed air supplied through the inlet manifold and reverse force of the helical spring to vary rate of opening of the breathing ports to regulate the air throttle valve.

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— *of inventorship (Rule 4.17(iv))*

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A SELF REGULATING AIR THROTTLE VALVE, METHOD OF REGULATING AIR, AND METHOD OF ASSEMBLING THEREOF

TECHINCAL FIELD

Embodiments of the present disclosure relate to air throttle valve, more particularly relates to self regulating air throttle valve used in fuel cell.

BACKGROUND OF THE DISCLOSURE AND PRIOR ARTS

Polymer electrolyte fuel cell stack is used for generation of power on-board. Hydrogen is used as fuel and air is used as oxidant. Hydrogen and air is humidified prior to feeding into fuel cell stack. Both hydrogen and air pressurized and pressure balanced for optimum performance of stack. There is a requirement of valve for throttling and regulation of air at the out of stack. Air throttle valve may be of motorized or pneumatic type. An airflow regulation system and method for fuel cell stack includes a compressor that supplies air. Fuel cell air subsystems outlet is connected to the air throttle valve. This throttling is required to maintain the humidity of air for maintaining the high proton conductivity for optimum performance of fuel cell stack.

STATEMENT OF THE DISCLOSURE

Accordingly, the present disclosure provides for a self regulating air throttle valve (1), comprising a male plunger (2) and a female plunger (3) of predetermined shapes; a helical spring (7) supporting the male plunger (2) at one end of the spring (7) and other end of the spring is fixed to a flange (14); a plunger guide (4) passing through the helical spring (7) and attached to the flange (14) at one end using fasteners (15) and other end is passed through the male plunger (2); a manifold (5) comprising one or more breathing ports (6) on its surface, said manifold (5) is configured to house said male (2) and said female plungers (3); and an outer cover (8), housing the manifold (5), wherein said outer cover (8) is attached with an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8), wherein said male plunger (2) is regulated by force of compressed air supplied through the inlet manifold (9) and reverse force of the helical spring (7) to vary rate of opening of the breathing ports (6) to regulate the air throttle valve, also provides for a method of regulating air using a self regulating air throttle valve (1), said method comprising act

of exerting pressure of air onto a male plunger (2) through inlet manifold (10) using a compressor, wherein reverse force generated by helical spring regulates movement of male plunger (2) for varying opening of breathing ports (6) for regulating air through the valve (1), and also provides for a method of assembling a self regulating air throttle valve (1), said method comprising acts of supporting a helical spring (7) to male plunger (2) at one end of the helical spring (7) and fixing other end of the spring to a flange (14); passing a plunger guide (4) through the helical spring (7) and attaching to the flange (14) at one end using fasteners (15) and passing other end of the plunger guide through the male plunger (2); connecting a female plunger to a flange (12); mounting a manifold (5) to house said male (2) and said female plungers (3) using fasteners (16); attaching an outer cover (8) to the manifold (5) through the flange (12) to house the manifold (5); and fixing an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8) through flanges (12, 13).

OBJECTS OF THE DISCLOSURE

The object is to provide a self regulating air throttle valve.

Another object is to provide a method of regulating air using self regulating air throttle valve.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The novel features and characteristic of the disclosure are set forth in the appended claims. The disclosure itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying figures. One or more embodiments are now described, by way of example only, with reference to the accompanying figures wherein like reference numerals represent like elements and in which:

FIGS. 1 and 2 shows a self regulating air throttle valve according to present disclosure; and

FIG. 3 shows graph of Force Vs Deflection for the spring according to the present disclosure.

The figures depict embodiments of the disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying figures, which form a part hereof. In the figures, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, and figures are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the figures, can be arranged, substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and make part of this disclosure.

This disclosure is drawn, *inter-alia*, to a self regulating air regulating valve, a method of regulating air and a method of assembling.

In one embodiment, a self regulating air throttle valve (1), comprising a male plunger (2) and a female plunger (3) of predetermined shapes; a helical spring (7) supporting the male plunger (2) at one end of the spring (7) and other end of the spring is fixed to a flange (14); a plunger guide (4) passing through the helical spring (7) and attached to the flange (14) at one end using fasteners (15) and other end is passed through the male plunger (2); a manifold (5) comprising one or more breathing ports (6) on its surface, said manifold (5) is configured to house said male (2) and said female plungers (3); and an outer cover (8), housing the manifold (5), wherein said outer cover (8) is attached with an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8); wherein said male plunger (2) is regulated by force of compressed air supplied through the inlet manifold (9) and reverse force of the helical spring (7) to vary rate of opening of the breathing ports (6) to regulate the air throttle valve.

In one embodiment said male (2) and female (3) plungers are made of corrosion resistant material selected from a group comprising Teflon, Stainless Steel, Titanium, poly Vinyl dine fluoride, and Aluminum Alloys.

In one embodiment the inlet manifold, the female plunger, the male plunger and the outlet manifold are axially aligned with each other.

In one embodiment shape of the male plunger (2) is conical, wherein shape of said female plunger (3) matches with the shape of the male plunger (2).

In one embodiment, the manifold (5) comprises one or more vent ports (11) on its surface to prevent chocking of air inside the manifold (5).

In one embodiment said outer cover (8) is a cylindrical structure, wherein the inlet manifold (9) and the outlet manifold (10) are attached to the outer cover (8) through flanges (12, 13).

In one embodiment, a method of regulating air using a self regulating air throttle valve (1), said method comprising act of exerting pressure of air onto a male plunger (2) through inlet manifold (10) using a compressor, wherein reverse force generated by helical spring regulates movement of male plunger (2) for varying opening of breathing ports (6) for regulating air through the valve (1).

In one embodiment, a method of assembling a self regulating air throttle valve (1), said method comprising acts of supporting a helical spring (7) to male plunger (2) at one end of the helical spring (7) and fixing other end of the spring to a flange (14); passing a plunger guide (4) through the helical spring (7) and attaching to the flange (14) at one end using fasteners (15) and passing other end of the plunger guide through the male plunger (2); connecting a female plunger to a flange (12); mounting a manifold (5) to house said male (2) and said female plungers (3) using fasteners (16); attaching an outer cover (8) to the manifold (5) through the flange (12) to house the manifold (5); and fixing an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8) through flanges (12, 13).

FIGS. 1 and 2 illustrate a self regulating air throttle valve according to the disclosure. The valve comprises an inlet manifold attached at its top for receiving compressed air from a compressor. The said inlet manifold is of tubular shape and is gradually converging for channelizing the inlet air. The inlet manifold is attached to the outer cover through a flange using fasteners. One end of the inlet manifold is connected to the compressor for receiving the pressurized air and other is connected to female plunger which is fixed at top of the outer cover. Inner diameter of the inlet manifold and inner diameter of the female plunger are same to maintain pressure of the air entering through the female plunger. The female plunger is fixed to the flange and mounted inside the manifold. The manifold is aligned axially with the outer cover and fixed to it through a flange using fasteners like screws. The manifold further comprises a plunger guide axially fixed at bottom of the manifold using another flange. A helical spring is mounted around the plunger guide and is attached to the flange at one end and its free end is fixed to a male plunger at its top. The male plunger is mounted inside the manifold such that the helical spring is supporting the male plunger and is guided by the plunger guide longitudinally or axially. Both the male plunger and the female plunger are made of alloy material such as Teflon, Stainless Steel, Titanium, poly Vinyl dine fluoride, Aluminum Alloys which is resistant to corrosion, withstand a temperature ranging from about 40°C to about 100°C and 100% saturated air. The female plunger has an inward conical end which matches and receives protruded conical end of the male plunger. The manifold comprises four breathing ports about its surface at the junction where the female plunger and the male plunger ends meets. The opening of the breathing ports is used for regulating air which is being regulated due to movement of the male plunger axially along the plunger guide. The air enters through the inlet manifold, passes through the female plunger and the opening of the breathing ports and enters to the space in the outer cover to come out of the valve through the outlet manifold. The outlet manifold is further connected to a fuel cell stack for oxidation for generating energy.

The manifold also has plurality of vent ports about its surface at the portion where the helical spring is mounted and below the male plunger during non operating condition. The non operating condition is one in which there is no gap between the male and female plunger. The vent ports help in escaping invaded air through it and prevent

chocking of the air inside the manifold. The manifold is made of SS 316, SS304 material and is a cylindrical structure. The plunger guide, the outer cover, the inlet and outlet manifold are made of metallic material like SS 316, SS304.

The air throttle valve is designed based on the principle of balancing of forces due to pressure and opposing force by spring due to tension arising due to compression of steel spring. The throttle valve is self regulating type and does not require any controller for adjusting the venting rate. The spring is chosen such that it matches the force exerted by pressure of air and vent openings is adjusted by moving piston and vent is opened. The vent port is designed such that vent opening is adjusted by movement of piston required level of throttle is achieved and required back pressure is created for various operating conditions. Air compressor thrust increases RPM with increasing current demand; the thrust on the spring also increases (compression) which results in movement of male plunger and to increase in the venting area.

As highly water vapor saturated air is used and the temperature fluid is at about 75°C, the design of the valve has to withstand the operating conditions. The working pressure of the valve is between 1 bar to 3 bars, and maximum pressure for Teflon plunger at 65°C is 18 bars.

The humidity of fuel cell stack and thermal balance due to water condensation is maintained and water retention by polymer electrolyte is improved. Thereby high ionic conductivity is maintained at all operating conditions like Air mass flow rate, pressure, temperature and humidity.

Working of the self regulated air throttle valve

The Self Regulated Air Throttle Valve (SRATV) regulates the stack pressure by controlling the flow of air with saturated water vapor delivered by the stack. The air throttle valve comprises of variable nozzle, spring and housing of blocks. The SRATV works on the principle of balancing thrust exerted by pressure by air compressor and tension on the spring which counters the force exerted by air compressor. Two Teflon rods are aligned in line in the flow direction and are configured as male and female plungers. The Teflon male plunger is conical shaped and Teflon female plunger is machined such that Teflon male plunger mates over without an air gap when air

compressor is not operating. The Teflon male plunger is allowed to move freely and the movement is regulated by supporting steel spring. Tension on the steel spring and thrust exerted by air compressor counters each other and resulting in thrust force to decide the location of the Teflon male plunger's position. The gap between male and female plungers regulates the flow of air. As the air compressor thrust increases with RPM (increasing current demand), the thrust on the steel spring also increases which results in movement of Teflon male plunger and also increased in the venting area. The Air Throttle Valve is designed in such a way that for various air compressor RPM, the valve is opened and vented the air and maintain the pressure of stack to a required level. The opening is directly proportional to the thrust exerted by the air compressor. The pressure regulation is done automatically and there is no need of any Engine Control Unit (ECU) generated signal for pressure regulation. The area and steel spring with appropriate tension is chosen for construction. FIG. 3 illustrates graph of Force Vs Deflection for the spring according to the present disclosure, wherein the force is directly proportional to the displacement of the spring for the specific requirement. This further is dependent on the design of fuel cell stack.

Advantages and applications

The air throttle valve doesn't require electric controller.

The air throttle valve is a pneumatic in nature and is self regulating.

The air throttle valve is simpler in construction, cost effective, compact, ease in assembling and manufacture.

The air throttle valve is applicable, wherever self regulation is required depending on the input pressure.

Referral Numerals:

1: Self regulating air throttle valve,

2: Male plunger,

3: Female plunger,

4: Plunger guide,

5: Manifold,

6: Breathing ports,

7: Helical spring,

8: Outer cover,

9: Inlet manifold,

10: Outlet manifold,

11: Vent Ports,

12, 13, and 14: Flanges, and

15, 16: Fasteners

Equivalents

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation *is* explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean *at least* the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means *at least* two recitations, or *two or more* recitations). Furthermore, in

those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

We claim:

1. A self regulating air throttle valve (1), comprising:
   a. a male plunger (2) and a female plunger (3) of predetermined shapes;
   b. a helical spring (7) supporting the male plunger (2) at one end of the spring (7) and other end of the spring is fixed to a flange (14);
   c. a plunger guide (4) passing through the helical spring (7) and attached to the flange (14) at one end using fasteners (15) and other end is passed through the male plunger (2);
   d. a manifold (5) comprising one or more breathing ports (6) on its surface, said manifold (5) is configured to house said male (2) and said female plungers (3); and
   e. an outer cover (8), housing the manifold (5), wherein said outer cover (8) is attached with an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8);

   wherein said male plunger (2) is regulated by force of compressed air supplied through the inlet manifold (9) and reverse force of the helical spring (7) to vary rate of opening of the breathing ports (6) to regulate the air throttle valve.

2. The self regulating air throttle valve as claimed in claim 1, wherein said male (2) and female (3) plungers are made of corrosion resistant material selected from a group comprising Teflon, stainless steel, titanium, poly Vinyl dine fluoride, and aluminum alloys.

3. The self regulating air throttle valve as claimed in claim 1, wherein the inlet manifold, the female plunger, the male plunger and the outlet manifold are axially aligned with each other.

4. The self regulating air throttle valve as claimed in claim 1, wherein shape of the male plunger (2) is conical, wherein shape of said female plunger (3) matches with the shape of the male plunger (2).

5. The self regulating air throttle valve as claimed in claim 1, wherein the manifold (5) comprises one or more vent ports (11) on its surface to prevent chocking of air inside the manifold (5).

6. The self regulating air throttle valve as claimed in claim 1, wherein said outer cover (8) is a cylindrical structure, wherein the inlet manifold (9) and the outlet manifold (10) are attached to the outer cover (8) through flanges (12, 13).

7. A method of regulating air using a self regulating air throttle valve (1), said method comprising act of exerting pressure of air onto a male plunger (2) through inlet manifold (10) using a compressor, wherein reverse force generated by helical spring regulates movement of male plunger (2) for varying opening of breathing ports (6) for regulating air through the valve (1).

8. A method of assembling a self regulating air throttle valve (1), said method comprising acts of:
   a. supporting a helical spring (7) to male plunger (2) at one end of the helical spring (7) and fixing other end of the spring to a flange (14);
   b. passing a plunger guide (4) through the helical spring (7) and attaching to the flange (14) at one end using fasteners (15) and passing other end of the plunger guide through the male plunger (2);
   c. connecting a female plunger to a flange (12);
   d. mounting a manifold (5) to house said male (2) and said female plungers (3) using fasteners (16);
   e. attaching an outer cover (8) to the manifold (5) through the flange (12) to house the manifold (5); and
   f. fixing an inlet manifold (9) at top of the outer cover (8) and an outlet manifold (10) at bottom of the outer cover (8) through flanges (12, 13).

9. A fuel cell comprising a self regulating air throttle valve (1) as claimed in claim 1.

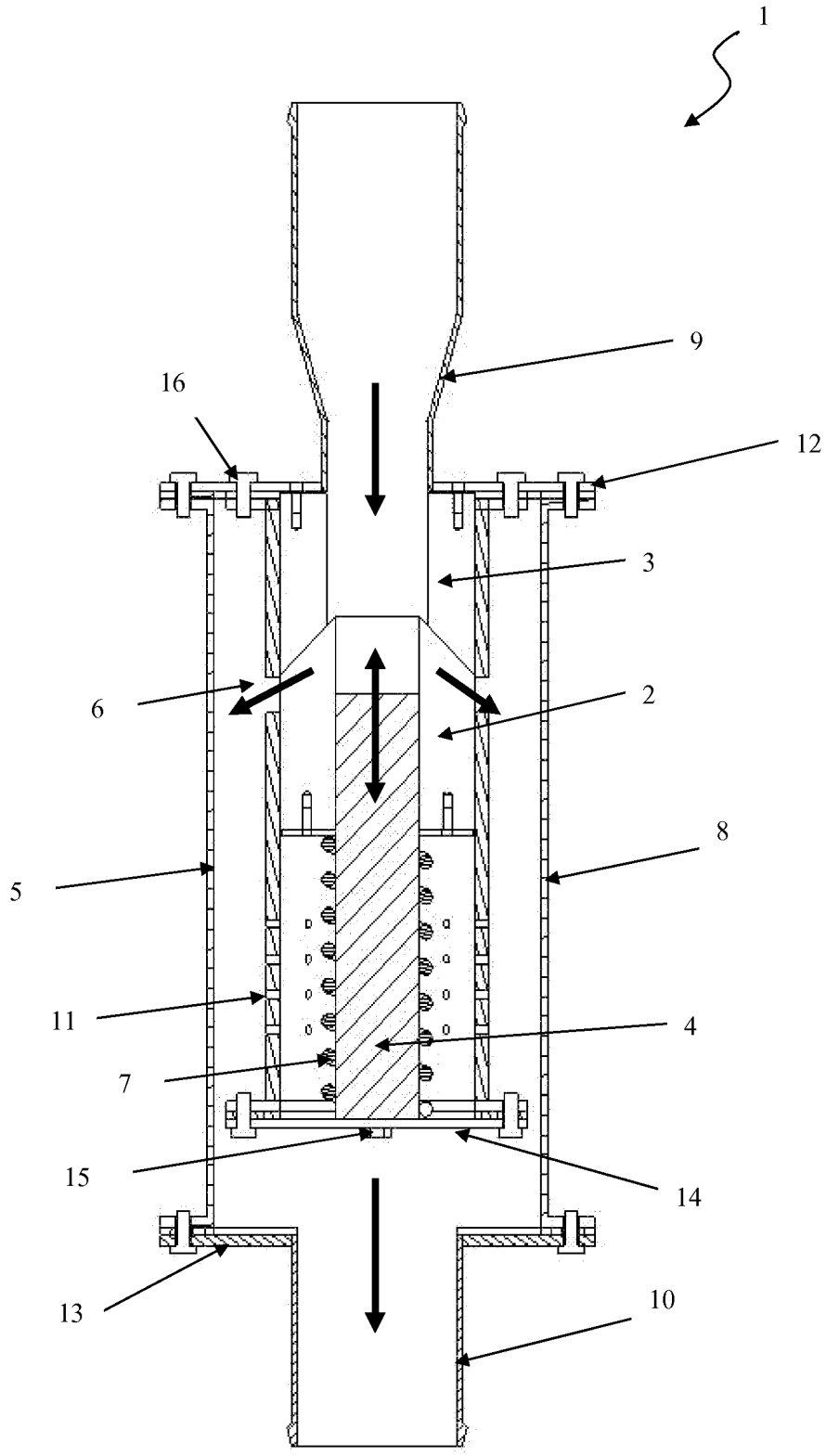

FIG. 1

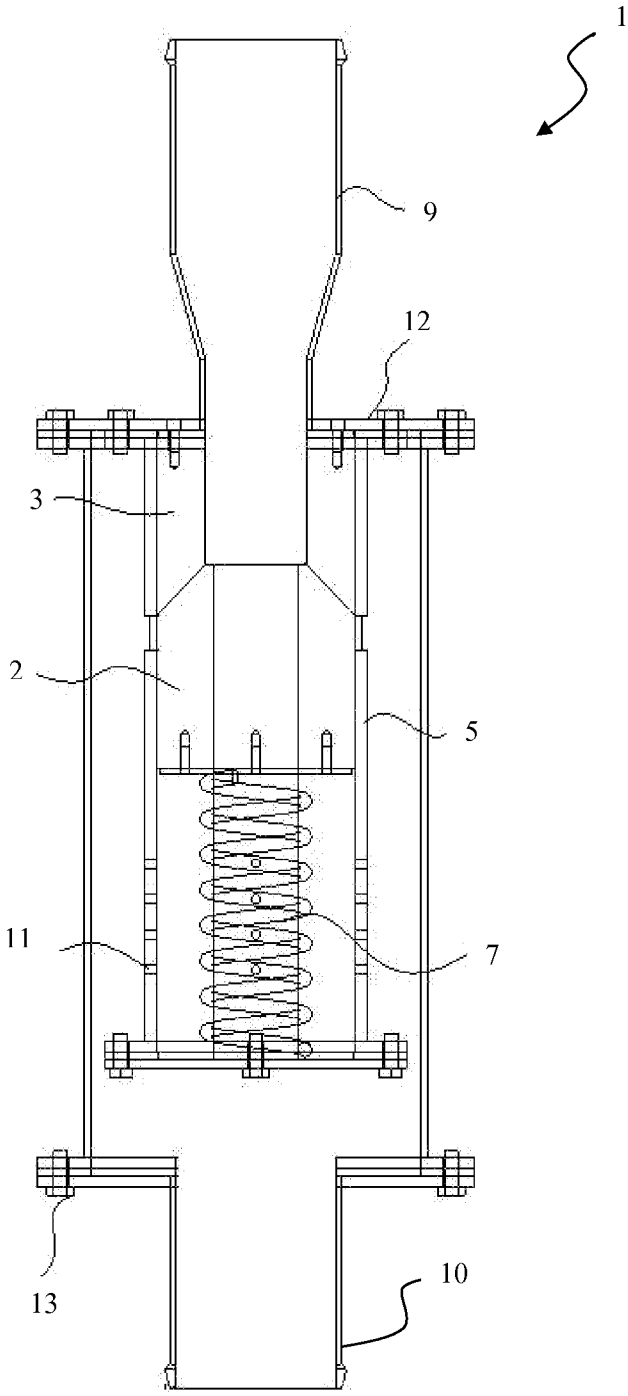

FIG. 2

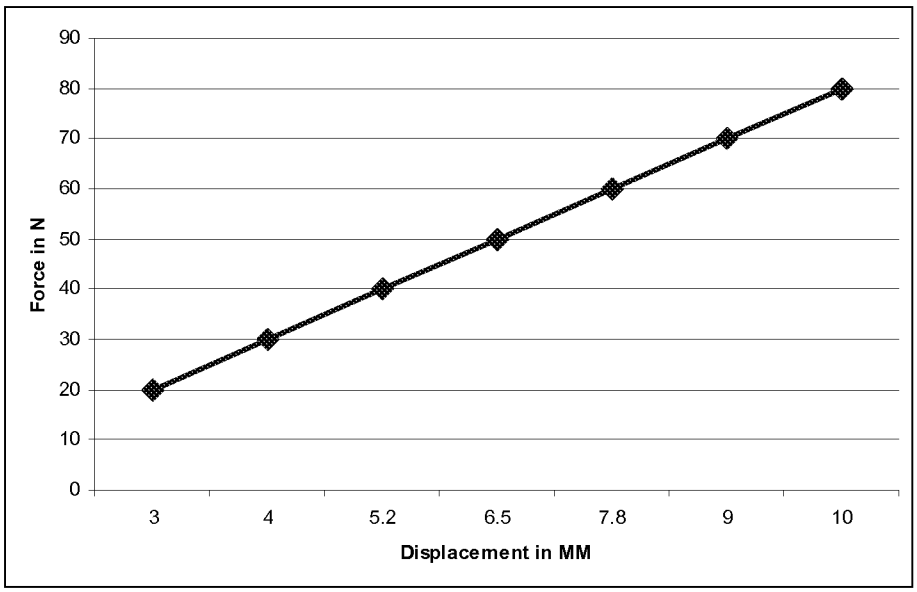
90
80
70
60
50
40
30
20
10
0
Force in N
3
4
5.2
6.5
7.8
9
10
Displacement in MM

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/051055

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K15/02 H01M8/04
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)
H01M F16K

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.
A	US 4 911 196 A (KEMP WILLARD E [US]) 27 March 1990 (1990-03-27) column 3, line 3 - column 4, line 30; figure 1	1-8
A	GB 565 291 A (ARTHUR LARUE PARKER) 3 November 1944 (1944-11-03) page 1, line 55 - page 2, line 121; figure 2	1
A	DE 10 2009 012946 A1 (MAHLE INT GMBH [DE]) 16 September 2010 (2010-09-16) paragraphs [0015] - [0021]; figures 1,2	1
A	DE 196 16 646 A1 (MANN & HUMMEL FILTER [DE]) 6 November 1997 (1997-11-06) column 2, lines 26-34; figure 1	1

☐ 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

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"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)

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

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"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

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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
19 June 2012	28/06/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hatzenbichler, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2012/051055

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4911196 A	27-03-1990	NONE	
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