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

(11) **EP 3 557 059 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.10.2019 Bulletin 2019/43

(51) Int Cl.:
F04B 43/02 *(2006.01)* ***F04B 43/06*** *(2006.01)*
F04B 53/06 *(2006.01)*

(21) Application number: **19161805.7**

(22) Date of filing: **11.03.2019**

(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

(30) Priority: **19.04.2018 IT 201800004722**

(71) Applicant: **Annovi Reverberi S.p.A.**
41122 Modena (IT)

(72) Inventor: **ORLANDINI, Giuseppe**
42048 RUBIERA (RE) (IT)

(74) Representative: **Corradini, Corrado et al**
Ing. C. Corradini & C. S.r.l.
Via Dante Alighieri 4
42121 Reggio Emilia (IT)

(54) **VOLUMETRIC MEMBRANE PUMP**

(57) A volumetric membrane pump (100) is described, comprising: a guide cylinder (110), a flexible membrane (150) placed so as to close an axial end of the guide cylinder (110), a head (155) designed to define a pumping chamber (160) with the flexible membrane (150), a piston (115) fixed to the flexible membrane (150) and slidable inside the guide cylinder (110) between an upper dead centre position and a lower dead centre position, an intermediate chamber (195) defined inside the guide cylinder (110) between the flexible membrane (150) and the piston (115), a casing (140) defining an internal volume (145) suitable for being filled with lubricating oil, at least one un primary passage (205) suitable for placing the intermediate chamber (195) in communication with the internal volume (145) of the casing (140) when the piston (115) is in the lower dead centre position, and at least one secondary passage (210) suitable for placing the intermediate chamber (195) in communication with the internal volume (145) of the casing (140) when the piston (115) is in the upper dead centre position.

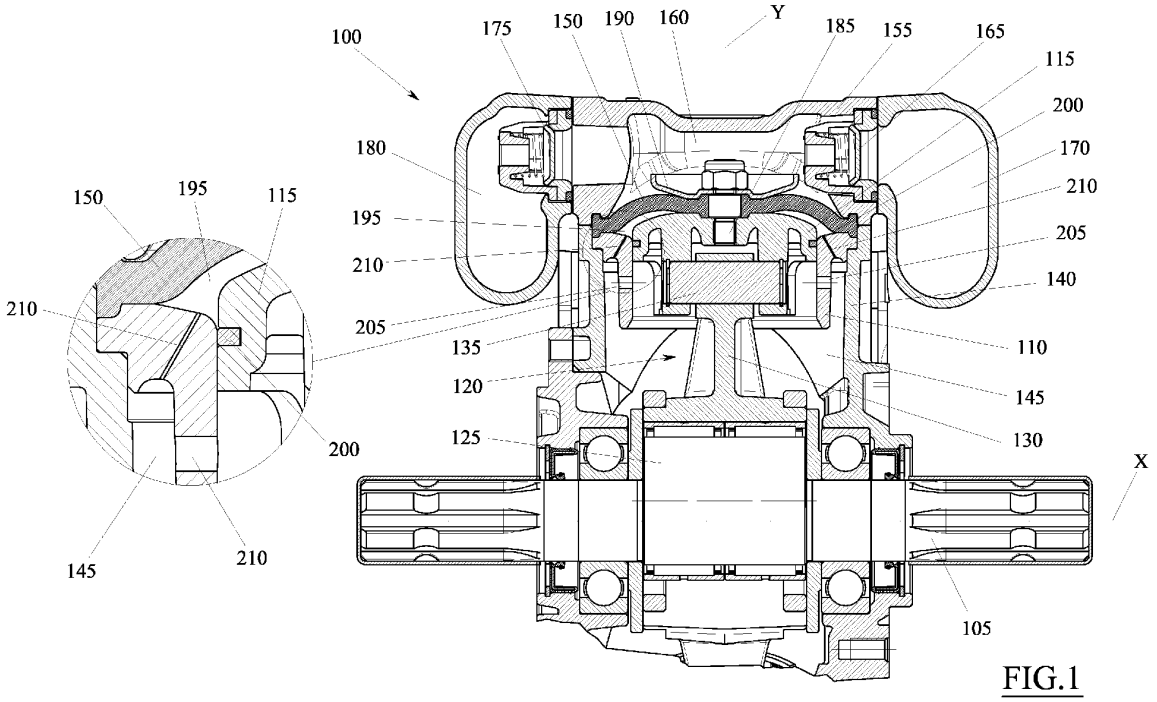

FIG.1

EP 3 557 059 A1

Description

Technical field

[0001] The present invention relates to a volumetric membrane pump suitable for being used in the agricultural field, for example for spraying protective liquids, fertilizing liquids or liquids of other type over the crops.

Known technique

[0002] As is known, volumetric membrane pumps comprise a guide cylinder, a flexible membrane placed to close an axial end of the guide cylinder, a head suitable for cooperating with the membrane to define a pumping chamber, and a piston fixed to the membrane and slidingly housed in the guide cylinder.

[0003] The piston is connected to a drive kinematism, typically of the connecting rod-crank type, which allows it to slide between an upper dead centre position and a lower dead centre position.

[0004] By sliding towards the lower dead centre position, the piston performs a suction stroke in which it drags the membrane away from the head, thus increasing the volume of the pumping chamber and sucking liquid through an inlet valve.

[0005] By sliding vice versa towards the upper dead centre position, the piston performs a compression stroke in which it pushes the membrane close to the head, thus reducing the volume of the pumping chamber and pushing the liquid out through an outlet valve.

[0006] The drive kinematism generally is enclosed in a casing, which internal volume is filled with lubricating oil so as to keep lubricated the piston and the other movable parts of the pump.

[0007] To improve the thrust exerted on the membrane during the compression stroke, the guide cylinder has at least one passage which when the piston is in the lower dead centre position, is suitable for placing the internal volume of the casing in communication with an intermediate chamber defined inside the guide cylinder between the membrane and the top of the piston.

[0008] In this manner, the lubricating oil also fills the intermediate chamber of the cylinder and being incompressible, allows actively supporting the membrane during the compression stroke, thus transferring the thrust exerted by the piston to it in substantially uniform manner.

[0009] However, a drawback of this solution consists of the fact that small air locks may remain trapped in the intermediate chamber of the cylinder, between the membrane and the piston, during the first filling of the casing with lubricating oil.

[0010] If this occurs, rather than simply moving the oil during the compression stroke, the piston also compresses the air inside the intermediate chamber, thus creating a vacuum in the volume of oil behind the membrane that affects the operation and duration thereof.

[0011] For this reason, one of the greatest difficulties in making a membrane pump currently is the one of succeeding in executing the best filling possible of the intermediate chamber of the cylinder, while trying to remove all the air locks that may remain trapped therein, for example by manually placing in movement the piston and simultaneously overturning and/or shaking the pump several times so that the air may leave through the passage that places the intermediate chamber in communication with the internal volume of the casing, possibly accumulating in areas where it does not create problems.

Description of the invention

[0012] It is an object of the present invention to resolve the mentioned drawback by making available a solution that allows avoiding a stagnation of the air in the intermediate chamber behind the membrane, or in any case, that allows a simpler evacuation of the air possibly accumulated.

[0013] Such objects are achieved by the features of the invention indicated in independent claim 1. The dependent claims outline preferred and/or particularly advantageous aspects of the invention.

[0014] In particular, one embodiment of the present invention provides a volumetric membrane pump, comprising:

- a guide cylinder,
- a flexible membrane placed so as to close an axial end of the guide cylinder,
- a head designed to define a pumping chamber with the flexible membrane,
- a piston fixed to the flexible membrane and slidable inside the guide cylinder between an upper dead centre position and a lower dead centre position,
- an intermediate chamber defined inside the guide cylinder between the flexible membrane and the piston,
- a casing defining an internal volume suitable for being filled with lubricating oil,
- at least one primary passage suitable for placing the intermediate chamber in communication with the internal volume of the casing, when the piston is in the lower dead centre position, and
- at least one secondary passage suitable for placing the intermediate chamber in communication with the internal volume of the casing, when the piston is in the upper dead centre position.

[0015] In this manner, the air possibly trapped inside the intermediate chamber may always and easily flow towards the internal volume of the casing through the secondary passage without stagnating and therefore without creating that vacuum in the volume of oil behind the membrane that could worsen the operation and duration thereof.

[0016] According to one aspect of the invention, the secondary passage may be made in the guide cylinder.

[0017] This solution provides a very simple construction method for placing the intermediate chamber of the guide cylinder in communication with the internal volume of the casing.

[0018] According to another aspect of the invention, the secondary passage may have a passing through cross-section which extension is less than 0.2 mm^2, and more preferably, less than 0.05 mm^2.

[0019] In this manner, the secondary passage generates a rather increased hydraulic resistance which even though it allows the outlet of the air, it allows keeping the lubricating oil inside the intermediate chamber also during the compression stroke of the piston, or it at least allows having only a minimum leak that does not affect the pressure of the lubricating oil in the intermediate chamber in an apparent manner.

[0020] For example, the secondary passage may be made in the shape of a through hole, which may have a diameter less than 0.5 mm, and more preferably, less than or equal to 0.2 mm.

[0021] According to a further aspect of the present invention, the pump may comprise a plurality of secondary passages, which may be for example, arranged angularly equidistant from one another about a longitudinal axis of the guide cylinder.

[0022] In this manner, the evacuation of the air advantageously is promoted from the intermediate chamber of the cylinder.

Brief description of the drawings

[0023] Further features and advantages of the invention will be more apparent after reading the following description provided by way of a non-limiting example, with the aid of the accompanying drawings.

Figure 1 is a cross section of a membrane pump according to an embodiment of the present invention, shown with the piston in the upper dead centre position.

Figure 2 is the cross section of figure 1, shown with the piston in the lower dead centre position.

Detailed description

[0024] The invention relates to a volumetric membrane pump 100 for pumping fluids, in particular for pumping liquids. For example, the pump 100 may be used in the agricultural field for pumping protective liquids, fertilizing liquids or liquids of other type towards specific dispensing nozzles intended to spray or in any case dispense such liquids over the crops. However, it is not excluded for the pump 100 to also be used in other fields and/or for pumping other types of fluids.

[0025] The pump 100 may comprise a drive shaft 105 that is suitable for rotating on itself about its middle axis X.

[0026] The rotation of the drive shaft 105 may be obtained by means of direct or indirect connection with a thermic engine, for example with the motor of an agricultural tractor through a power take-off, or with an electric motor.

[0027] The pump 100 also comprises a guide cylinder or sleeve 110 having a longitudinal axis Y that may be oriented perpendicularly to the middle axis X of the drive shaft 105.

[0028] A piston 115 is slidingly housed inside the guide cylinder 110, which piston is connected to the drive shaft 105 through a kinematism 120 that is suitable for transforming the rotary movement of the drive shaft 105 into a linear and reciprocating movement of the piston 115 inside the guide cylinder 110.

[0029] In this manner, the piston 115 is cyclically suitable for moving between a lower dead centre position, in which it is at the minimum distance from the drive shaft 105 (see fig. 2) and an upper dead centre position, in which it is at the maximum distance from the drive shaft 105 (see fig. 1).

[0030] A coaxial sealing ring 200 may be interposed between the outer side surface of the piston 115 and the inner side surface of the guide cylinder 12, which coaxial sealing ring may be axially blocked inside a corresponding cavity made in the piston 115.

[0031] In the example shown, the kinematism 120 comprises an eccentric 125 rigidly fixed to the drive shaft 105, for example made in a single piece therewith, and a connecting rod 130 articulated to said eccentric 125 and to a transverse pin 135 of the piston 115.

[0032] The eccentric 125 may have a substantially cylindrical shape with axis parallel to but spaced apart from the middle axis X of the drive shaft 105.

[0033] In this manner, a thrust linkage is obtained capable of transforming the rotary movement of the drive shaft 105 into a reciprocating movement of the piston 115.

[0034] The pump 100 also comprises a casing 140 that cooperates with the guide cylinder 110 and with the piston 115 to define a closed internal volume 145 that contains the kinematism 120, i.e. in the example, at least the connecting rod 130, the eccentric 125 and the transverse pin 135.

[0035] The internal volume 145 may also contain bench bearings for the drive shaft 105 and/or a stretch of the drive shaft 105 comprised between said bench bearings.

[0036] The guide cylinder 110 may be shaped so as to at least partially extend inside the casing 140, substantially in cantilevered manner, so that an annular gap belonging to the internal volume 145 is defined between the outer side surface of the guide cylinder 110 and the inner surface of the casing 140. The internal volume 145 is completely filled with lubricating oil, a function of which is to keep the piston 115 and the kinematism 120 lubricated.

[0037] In the example shown, the casing 140 is made as a separate body with respect to the guide cylinder 110, to which it may be fixed by means of threaded mem-

bers. However, other embodiments do not exclude for the guide cylinder 110 and the casing 140 to have a different geometry and/or to be made in a single piece.

[0038] The free end of the guide cylinder 110, i.e. the one placed at the maximum radial distance from the drive shaft 105, is closed by a flexible membrane 150 which may be made of elastomeric material (typically rubber).

[0039] In particular, the flexible membrane 150 is interposed and blocked between the free end of the guide cylinder 110 and a head 155, which may be fixed to said guide cylinder 110 and/or to the casing 140, for example by means of threaded members, and is suitable for cooperating with the flexible membrane 150 to define a pumping chamber 160.

[0040] The head 155 may be provided with an automatic inlet valve 165 suitable for selectively placing the pumping chamber 160 in communication with an inlet manifold 170, and with an automatic outlet valve 175 suitable for selectively placing the pumping chamber 160 in communication with a delivery manifold 180.

[0041] The piston 115 is positioned outside the pumping chamber 160 and is fixed to the flexible membrane 150.

[0042] In particular, the outer surface of the flexible membrane 150, i.e. the one facing the drive shaft 105, may be placed in contact with and fixed to the thrust surface (or top) of the piston 115, for example by means of a screw 185 and a fixing washer 190 placed in middle position both with respect to the flexible membrane 150 and with respect to the piston 115.

[0043] When the piston 115 performs a suction stroke towards the lower dead centre (see fig. 2), the flexible membrane 150 is deformed towards the drive shaft 105, causing an increase of the volume of the pumping chamber 160 and therefore a reduction of the internal pressure that allows the opening of the inlet valve 165 and the inlet of the fluid to be pumped coming from the inlet manifold 170.

[0044] Vice versa, when the piston 115 performs a compression stroke towards the upper dead centre (see fig. 1), the flexible membrane 150 is deformed in opposite direction, causing a reduction of the volume of the pumping chamber 160 and therefore an increase of the internal pressure, up to causing the opening of the outlet valve 175 and the outlet of the high-pressure fluid towards the delivery manifold 180.

[0045] An intermediate chamber 195 is further defined inside the guide cylinder 110, between the flexible membrane 150 and the top of the piston 115.

[0046] When the piston 115 is in lower dead centre position (see fig. 2), the intermediate chamber 195 is in communication with the internal volume 145 of the casing 140 through one or more primary passages 205, each of which may be made in the shape of a through hole that radially crosses the wall of the guide cylinder 110.

[0047] In the example shown, two primary passages 205 are shown, arranged on diametrically opposite sides of the guide cylinder 110. However, it is not excluded in other embodiments for there to be a larger number of primary passages 205, possibly arranged angularly equidistant from one another with respect to the longitudinal axis Y of the guide cylinder 110.

[0048] In any case, when the piston 115 is in the lower dead centre position, the sealing ring 200 is positioned below or at least at the aforesaid primary passages 205, thus allowing the latter to create a direct communication between the intermediate chamber 195 and the internal volume 145 of the casing 140. In this manner, when the internal volume 145 of the casing 140 is filled with the lubricating oil, the latter may also penetrate and completely fill the intermediate chamber 195, thus creating a lubricating oil cushion which concurs to transmitting the thrust exerted by the piston 115 during the compression stroke, to the flexible membrane 150.

[0049] In fact, while the piston 115 moves towards the upper dead centre position, the sealing ring 200 first moves above the primary passages 205, closing the communication with the internal volume 145 of the casing 140, and then pressurizes the lubricating oil contained in the intermediate chamber 195, which by being incompressible, transmits the pressure directly to the flexible membrane 150, thus deforming it.

[0050] The pump 100 further comprises one or more secondary passages 210, each of which is suitable for placing the intermediate chamber 195 in communication with the internal volume 145 of the casing 140 also when the piston 115 is in upper dead centre position and, preferably, for any position of the piston 115 inside the guide cylinder 110.

[0051] Each of these secondary passages 210 may be made in the guide cylinder 110, for example in the shape of a through hole which crosses the side wall of the guide cylinder 110 close to the flexible membrane 150.

[0052] In general, it is preferable for each secondary passage 210 to make available a sufficiently large cross section of passage to allow the evacuation of any air locks that may accumulate in the intermediate chamber 195, for example during the filling step with the lubricating oil, but sufficiently small enough to prevent the outlet of the lubricating oil during the compression stroke of the piston 115, or at least so as to allow only a minimum leak that does not affect the pressure of the lubricating oil in the intermediate chamber 195 in an apparent manner.

[0053] For this reason, it is preferable for the passing through cross-section of each secondary passage 210 to have an extension which is less than 0.2 mm^2, and more preferably less than 0.05 mm^2.

[0054] For example, each secondary passage 210 may be made like a through hole having a diameter less than 0.5 mm, and more preferably, less than or equal to 0.2 mm.

[0055] Such through hole may also have a rectilinear but inclined extension with respect to the longitudinal axis Y of the guide cylinder 110, for example with an efferent end in the intermediate chamber 195 that is placed closer to the flexible membrane 150 with respect to the opposite

efferent end in the internal volume 145 of the casing 140.

[0056] In the example shown, two identical secondary passages 210 are shown, arranged on diametrically opposite sides of the guide cylinder 110. However, it is not excluded in other embodiments for there to be a greater number of secondary passages 210, possibly arranged angularly equidistant from one another with respect to the longitudinal axis Y of the guide cylinder 110.

[0057] In conclusion, it is worth noting that the cross section of passage of each primary passage 205 preferably is greater with respect to the cross section of passage of each secondary passage 210 so that during the filling step of the pump 100, the lubricating oil may easily flow into and fill the intermediate chamber 195, as explained above.

[0058] Obviously, an expert in the field may make several technical-applicative modifications to the above-described pump 100, without departing from the scope of the invention as hereinbelow claimed.

Claims

1. A volumetric membrane pump (100), comprising:

- a guide cylinder (110),
- a flexible membrane (150) so placed as to close an axial end of the guide cylinder (110),
- a head (155) designed to define a pumping chamber (160) with the flexible membrane (150),
- a piston (115) fixed to the flexible membrane (150) and slidable inside the guide cylinder (110) between an upper dead centre position and a lower dead centre position,
- an intermediate chamber (195) defined inside the guide cylinder (110) between the flexible membrane (150) and the piston (115),
- a casing (140) defining an internal volume (145) suitable for being filled with lubricating oil, and
- at least one primary passage (205) suitable for placing the intermediate chamber (195) in communication with the internal volume (145) of the casing (140), when the piston (115) is in the lower dead centre position,

characterized in that it comprises at least one secondary passage (210) suitable for placing the intermediate chamber (195) in communication with the internal volume (145) of the casing (140), when the piston (115) is in the upper dead centre position.

2. A pump (100) according to claim 1, **characterized in that** said secondary passage (210) is afforded within the guide cylinder (110).

3. A pump (100) according to claim 1 or 2, **characterized in that** the secondary passage (210) has a passing through cross-section which extension is lower than 0.2 mm^2.

4. A pump (100) according to any one of the preceding claims, **characterized in that** the secondary passage (210) is a through hole.

5. A pump (100) according to claim 4, **characterized in that** said through hole has a diameter being less than a 0.5 mm.

6. A pump (100) according to any one of the preceding claims, **characterized in that** it comprises a plurality of said secondary passages (210).

7. A pump (100) according to claim 6, **characterized in that** said secondary passages (210) are arranged angularly equidistant from one another about a longitudinal axis (Y) of the guide cylinder (110).

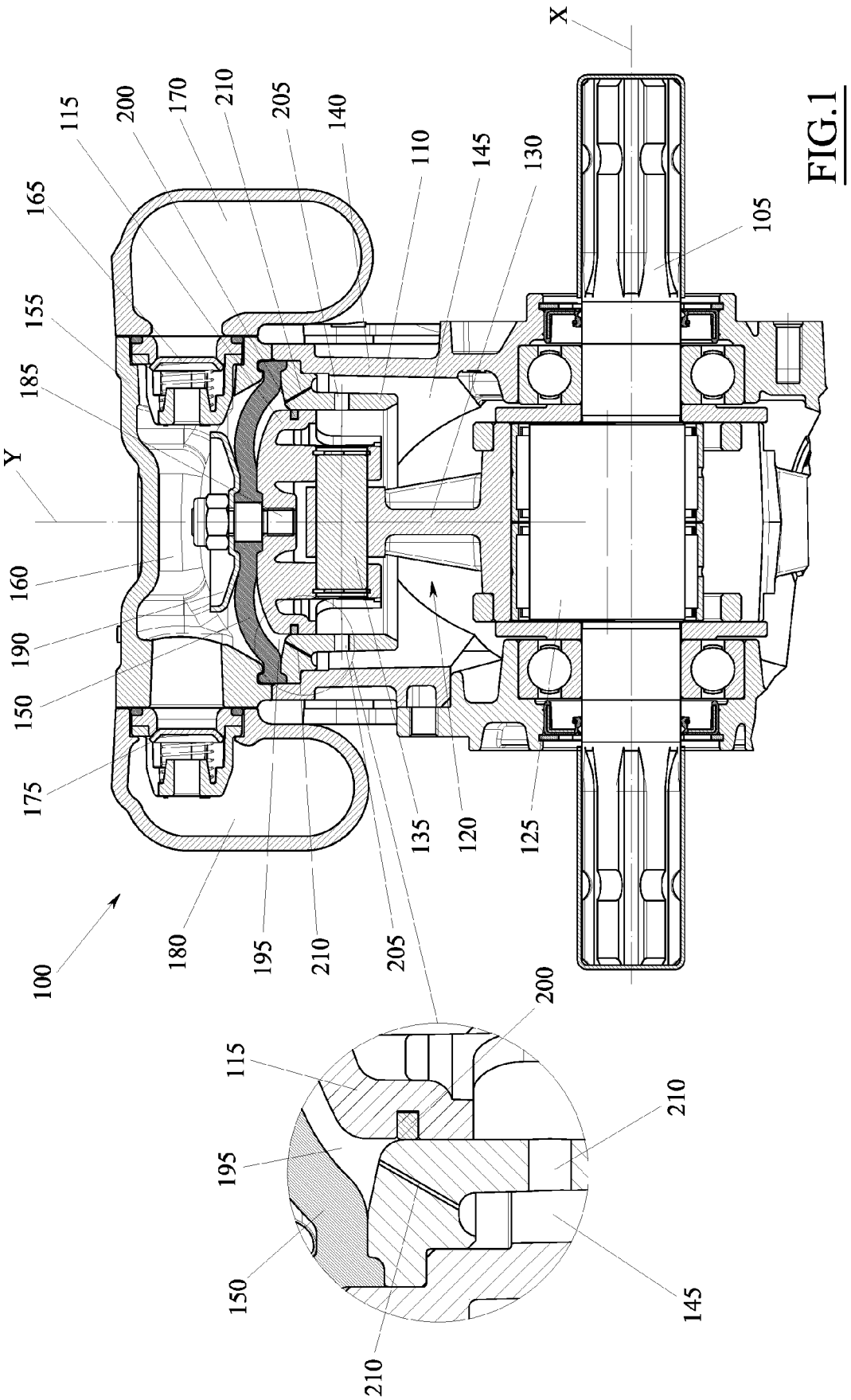
X
Y
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
210
115
200
195
210
150
145
210

FIG.1

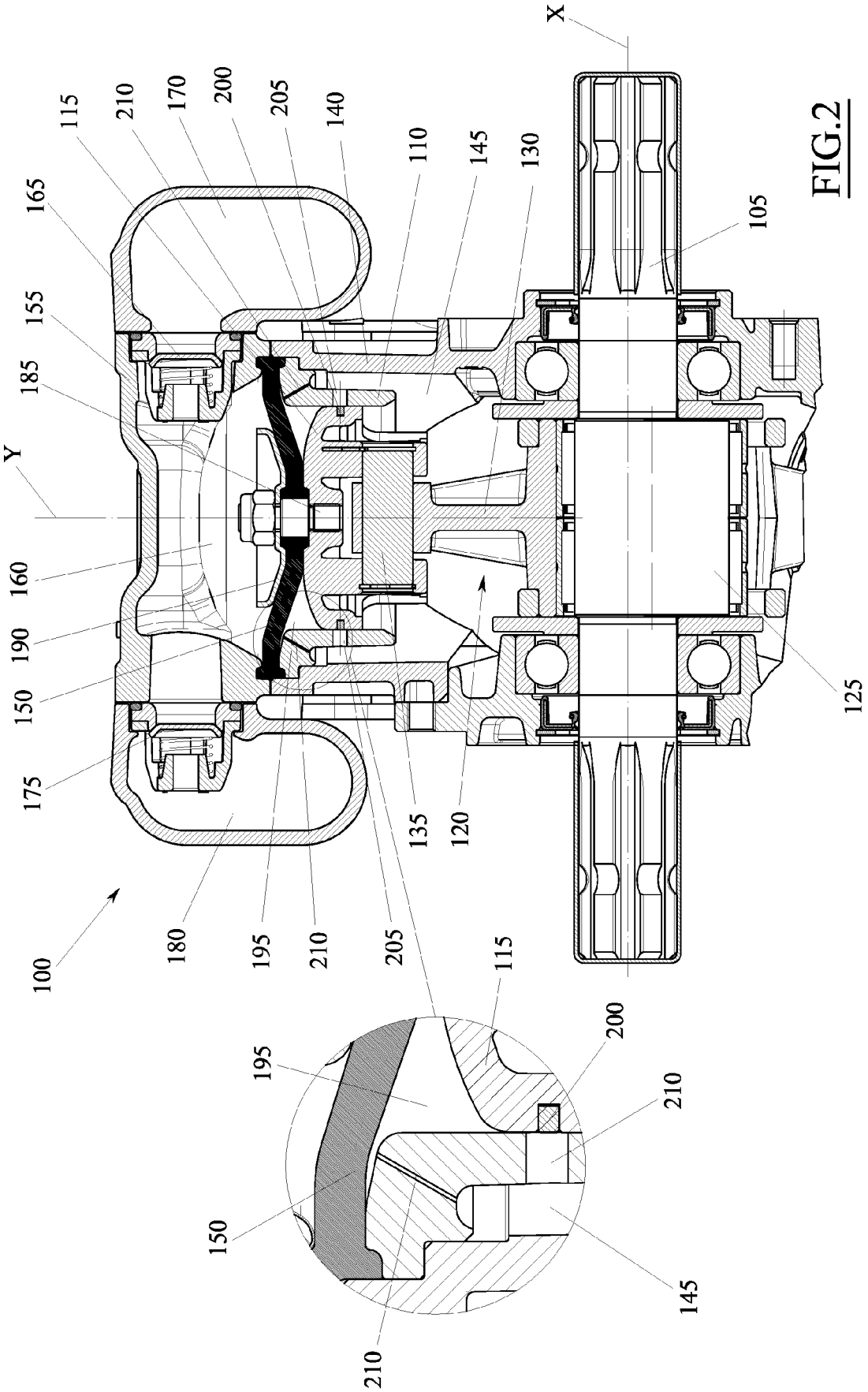
X
Y
115
210
170
200
205
140
110
145
130
165
105
155
185
160
190
150
175
125
135
120
100
180
195
210
205
115
200
195
210
150
145
210

FIG.2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 16 1805

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	US 5 246 351 A (HORN WALDEMAR [DE] ET AL) 21 September 1993 (1993-09-21) * abstract *; figures * * column 6, line 58 - column 6, line 66 * * column 7, line 62 - column 8, line 5 * * column 9, line 27 - column 9, line 39; figure 7 *	1-7	INV. F04B43/02 F04B43/06 F04B53/06
X	US 3 075 468 A (EIFEL PAUL J) 29 January 1963 (1963-01-29) * figure 2 * * column 5, line 35 - column 6, line 12 * * column 7, line 24 - column 7 *	1-7	
X A	WO 2004/106884 A1 (WANNER ENGINEERING [US]) 9 December 2004 (2004-12-09) * abstract *; figures * * page 12, line 21 - page 12, line 26 * * page 20, line 12 - page 21, line 29 *	1-4 5-7	
A	WO 00/68574 A1 (MILTON ROY CO [US]) 16 November 2000 (2000-11-16) * figures *	1	TECHNICAL FIELDS SEARCHED (IPC) F04B
A	EP 2 921 705 A1 (ANNOVI REVERBERI SPA [IT]) 23 September 2015 (2015-09-23) * figures *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 April 2019	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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 16 1805

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.

11-04-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5246351 A	21-09-1993	DE 4141670 A1	01-07-1993
		EP 0547404 A1	23-06-1993
		JP H05240162 A	17-09-1993
		US 5246351 A	21-09-1993
US 3075468 A	29-01-1963	NONE	
WO 2004106884 A1	09-12-2004	AU 2003245292 A1	21-01-2005
		BR 0318302 A	11-07-2006
		CN 1781015 A	31-05-2006
		DK 1625377 T3	22-05-2017
		EP 1625377 A1	15-02-2006
		EP 3096013 A1	23-11-2016
		ES 2630179 T3	18-08-2017
		JP 4530988 B2	25-08-2010
		JP 2006526099 A	16-11-2006
		WO 2004106884 A1	09-12-2004
WO 0068574 A1	16-11-2000	CN 1350616 A	22-05-2002
		US 6264436 B1	24-07-2001
		WO 0068574 A1	16-11-2000
EP 2921705 A1	23-09-2015	CN 104929924 A	23-09-2015
		DK 2921705 T3	07-01-2019
		EP 2921705 A1	23-09-2015
		US 2015267694 A1	24-09-2015

EPO FORM P0459

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