(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 023 885 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.07.2022 Bulletin 2022/27

(21) Application number: **21150339.6**

(22) Date of filing: **05.01.2021**

(51) International Patent Classification (IPC):
F04B 39/12 *(2006.01)* ***F04B 41/02*** *(2006.01)*
F04C 23/00 *(2006.01)* ***F17C 1/14*** *(2006.01)*
F04B 39/14 *(2006.01)* *F04B 39/06* *(2006.01)*
F04B 35/04 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04B 41/02; F04B 39/121; F04B 39/127; F04B 39/14; F04B 35/04; F04B 39/064; F04B 39/066; F04B 2201/0801; F04B 2205/063

(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:
KH MA MD TN

(71) Applicant: **Streetec GmbH**
64739 Höchst (DE)

(72) Inventors:
- **STUTZ, Michael**
  64739 Höchst (DE)
- **STUTZ, Sven**
  64739 Höchst (DE)
- **SEE, Daniel**
  64739 Höchst (DE)

(74) Representative: **Kompter, Hans-Michael Heumann**
Rechtsanwälte- und Patentanwälte
Spessartring 63
64287 Darmstadt (DE)

(54) **A MODULAR PRESSURE VESSEL**

(57) The invention relates to a modular pressure vessel comprising a center section having a rounded, longitudinal sidewall, the sidewall defining a longitudinal axis and extending from a first opening at a first end of the center section to a second opening at a second end of the center section that is opposite the first end,
a first cap configured to removably attach to the first end of the vessel;
a second cap configured to removably attach to the second end of the vessel; and
a third cap configured to divide the cavity of the vessel into two separate compartments,
wherein the first compartment comprises a compressor with means to control it, as well as means for conditioning the compressed media; and the cavity of the second compartment is configured to store therein a pressurized medium.

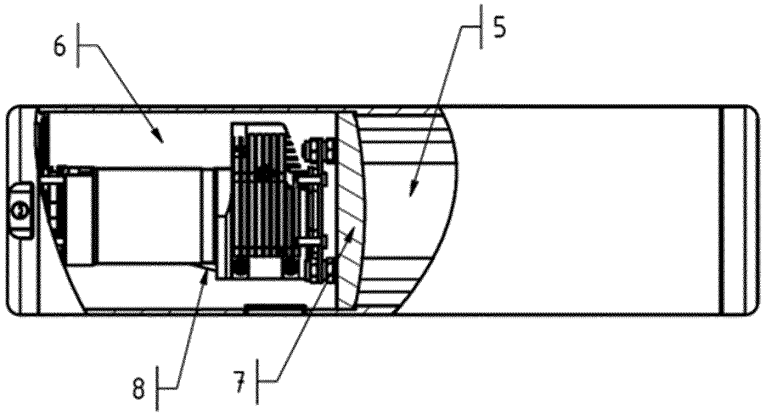

Fig. 3

EP 4 023 885 A1

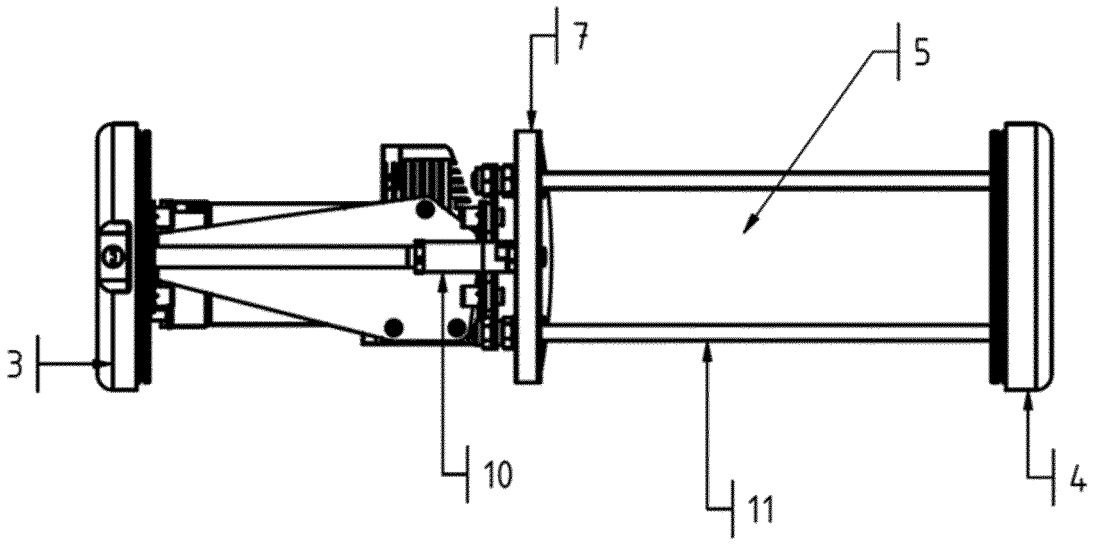

Fig. 8

Description

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The invention relates to a modular pressure vessel comprising a center section having a rounded, longitudinal sidewall, the sidewall defining a longitudinal axis and extending from a first opening at a first end of the center section to a second opening at a second end of the center section that is opposite the first end,

a first cap configured to removably attach to the first end of the vessel;
a second cap configured to removably attach to the second end of the vessel; and
a third cap configured to divide the cavity of the vessel into two separate compartments,

wherein the first compartment comprises a compressor with means to control it, as well as means for conditioning the compressed media; and the cavity of the second compartment is configured to store therein a pressurized medium.

2. BACKGROUND INFORMATION

[0002] Pressure vessels contain pressurized fluid, such as air. By "pressurized" it is meant the pressure inside the vessel is greater than the ambient atmospheric pressure. Pressure vessels have many applications, such as in automotive air suspension systems, for portable air supply systems, industrial air tanks, and others. Typical pressure vessels are limited in their capability, where a given vessel structure is suited for only one specific application and cannot be easily changed or expanded for other applications. Existing pressure vessels require complex manufacturing methods and produce unreliable and non-durable fluid retaining structures. Repairs thereto often are required, which are expensive and labor-intensive.

[0003] The US patent US 10,436,386 B2 describes a modular pressure vessel consisting of an extruded center section with two end caps, which creates a space for storing a pressurized fluid and containing a rail system for mounting technical components, like a compressor for instance, within the vessel.

[0004] Mounting the compressor within a pressurized atmosphere as suggested by US 10,436,386 B2 causes reduces the lifetime of said compressor. This problem is due to the lack of media exchange with the atmosphere as well as humidity accumulation within the vessel due to the compression of the media. This humidity accumulation results in corrosion of the compressor head and ultimately leads to the failure of the device.

[0005] The problem underlying the present invention was to provide a modular pressure vessel which does not suffer from the disadvantages of those suggested by the art.

[0006] This problem has been solved according to the present invention by a modular pressure vessel, in which the compressor is outside of the space, in which the pressurized fluid is stored.

BRIEF SUMMARY OF THE INVENTION

[0007] Accordingly, the invention relates to a modular pressure vessel comprising a center section having a rounded, longitudinal sidewall, the sidewall defining a longitudinal axis and extending from a first opening at a first end of the center section to a second opening at a second end of the center section that is opposite the first end,

a first cap configured to removably attach to the first end of the vessel;
a second cap configured to removably attach to the other end of the vessel; and
a third cap configured to divide the cavity of the vessel into two separate compartments;

wherein the first compartment, which is formed by the rounded, longitudinal sidewall, the second cap and the third cap, comprises a compressor with the components necessary to drive it, and means for conditioning the compressed media; and
the cavity of the second compartment, which is formed by the rounded, longitudinal sidewall, the first cap and the third cap, is configured to store therein a pressurized medium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings illustrate embodiments of the invention, and, together with specification, including the general description above and the detailed description, which follows, explain the features of the present invention.

Figure 1 is a perspective view of the outside of an embodiment of a modular pressure vessel according to the invention.
Figure 2 is an exploded view of the center section and the end caps of a modular pressure vessel according to the invention.
Figure 3 is a cut view of an embodiment of a modular pressure vessel according to the invention, which shows the position of the caps and the compartments.
Figure 4 shows the geometry of the extrusion of the center section of an embodiment of a modular pressure vessel according to the invention.
Figure 5 shows the center section of an embodiment of a modular pressure vessel according to the invention after mechanical processing.

Figure 6 shows the end cap of the pressurized compartment.

Figure 7 shows the center divider, splitting the modular pressure vessel according to the invention into two compartments.

Figure 8 shows the basic structure of the first compartment of modular pressure vessel according to the invention while hiding the center section.

Figure 9 shows the basic internal structure of a modular pressure vessel, while hiding the center section, highlighting the position of the pressure sensor.

Figure 10 shows an alternative embodiment of the compressor mounted within the second compartment.

DETAILED DESCRIPTION OF CERTAIN ILLUSTRATIVE EMBODIMENTS

[0009] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art may 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.

[0010] It will be understood by those within the art that, in general, terms used herein 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 embodiments 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."

[0011] All references cited herein are incorporated herein by reference in their entirety. To the extent publications and patents or patent applications incorporated by reference contradict the disclosure contained in the specification, the specification is intended to supersede and/or take precedence over any such contradictory material.

[0012] The term "comprising" as used herein is synonymous with "including," "containing," or "characterized by," and is inclusive or open-ended and does not exclude additional, unrecited elements or method steps.

[0013] All numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should be construed in light of the number of significant digits and ordinary rounding approaches.

[0014] The following detailed description is directed to certain specific embodiments of the invention. In this description, reference is made to the drawings wherein like parts or steps may be designated with like numerals throughout for clarity. Reference in this specification to "one embodiment," "an embodiment," or "in some embodiments" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of the phrases "one embodiment," "an embodiment," or "in some embodiments" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or

alternative embodiments necessarily mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but may not be requirements for other embodiments.

[0015] Embodiments of the invention will now be described with reference to the accompanying figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be interpreted in any limited or restrictive manner, simply because it is being utilized in conjunction with a detailed description of certain specific embodiments of the invention. Furthermore, embodiments of the invention may include several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to practicing the invention described herein.

[0016] The present disclosure generally relates to a modular pressure vessel having two separate compartments. In some embodiments, the modular pressure vessel comprises the following features:

(A) A modular pressure vessel according to the invention, wherein the internal pressure of the second compartment is from 12 to 20 bar, preferably from 14 to 19 bar, in particular from 16 to 18 bar.

(B) A modular pressure vessel according to the invention, wherein the wherein the first compartment comprises a compressor, a pressure regulating valve, an electronic control unit, which controls the compressor, monitors its temperature and the pressure within the second compartment.

(C) A modular pressure vessel of according to the invention, wherein the compressor is mounted on one or more, preferably one, two, three or four fastening elements, which are decoupled from the center section and the caps. These fastening elements are preferably flexible metal sheets, which absorb the vibration generated by the compressor and thereby reduce the noise during operation of the compressor.

(D) A modular pressure vessel according to the invention, wherein the first compartment comprises a pressure regulating valve, which reduces the outgoing pressure to a maximum pressure of 12 bar.

(E) A modular pressure vessel according to the invention, wherein the pressurized medium is pressurized air or a pressurized fluid.

(F) A modular pressure vessel according to the invention, wherein the three caps are centered and guided within the center section using an O-ring.

(G) A modular pressure vessel according to the invention, wherein the second compartment is sealed using a profiled seal between the caps and the machined surfaces of the center section.

(H) A modular pressure vessel according to the invention, wherein the central section has one or more holes along its longitudinal axis in order to guide one or more threaded rods through it, in order to attach the second cap of the pressurized compartment to the third cap.

(I) A modular pressure vessel according to the invention, wherein the compressor is mounted within the first compartment with the aid of threaded rods.

(J) A modular pressure vessel according to the invention, wherein the first compartment comprises ventilation slots.

(K) A modular pressure vessel according to the invention, wherein the first compartment comprises ventilation slots, to which a fan is mounted to force air exchange between the ambient and the first compartment.

(L) A modular pressure vessel according to the invention, wherein the second cap comprises an outlet for the pressurized media.

(M) A modular pressure vessel according to the invention, wherein the center section of the vessel is an extruded metal profile

(N) A modular pressure vessel according to the invention, wherein center section of the vessel is an extruded aluminum profile.

[0017] Fig. 1 shows a modular pressure vessel (1), compromising a center section (2), two end caps (3, 4) and a divider cap (7) in the center, which is visible in Fig. 3. As shown in Fig. 3 the divider cap (7) splits the vessel into two compartments (5 ,6), of which the first one (6) is housing a compressor (8) and related components, as well as a pressure reduction valve (10). The second compartment (5) is used to store pressurized air.

[0018] The center section (2) of the vessel consists of an extruded aluminum profile, which has four holes along its longitudinal axis to guide threaded rods (11) through it. These threaded rods (11) are used to attach the end cap of the pressurized compartment (4) to the divider cap (7). In addition to that, the threaded rods (11) are used as guides for mounting the compressor (8) within the first compartment (6).

[0019] The extruded center section (2) is mechanical processed to remove the longitudinal holes in the length of the first compartment (6), to ensure enough space for the compressor and for ease of mounting the divider cap

(7). All caps are centered and guided within the center section using an O-Ring. The pressure compartment is sealed using a profiled seal between the caps and the machined surfaces of the center section.

[0020] Fig. 8 shows the layout of the compartment (6) housing, the compressor (8) and related components. As shown in Figure 10 the compressor (8) is mounted to two metal sheets (12), which are decoupled from the center section and the caps. This decoupling (13) is reducing the overall noise level when the compressor is running. The outlet port of the compressor (8) is connected to the second compartment (5), so the sucked in air is compressed into the pressurized compartment (5). Fig. 9 shows that pressure sensor (14) is mounted to the dividing cap (7) to measure the pressure inside the pressurized compartment (5). Depending on the pressure within the pressurized compartment (5) and the temperature of the compressor (8), the compressor (8) is either switched on or off by the internal control unit. A fan can be mounted to the ventilation slots which are machined into the center section (2) to force air exchange between the ambient and the first compartment. The airflow is of additional use to cool the compressor (8). Ventilation openings can also be added to the cap of the first compartment (3), which also includes the electrical connections as well as the compressed media output. Running the compressor (8) at ambient pressure and with constant exchange of air between the ambient and the compartment (6) assures, that there will not be excess humidity accumulating within the compressor (8). In addition to that, it is not necessary to decompress the compressors (8) head in order to run it, which leads in less mechanical stress for the parts. All in all, the lifetime of the compressor (8) can be vastly increased, and the compressor (8) can be run to its specifications.

[0021] Splitting the pressure vessel (1) into a pressurized (5) and a not pressurized compartment (6) results into a loss of volume to store compressed air in. To make up for that loss, the internal pressure of the vessel (1) may be increased up to 18 bar, which results in a near equalization of the product of pressure and volume. This means, that nearly the same amount of media can be stored within the vessel (1). Furthermore, when increasing the overall size of the vessel (1), the product of pressure and volume increases at a rate of around 30% greater than current implementations of the state of the art.

[0022] Because most of pneumatic peripherals are designed to operate at a maximum pressure of 12 bar to 13,79 bar (200 psi), a pressure reduction valve (10) is added to the device within the first compartment (6). This valve assures (10), that the output pressure does not exceed 12 bar. The second compartment (5) and the compressed media output are connected via a hole in the dividing cap (5), as well as a pipe.

[0023] The above description discloses several methods and materials of the present invention. This invention is susceptible to modifications in the methods and materials, as well as alterations in the fabrication methods and equipment. Such modifications will become apparent to those skilled in the art from a consideration of this disclosure or practice of the invention disclosed herein. Consequently, it is not intended that this invention be limited to the specific embodiments disclosed herein, but that it covers all modifications and alternatives coming within the true scope and spirit of the invention as embodied in the attached claims.

Claims

1. A modular pressure vessel comprising a center section having a rounded, longitudinal sidewall, the sidewall defining a longitudinal axis and extending from a first opening at a first end of the center section to a second opening at a second end of the center section that is opposite the first end,

   a first cap configured to removably attach to the first end of the vessel;
   a second cap configured to removably attach to the other end of the vessel; and
   a third cap configured to divide the cavity of the vessel into two separate compartments;

   wherein the first compartment, which is formed by the rounded, longitudinal sidewall, the second cap and the third cap, comprises a compressor with the components necessary to drive it, and means for conditioning the compressed media; and
   the cavity of the second compartment, which is formed by the rounded, longitudinal sidewall, the first cap and the third cap, is configured to store therein a pressurized medium.

2. The modular pressure vessel of claim 1, wherein the internal pressure of the second compartment is from 12 to 20 bar, preferably from 14 to 19 bar, in particular 16 to 18 bar.

3. The modular pressure vessel of claim 1 or 2, wherein the wherein the first compartment comprises a compressor, a pressure regulating valve, an electronic control unit, which controls the compressor, monitors its temperature and the pressure within the second compartment.

4. The modular pressure vessel of one of claims 1 to 3, wherein the compressor is mounted on one or more fastening elements, which are decoupled from the center section and the caps.

5. The modular pressure vessel of one of claims 1 to 4, wherein the first compartment comprises a pressure regulating valve, which reduces the outgoing pressure to a maximum pressure of 12 bar.

6. The modular pressure vessel of one of claims 1 to 5, wherein the pressurized medium is pressurized air or a pressurized fluid.

7. The modular pressure vessel of one of claims 1 to 6, wherein the three caps are centered and guided within the center section using an O-ring.

8. The modular pressure vessel of one of claims 1 to 7, wherein the second compartment is sealed using a profiled seal between the caps and the machined surfaces of the center section.

9. The modular pressure vessel of one of claims 1 to 8, wherein the central section has one or more holes along its longitudinal axis in order to guide one or more threaded rods through it, in order to attach the second cap of the pressurized compartment to the third cap.

10. The modular pressure vessel of one of claims 1 to 9, wherein the compressor is mounted within the first compartment with the aid of threaded rods.

11. The modular pressure vessel of one of claims 1 to 10, wherein the first compartment comprises ventilation slots.

12. The modular pressure vessel of one of claims 1 to 11, wherein the first compartment comprises ventilation slots, to which a fan is mounted to force air exchange between the ambient and the first compartment.

13. The modular pressure vessel of one of claims 1 to 12, wherein the second cap comprises an outlet for the pressurized media.

14. The modular pressure vessel of one of claims 1 to 13, wherein the center section of the vessel is an extruded metal profile

15. The modular pressure vessel of claim 14, wherein center section of the vessel is an extruded aluminum profile.

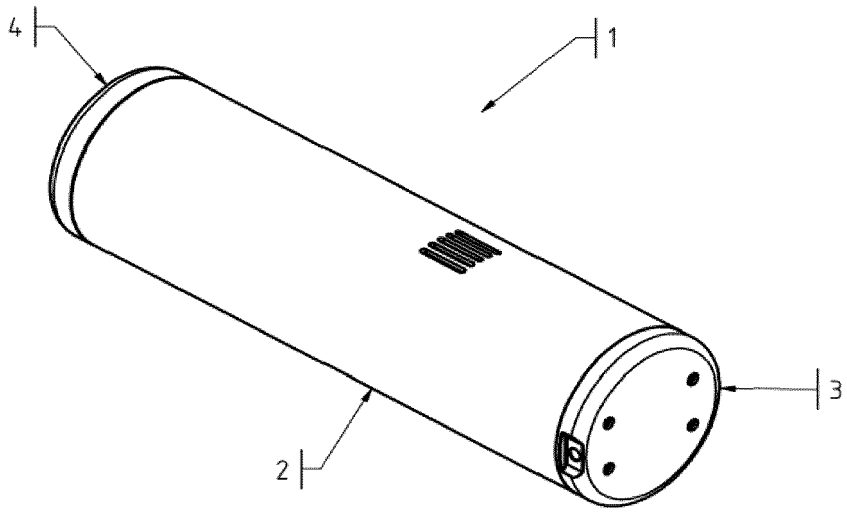

Fig. 1

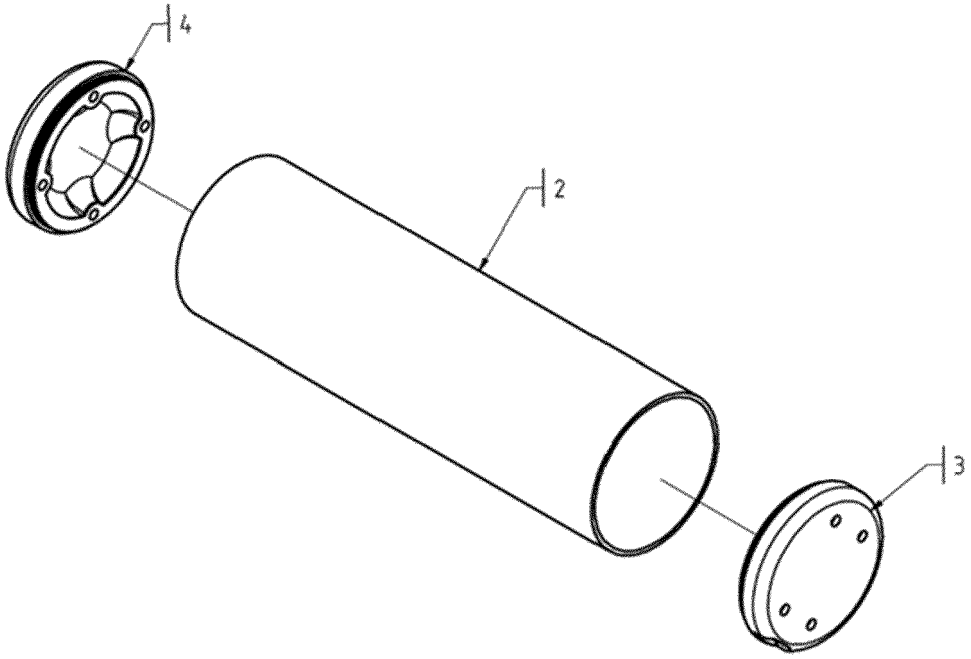

Fig. 2

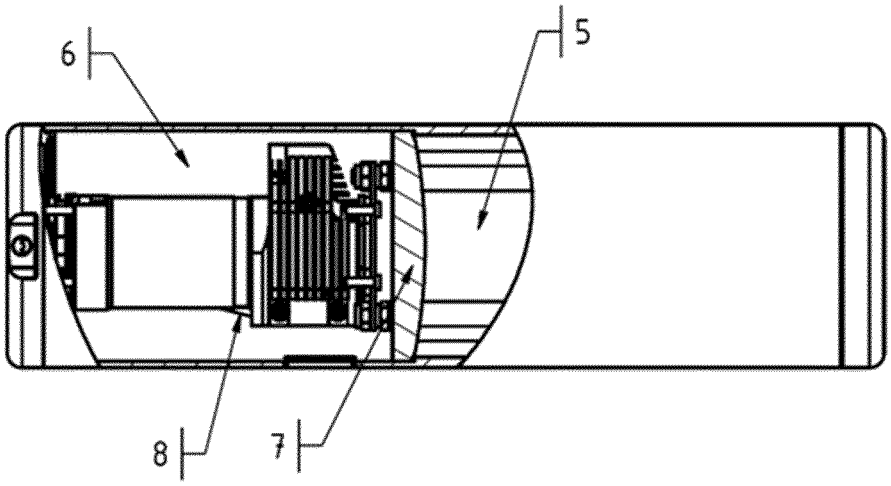

Fig. 3

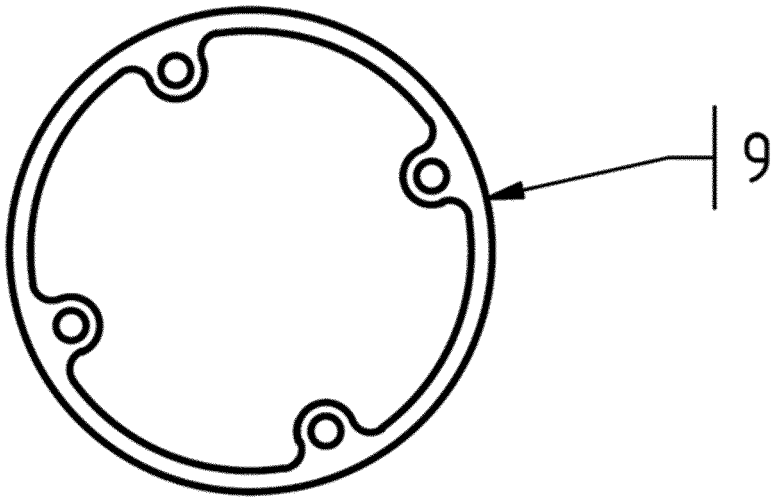

Fig. 4

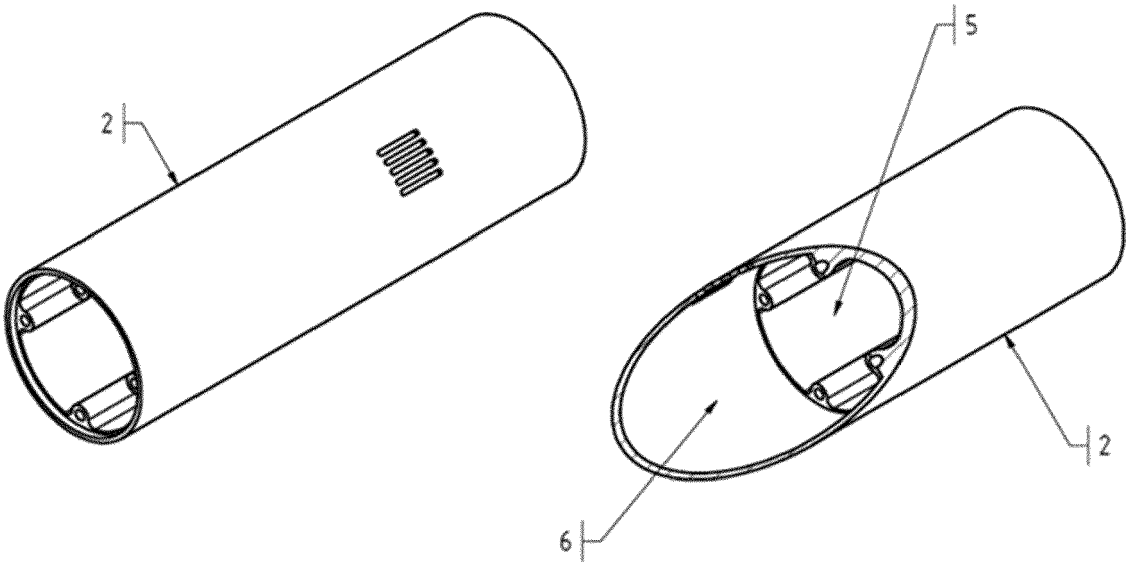

Fig. 5

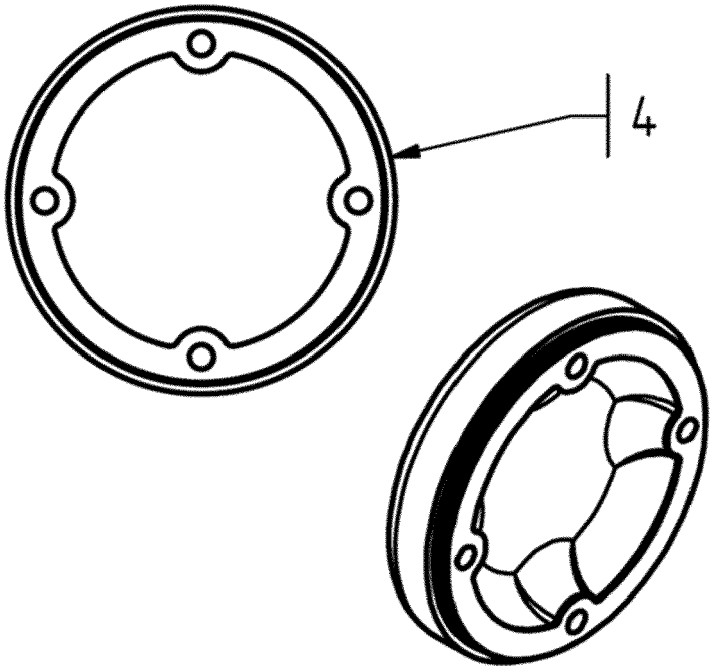

Fig. 6

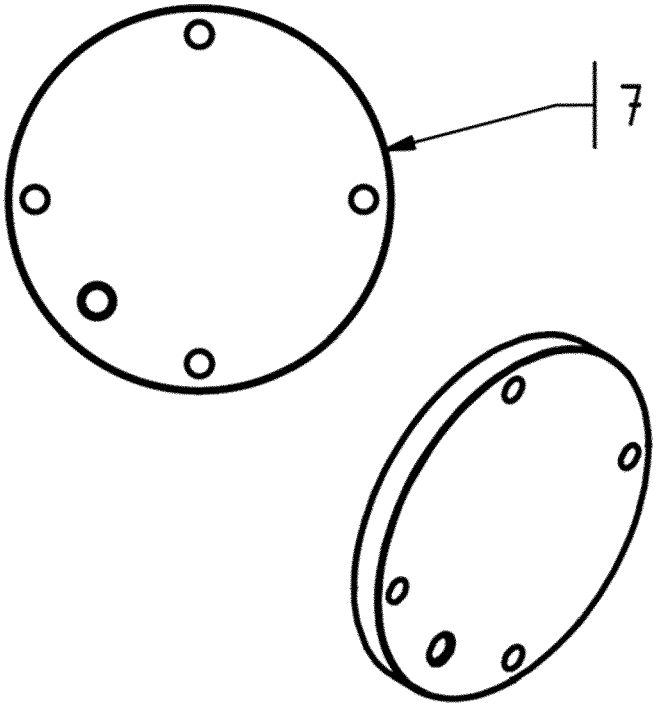

Fig. 7

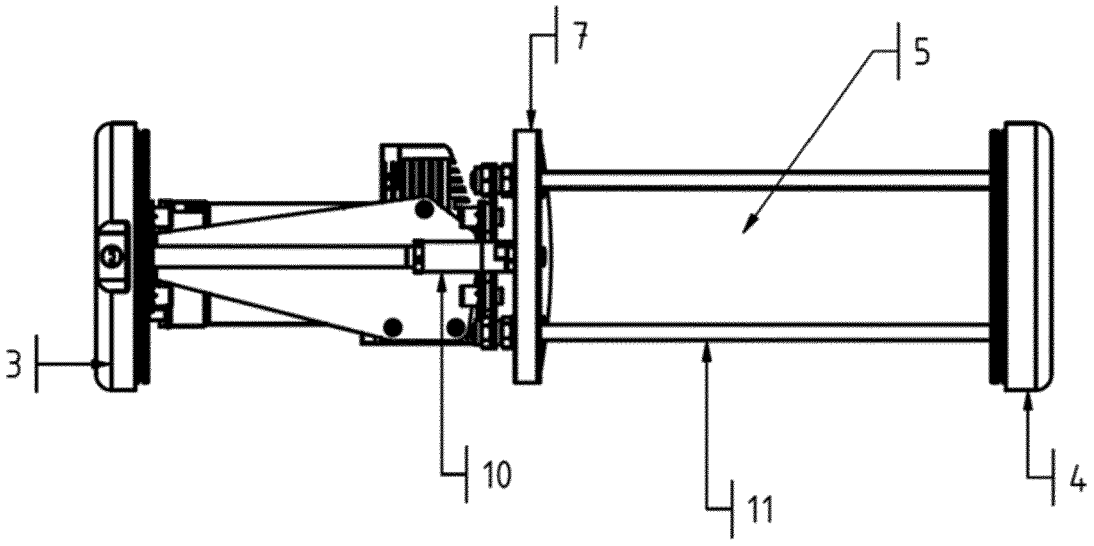

Fig. 8

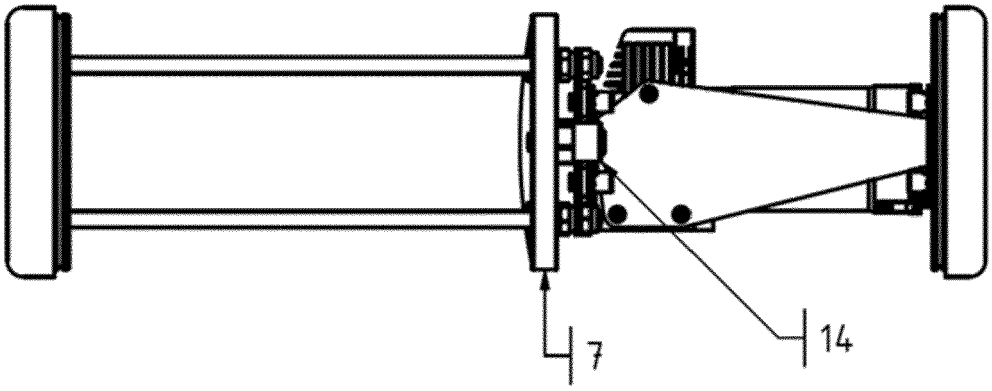

Fig. 9

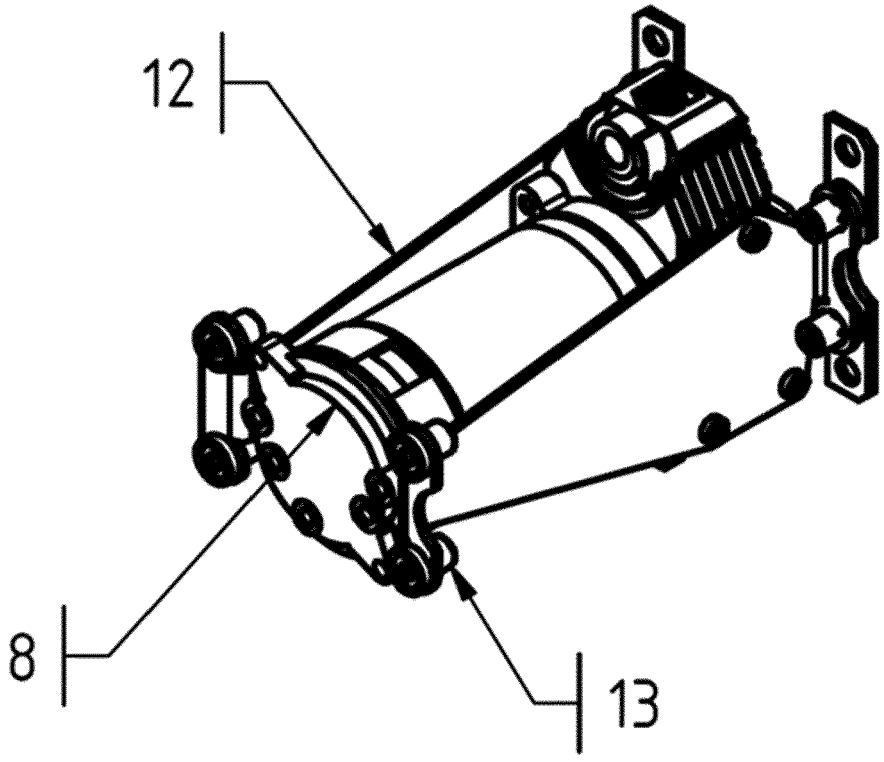

Fig. 10

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 15 0339

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	US 10 436 386 B2 (ACCUAIR CONTROL SYSTEMS LLC [US]) 8 October 2019 (2019-10-08) * figures 1-9 * * column 2, line 4 - line 23 * * column 6, line 1 - column 15, line 37 *	1-15	INV. F04B39/12 F04B41/02 F04C23/00 F17C1/14 F04B39/14
Y	US 2 314 438 A (BANNING JOHN D ET AL) 23 March 1943 (1943-03-23) * figures 1-3 * * column 1, line 37 - line 40 * * column 1, line 51 - column 4, line 37 *	1-15	ADD. F04B39/06 F04B35/04
A	KR 102 047 268 B1 (CKD CORP [JP]) 21 November 2019 (2019-11-21) * figures 1-4 * * paragraph [0016] - paragraph [0058] *	1-15	
A	US 4 966 206 A (BAUMANN HEINZ [CH] ET AL) 30 October 1990 (1990-10-30) * figures 1-7 * * column 2, line 40 - column 6, line 46 *	1-15	TECHNICAL FIELDS SEARCHED (IPC)
A	EP 2 993 349 A1 (PANASONIC IP MAN CO LTD [JP]) 9 March 2016 (2016-03-09) * figure 1 * * paragraph [0028] - paragraph [0043] *	1-15	F04B F17C F04C F04D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 May 2021	Ricci, Saverio

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 15 0339

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.

28-05-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 10436386 B2	08-10-2019	NONE	
US 2314438 A	23-03-1943	NONE	
KR 102047268 B1	21-11-2019	CN 109653986 A	19-04-2019
		JP 6748048 B2	26-08-2020
		JP 2019070353 A	09-05-2019
		KR 20190040450 A	18-04-2019
		TW 201923229 A	16-06-2019
US 4966206 A	30-10-1990	AU 604344 B2	13-12-1990
		AU 625136 B2	02-07-1992
		CA 1294930 C	28-01-1992
		EP 0300222 A1	25-01-1989
		NZ 225254 A	28-11-1989
		US 4966206 A	30-10-1990
EP 2993349 A1	09-03-2016	CN 105164419 A	16-12-2015
		CN 105190043 A	23-12-2015
		CN 105190044 A	23-12-2015
		CN 105209761 A	30-12-2015
		EP 2993349 A1	09-03-2016
		EP 2993350 A1	09-03-2016
		EP 2993351 A1	09-03-2016
		EP 2993352 A1	09-03-2016
		JP 6304663 B2	04-04-2018
		JP 6344573 B2	20-06-2018
		JP 6344574 B2	20-06-2018
		JP 6395059 B2	26-09-2018
		JP 6578504 B2	25-09-2019
		JP 2014231833 A	11-12-2014
		JP WO2014178188 A1	23-02-2017
		JP WO2014178189 A1	23-02-2017
		JP WO2014178190 A1	23-02-2017
		JP WO2014178191 A1	23-02-2017
		US 2016084250 A1	24-03-2016
		US 2016090986 A1	31-03-2016
		US 2016102665 A1	14-04-2016
		US 2016102667 A1	14-04-2016
		WO 2014178188 A1	06-11-2014
		WO 2014178189 A1	06-11-2014
		WO 2014178190 A1	06-11-2014
		WO 2014178191 A1	06-11-2014

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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 10436386 B2 **[0003] [0004]**