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(54) **A PUMP PROVIDED WITH SENSORS**

(57) A pump (100) is described, for example a volumetric diaphragm pump, comprising an intake manifold (175), a delivery manifold (185), at least one pumping unit (110) adapted to transfer a fluid from the intake manifold (175) to the delivery manifold (185), a pump body (150) adapted to contain a lubricating oil for the pumping unit, and one or more sensors (500, 505, 510, 515, 520), of which at least one lubricating oil temperature sensor (505), which is coupled to an exhaust hole (552) of the pump body (150).

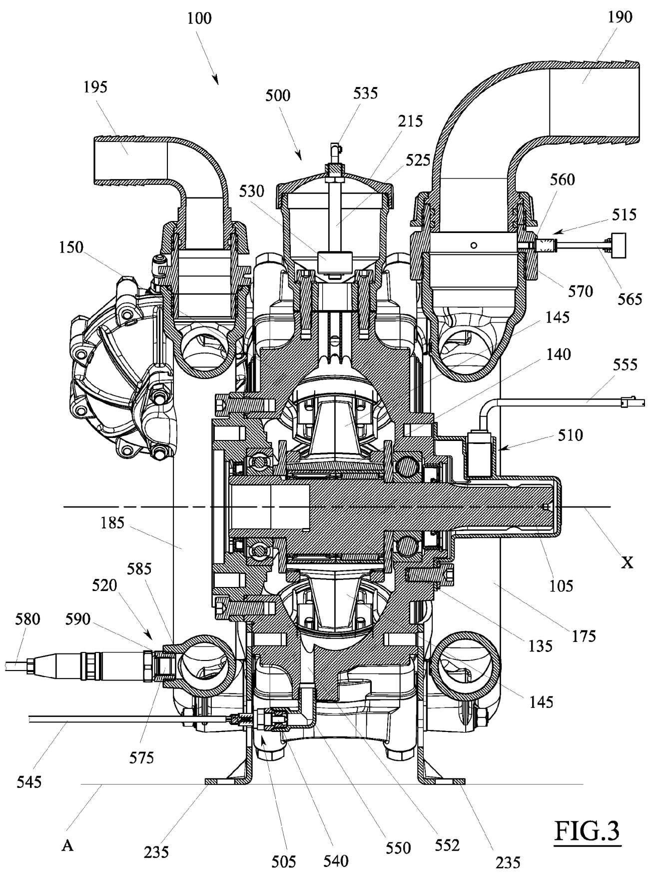

FIG.3

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Description

Technical Field

[0001] The present invention relates to a pump, for example but not limited to a volumetric pump.

Prior art

[0002] A volumetric pump is a device that schematically comprises an intake manifold, a delivery manifold and one or more pumping units adapted to transfer a fluid from the delivery manifold to the exhaust manifold, increasing the pressure thereof.

[0003] Each pumping unit normally comprises a pumping chamber, which is in communication with the intake manifold through an intake valve and with the delivery conduit through a delivery valve, and a movable member adapted to cyclically vary the volume inside the pumping chamber.

[0004] When the volume increases, a depression is created inside the pumping chamber which causes the opening of the intake valve and the inlet of fluid from the intake manifold.

[0005] When on the other hand the volume decreases, overpressure is created in the pumping chamber which closes the intake valve and opens the delivery valve, causing the exit of pressurized fluid towards the delivery manifold.

[0006] In the case of a volumetric diaphragm pump, the movable member that causes this volume variation is defined by a flexible diaphragm that partially delimits the pumping chamber and that is fixed to an activation piston, whose alternative movement causes the periodic introflexion and extroversion of the diaphragm.

[0007] This type of pump is widespread and is used, especially in the agricultural sector, e.g. for watering crops with protective liquids, fertilizers or other types. A drawback of current volumetric pumps however lies in that fact that they are completely free from any monitoring system to monitor their operating parameters, with the consequence that the adjustment and management of these pumps takes place solely with the visual or sensory control of the users.

[0008] As users are not always able to immediately notice any pump performance variations, it is clear how pumps can sometimes be left to operate in non-optimal conditions for relatively long periods, hence not only running into drops in efficiency but also malfunctioning that can sometimes damage them. This can happen, for example, when the lubricating oil for lubricating the moving parts of the pumping units reaches such high temperatures as to cause changes to some of its chemical/physical properties, e.g. viscosity.

[0009] In fact, under these conditions, the lubricating oil loses effectiveness, causing a drastic increase in wear and energy consumptions.

Disclosure of the invention

[0010] In light of the above, an object of the present invention is to solve, or at least significantly mitigate, the mentioned drawbacks of the prior art, within the context of a simple and rational solution and at a relatively contained cost. This and other objects are reached by the characteristics of the invention as set forth in the independent claim 1. The dependent claims outline preferred and/or particularly advantageous aspects of the invention.

[0011] In more detail, an embodiment of the present invention provides a pump, typically a volumetric diaphragm pump comprising an intake manifold, a delivery manifold, at least one pumping unit adapted to transfer a fluid from the intake manifold to the delivery manifold, a pump body (or case) adapted to contain a lubricating oil for the pumping unit, and one or more sensors, typically electric/electronic sensors, of which at least one lubricating oil temperature sensor, which is inserted inside an exhaust hole of the pump body.

[0012] Thanks to this solution, the pump is equipped with an electric/electronic system able to monitor at least the temperature of the lubricating oil, providing users with an effective and reliable tool for understanding whether the pump operates correctly or not.

[0013] Furthermore, being inserted inside the exhaust hole, the temperature sensor does not require any further holes or openings to be made in the pump body and allows the temperature sensor to also act as an exhaust plug. According to an advantageous aspect of the invention, the exhaust hole can be positioned in a portion of the pump proximal to a support surface of the pump.

[0014] In this way, when the pump is installed in operation, e.g. above an agricultural tractor or trailer, the exhaust hole is substantially located in the lowest area of the pump body, so that its opening, obtained by removing the temperature sensor, allows all the lubricating oil to be emptied effectively, without having to disassemble the pump.

[0015] According to another aspect of the invention, it is preferable for the sensors associated with the pump to comprise one or more of the following sensors: an intake pressure sensor, a delivery pressure sensor, a lubricating oil level sensor, a rotational speed sensor of a rotating shaft which is operable to actuate the pumping unit.

[0016] Thanks to this solution, users are effectively able to monitor almost all the important operating parameters of the pump by means of the sensors.

[0017] A further aspect of the invention envisages each sensor being able to be connected to an electronic data acquisition board, which can be assembled directly on the pump.

[0018] In this way, the pump becomes an integrated device which only needs to be connected with a device able to interface with the electronic data acquisition board.

[0019] In this connection, the electronic data acquisition board can also comprise an interfacing system with an electronic processor.

[0020] Thanks to this solution, the measurements performed by the sensors can be transmitted simply and immediately to the electronic processor, which can manage them and use them according to the most suitable methods based on their needs.

[0021] For example, the interfacing system may comprise a CAN-BUS connection port.

[0022] In this way, the electronic data acquisition board can be effectively connected with the electronic control unit of a vehicle, e.g. on a tractor on which the pump is installed, allowing such control unit to acquire the measurements performed by the sensors and to use them in the management not only of the pump but, possibly, also of other apparatuses.

[0023] According to another aspect of the invention, the interfacing system may comprise a wireless connection module, e.g. Bluetooth.

[0024] In this way, the electronic data acquisition board can be simply connected to the electronic processor of any portable device, e.g. a laptop, a tablet or a smartphone.

[0025] An aspect of the invention envisages that the electronic processor can be configured for displaying on a monitor the data measured by each sensor. This solutions allows users to have immediate control over the pump's operating parameters.

[0026] According to another aspect of the invention, the electronic processor can be configured to activate an alarm signal, if any data measured by at least one sensor satisfies a predetermined activation criterion, e.g. if it exceeds a predetermined maximum acceptable value or if it drops below a minimum acceptable value.

[0027] Thanks to this alarm signal, which may be of the visual, sound or any other type, users can be immediately and promptly warned of the operating status of the pump, e.g. of the onset of an abnormality, without them having to continuously monitor the operating parameters measured by the sensors.

Brief description of the drawings

[0028] Further characteristics and advantages of the invention will become clear from reading the following description provided as a non-limiting example, with the help of the figures illustrated in the attached tables.

Figure 1 is a side view of a pump according to an embodiment of the present invention.

Figure 2 is a front view of the pump of figure 1.

Figure 3 is the section III-III indicated in figure 2.

Figure 4 is the section IV-IV indicated in figure 1.

Detailed description

[0029] The mentioned figures show a volumetric membrane pump 100 for pumping fluids, in particular for pumping liquids. For example, the pump 100 can be used in the agricultural sector for pumping protective liquids, fertilizers or other types.

[0030] The pump 100 is adapted to be installed on board a machine, a system, an equipment, a vehicle, a trolley or any other apparatus on which the pump 100 needs to be used. For example, the pump 100 can be installed on board an agricultural tractor.

[0031] As illustrated in figures 3 and 4, the pump 100 comprises an activation shaft 105, which is adapted to rotate on itself about its own central axis X. The activation in rotation of the activation shaft 105 can be obtained through a direct or indirect connection with an electric motor or a heat engine, e.g. with the engine of the agricultural tractor through a power take off.

[0032] The pump 100 further comprises a plurality of pumping units 110, in the example six pumping units 110 arranged in a star geometry around the central axis X.

[0033] Each pumping unit 110 comprises a cylinder 120 having a longitudinal axis that is oriented perpendicular to the central axis X of the activation shaft 105. In particular, the longitudinal axes of the pumping units 110 are coplanar and angularly equidistant to each other.

[0034] Inside each cylinder 120 a respective piston 125 is slidably housed, which is connected to the activation shaft 105 through a mechanism 130 adapted to transform the rotary movement of the activation shaft 105 into a linear and alternative movement of the piston 125 inside its own cylinder 120.

[0035] In this way, each piston 125 is cyclically adapted to move between a bottom dead centre position, in which it is at the minimum distance from the activation shaft 105, and a top dead centre position, in which it is at the maximum distance from the activation shaft 105.

[0036] In the example illustrated, the mechanism 130 comprises a cylinder-shaped eccentric 135 which is fixed to the activation shaft 105, e.g. made in a single piece therewith, and a ring 140 coaxially and rotatably coupled to said eccentric 135, e.g. through the interposition of appropriate rolling bodies.

[0037] From the ring 140 a plurality of rods 145 derive radially, the free end of each of which is articulated to a respective piston 125.

[0038] In this way, a plurality of thrust crank mechanisms are obtained, able to transform the rotary movement of the activation shaft 105 into an alternative movement of the pistons 125.

[0039] The mechanism 130 is contained and protected inside a relevant pump body 150 (or case) being hollow inside, in which the main bearings are also housed for the activation shaft 105.

[0040] The internal volume of the pump body 105 is filled with an appropriate lubricating oil, whose main function is that of lubricating the moving parts of each pumping unit 110, in particular the interfacing surfaces between the piston 125 and cylinder 120, the articulation between the piston 125 and the rod 145, and the mechanism 130.

[0041] The free end of each cylinder 120, i.e. the one placed at the maximum radial distance from the activation shaft 105, is closed by a flexible diaphragm 155 which is preferably made of elastomeric material (typically rubber).

[0042] In particular, each flexible diaphragm 155 is interposed and locked between the free end of the respective cylinder 120 and a head 160, which is fixed to the pump body 150 (e.g. through screws) and cooperates with the flexible diaphragm 155 for defining a pumping chamber 165.

[0043] Each head 160 is provided with an automatic intake valve adapted to selectively place in communication the respective pumping chamber 165 with an intake manifold 175, and an automatic intake valve adapted to selectively place in communication the respective pumping chamber 165 with an intake manifold 185.

[0044] The intake and delivery valves are not illustrated herein as they are already widely known to a person skilled in the art.

[0045] In the example illustrated, the intake manifold 175 and/or the delivery manifold 185 are individually defined by an annular conduit, which extends along a closed path that substantially lies in a plane orthogonal to the central axis X of the activation shaft 105.

[0046] In particular, the intake manifold 175 and the delivery manifold 185 are preferably the same as each other, or almost, and are arranged coaxially with respect to the activation shaft 105, fixed to the pump body 150 on opposite sides with respect to the pumping units 110.

[0047] The intake manifold 175 and the delivery manifold 185 are further respectively connected to an inlet conduit 190, which can be connected to a tank of liquid to be pumped, and to an outlet conduit 195, which can be connected to the devices that are to receive the liquid at high pressure.

[0048] With particular reference to the section of figure 4, each flexible diaphragm 155 is centrally constrained to the piston 125 which is slidably coupled to the related cylinder 120.

[0049] In particular, the flexible diaphragm 155 can be locked between the thrust surface (ceiling) of the piston 125 and a fixing plate 200 that can be joined to the piston 125 through a central screw.

[0050] In this way, when the piston 125 is displaced towards the bottom dead centre, the flexible diaphragm 155 is deformed towards the activation shaft 105, causing an increase in the volume of the pumping chamber 165. This increase in volume causes a reduction of the internal pressure that allows the opening of the intake valve and therefore the inlet of the fluid to be pumped coming from the intake manifold 175.

[0051] Vice versa, when the piston 125 is displaced towards the top dead centre, the flexible diaphragm 155 is deformed in the opposite direction, causing a reduction in the volume of the pumping chamber 165 and therefore an increase in the internal pressure, to cause the opening of the intake valve and the outlet of the fluid at high pressure towards the delivery manifold 185. During the operation of the pump 100, the moving parts of the pumping units 110 are lubricated by the lubricating oil contained inside the pump body 150. To guarantee the presence of a sufficient quantity of lubricating oil inside the pump 100, the internal volume of the pump body 150 (the one that contains the oil) is in hydraulic communication with a basin 215, which is positioned at a higher height with respect to all the cylinders 120.

[0052] In particular, the basin 215 is fixed to the outside of the pump body 150 and is placed in communication with the internal volume of the pump body 150 through a rectilinear conduit 220 that extends with an orthogonal axis to the central axis X of the activation shaft 105 (see fig.4).

[0053] The pump 100 further comprises one or more connection brackets 235 defining a support surface A parallel to the central axis X of the activation shaft 105, through which the pump 100 can be supported and fixed onto an abutment element of the apparatus for which the pump 100 is intended. Preferably, the connection brackets 235 can be fixed to the outside of the heads 160 of the pumping units 110 or to the pump body 150 but on the opposite side with respect to the basin 215, so as to act as a pedestal that is interposed between the pump 100 and the intended apparatus.

[0054] In particular, the installation of the pump 100 envisages the support surface A being arranged horizontally, so that the central axis X is horizontal and the basin 215 is positioned at a higher height with respect to the abutment surface A.

[0055] Naturally, the connection brackets 235 described above can be replaced by any other element adapted to define a support surface for the pump 100.

[0056] The pump 100 further comprises a plurality of sensors, where "sensor" means an electrical, electronic or electromechanical transducer adapted to transform a physical input magnitude into an electrical output signal, typically but not necessarily into an analog signal, the value of a characteristic magnitude of which (e.g. the voltage or current) is directly related to the value of the physical input magnitude.

[0057] As can be seen in figure 3, the sensors of the pump 100 can comprise, for example, a level sensor 500 of the lubricating oil inside the pump body 150, a temperature sensor 505 of the lubricating oil, a rotation speed sensor 510 of the activation shaft 105, a sensor 515 of the intake pressure, i.e. of the pressure of the fluid upstream of the intake valves, and a sensor 520 of the delivery pressure, i.e. of the pressure of the fluid downstream of the delivery valves.

[0058] In more detail, the sensor 500 can be inserted into the basin 215 and can comprise a rectilinear guide rod 525 orthogonal to the support surface A, a float 530 slidably coupled to said guide rod 525, and an electrical terminal 535 adapted to transmit an electrical signal indicating the relative position of the float 530 with respect to the guide rod 525.

[0059] The sensor 505 is preferably coupled to an exhaust hole 552 of the pump body 150, which is adapted to place in communication the internal volume of the pump body 150 with the outside.

[0060] "Exhaust hole" means a hole through which the lubricating oil contained in the pump body 150 can be discharged to the outside of the pump 100, e.g. for being replaced.

[0061] In this way, the exhaust hole 552 is normally closed by the sensor 505 (which also acts like a plug), which can be removed if necessary to allow the outlet of all the lubricating oil contained in the pump body 105.

[0062] To allow the complete outflow of the lubricating oil, the exhaust hole 552 is preferably fashioned in the lower portion of the pump body 150, i.e. in the portion of the pump body 150 that is proximal (closest) to the support surface A.

[0063] In particular, the exhaust hole 552, which can extend in a rectilinear way with a perpendicular axis to the support surface A, has an lower end (i.e. closer to the support surface A) that is open to the outside and an upper end (i.e. further from the support surface A), that leads directly into the lower part (bottom) of the internal cavity of the pump body 150.

[0064] The sensor 505, which may be based on a thermoresistor or on any other known system, generally comprises a sensitive element 540 adapted to be in direct contact with the lubricating oil contained in the pump body 150 and an electrical terminal 545 adapted to transmit an electrical signal indicating the temperature of the sensitive element 540.

[0065] In the example illustrated, the sensitive element 540 is engaged with the end of a fitting 550, in this case an elbow fitting, whose second end is coupled to the lower end of the exhaust hole 552.

[0066] However, it is not excluded that, in other embodiments, the fitting 550 may have a different shape or possibly be missing completely, with the sensitive element 540 directly engaged in the exhaust hole 552.

[0067] The sensor 510 may be a magnetic or inductive or Hall effect sensor which, facing a grooved stretch of the activation shaft 105, is able to generate and to transmit through an electrical terminal 555 an electrical signal proportional to the rotation speed of the activation shaft 105 itself. Such sensor 510 can be housed inside an appropriate seat fashioned in a support body that surrounds the grooved stretch of the activation shaft 105 and that is fixed to the pump body 150.

[0068] The sensor 515, which may be of the piezoresistive type, of the diaphragm type with Wheatstone bridge resistors or of any other known type, generally comprises a sensitive element 560 adapted to be in direct contact with the fluid upstream of the intake valves and an electrical terminal 565 adapted to transmit an electrical signal indicating the pressure that said fluid exerts on the sensitive element 560.

[0069] In the example illustrated, the sensitive element 560 is inserted in a hole fashioned in a connection fitting 570 between the inlet conduit 190 and a mouth of the intake manifold 175, so that the pressure measurement is not excessively disturbed by the pressure waves due to the opening and closing of the intake valves.

[0070] Also the sensor 520 may be of the piezoresistive type, of the diaphragm type with Wheatstone bridge resistors or of any other known type, and may comprise a sensitive element 575 adapted to be in direct contact with the fluid downstream of the delivery valves and an electrical terminal 580 adapted to transmit an electrical signal indicating the pressure that said fluid exerts on the sensitive element 575.

[0071] In particular, it is preferable for the sensitive element 575 to be inserted inside an exhaust hole 585 in the delivery manifold 185.

[0072] "Exhaust hole" means a hole through which the fluid contained downstream of the delivery valves can be discharged to the outside of the pump 100, e.g. for cleaning the circuit before disassembling the pump 100 or before using it for pumping a different fluid.

[0073] To allow the complete outflow of the fluid, the exhaust hole 585 is generally positioned in the lower part of the delivery manifold 185, i.e. in the proximal portion (closer) to the support surface A.

[0074] In this way, the sensor 520, as well as effectively measuring the pressure of the fluid in the delivery manifold 185, also acts as a plug that closes the exhaust hole 585.

[0075] Possibly, to achieve such closing, an annular connector fitting 590 can be interposed between the sensitive element 575 of the sensor 520 and the exhaust hole 585.

[0076] All the sensors 500, 505, 510, 515 and 520 can be connected, through the respective electrical terminals 535, 545, 555, 565 and 580, to a single electronic data acquisition board 595 (see figs.1 and 2), which can assembled integrally onto the pump 100, e.g. fixed onto the outer side to the pump body 150 between two consecutive heads 160.

[0077] The electronic board 595 can generally be configured to receive the analog signals generated by each sensor 500, 505, 510, 515 and 520, to transform them into digital signals, and to transmit these digital signals to one or more external electronic processors.

[0078] For this reason, the electronic board 595 may comprise a relevant interfacing system.

[0079] Such interfacing system may comprise for example a CAN-BUS connection module, through which the electronic board 595 may be connected to the electronic control unit of a vehicle, e.g. of the tractor on which the pump 100 is installed.

[0080] Additionally or alternatively, the interfacing system may also comprise a wireless connection module, e.g. a bluetooth connection module, through which the electronic board 595 may be connected to the electronic processor of any portable device, such as a laptop, a tablet or a smartphone.

[0081] Naturally, the interfacing system could also comprise connection modules of another type, either wired or wireless, as long as they are suitable for establishing data exchange between the electronic board 595 and an electronic processor that is separate and independent from the pump 100.

[0082] Through at least one of the connection modules of the interfacing system, it is also envisaged that the external electronic processor may be able to program the electronic board 595.

[0083] Regardless of these considerations, the electronic processor that receives the signals from the electronic board 595 can generally be configured to display, for example on a monitor, the data measured by each sensor 500, 505, 510, 515 and 520, thus making them available to a user.

[0084] Additionally, the electronic processor can be configured to activate an alarm signal, if any of the data measured by at least one of the sensors satisfies a predefined activation criterion.

[0085] For example, the electronic processor can be configured to generate an alarm signal if the physical magnitude value measured by said sensor drops below a predetermined minimum threshold value and/or if vice versa it exceeds a predetermined maximum threshold value.

[0086] In particular, an alarm signal may be generated if the temperature of the lubricating oil measured by the sensor 505 exceeds a predetermined maximum threshold value.

[0087] The alarm signal may be a visual signal, e.g. projected onto the same monitor from which the data are projected, or a sound signal or any other signal perceivable by a user.

[0088] Obviously a person skilled in the art can make numerous modifications of a technical/application nature to the pump 10 described above, without departing from the scope of the invention as claimed below.

[0089] For example, although in the previous description a diaphragm pump 100 has been illustrated with six pumping units 110, in other embodiments, the pump 100 could comprise a different number of pumping units 110 or they could be of another type, e.g. a plunger piston pump.

Claims

1. A pump (100) comprising an intake manifold (175), a delivery manifold (185), at least one pumping unit (110) adapted to transfer a fluid from the intake manifold (175) to the delivery manifold (185), and a pump body (150) adapted to contain a lubricating oil for the pumping unit (110), **characterized in that** it comprises one or more sensors (500, 505, 510, 515, 520), of which at least one lubricating oil temperature sensor (505), which is coupled to an exhaust hole (552) of the pump body (150).

2. A pump (100) according to claim 1, **characterized in that** said exhaust hole (552) is positioned in a portion of the pump body (150) being proximal to a support surface (A) of the pump (100).

3. A pump (100) according to claim 1 or 2, **characterized in that** the sensors (500, 505, 510, 515, 520) comprise one or more of the following sensors: an intake pressure sensor (515), a delivery pressure sensor (520), a lubricating oil level sensor (500), a rotational speed sensor (510) of a rotating shaft (105) which is adapted to actuate the pumping unit (110).

4. A pump (100) according to any one of the preceding claims, **characterized in that** each sensor (500, 505, 510, 515, 520) is connected to an electronic data acquisition board (595).

5. A pump (100) according to claim 4, **characterized in that** the electronic board (595) is mounted on the pump (100).

6. A pump (100) according to claim 4 or 5, **characterized in that** the electronic board (595) comprises an interfacing system with an electronic processor.

7. A pump (100) according to claim 6, **characterized in that** the interfacing system comprises a CAN-BUS connection port.

8. A pump (100) according to claim 6 or 7, **characterized in that** the interfacing system comprises a wireless connection module.

9. A pump (100) according to any of the claims 6 to 8, **characterized in that** the electronic processor is configured to display on a monitor the data measured by each sensor (500, 505, 510, 515, 520).

10. A pump (100) according to any one of claims 6 to 9, **characterized in that** the electronic processor is configured to activate an alarm signal, if a data measured by at least one sensor (500, 505, 510, 515, 520) meets a predetermined activation criterion.

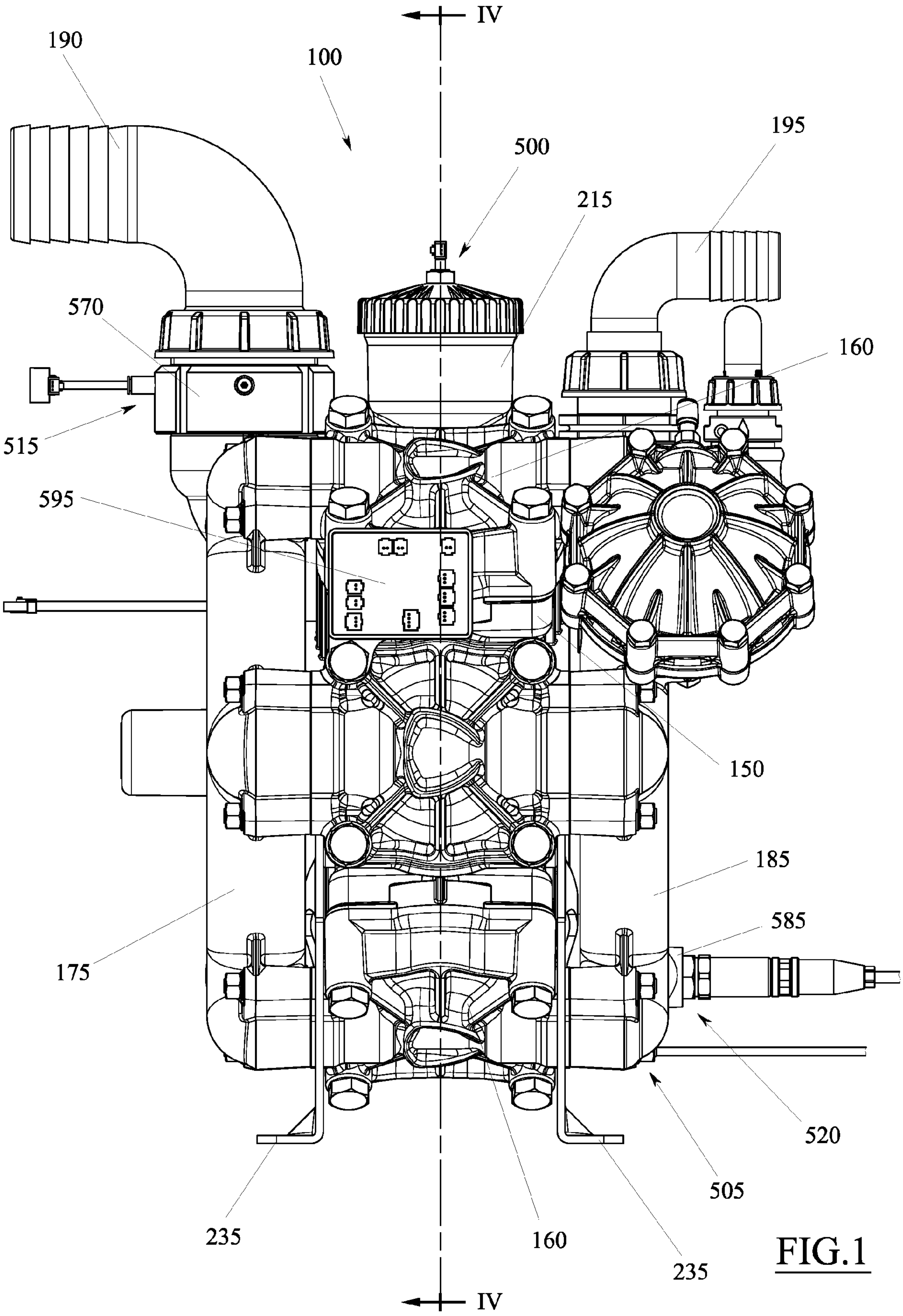
IV
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FIG.1

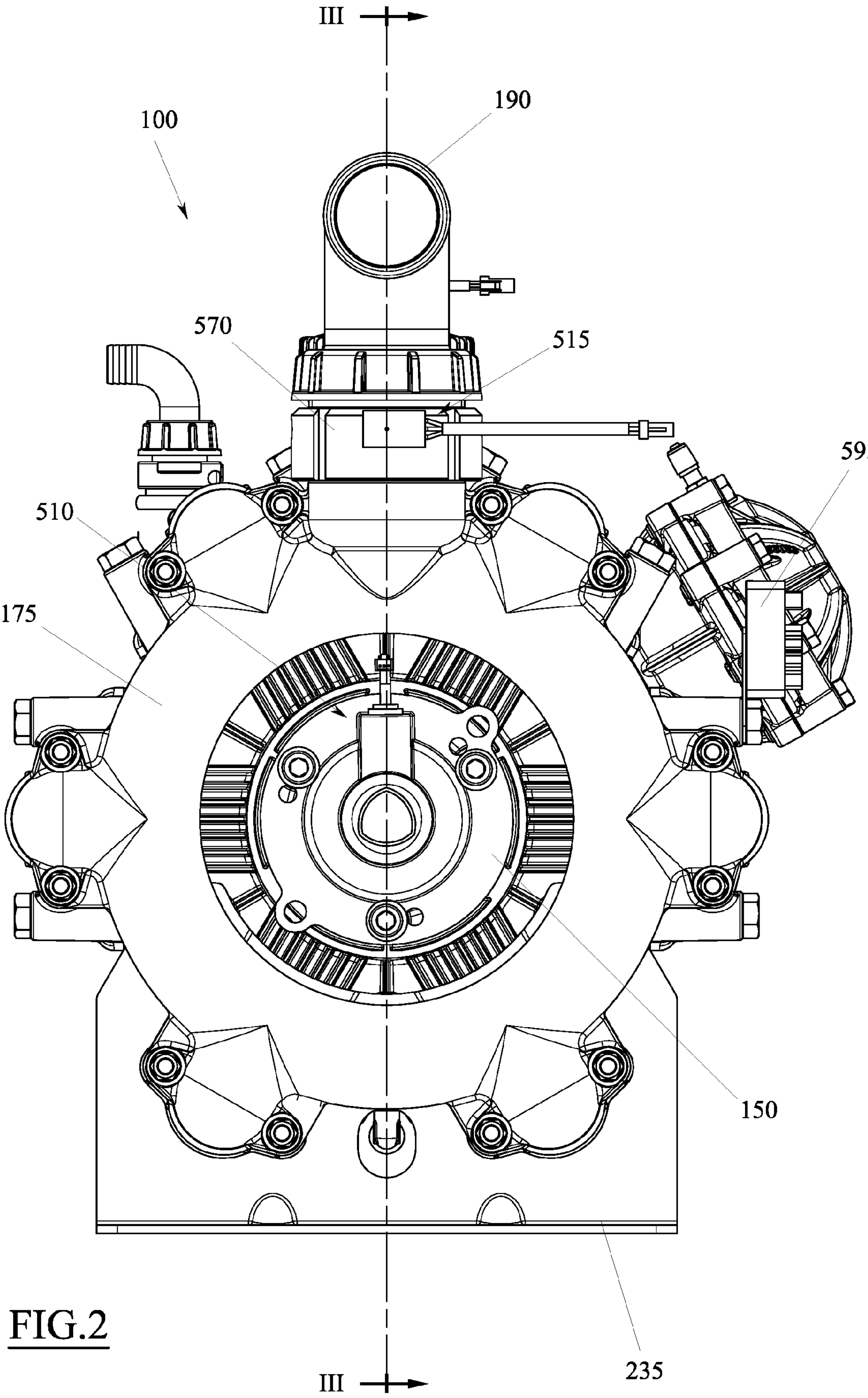

FIG.2

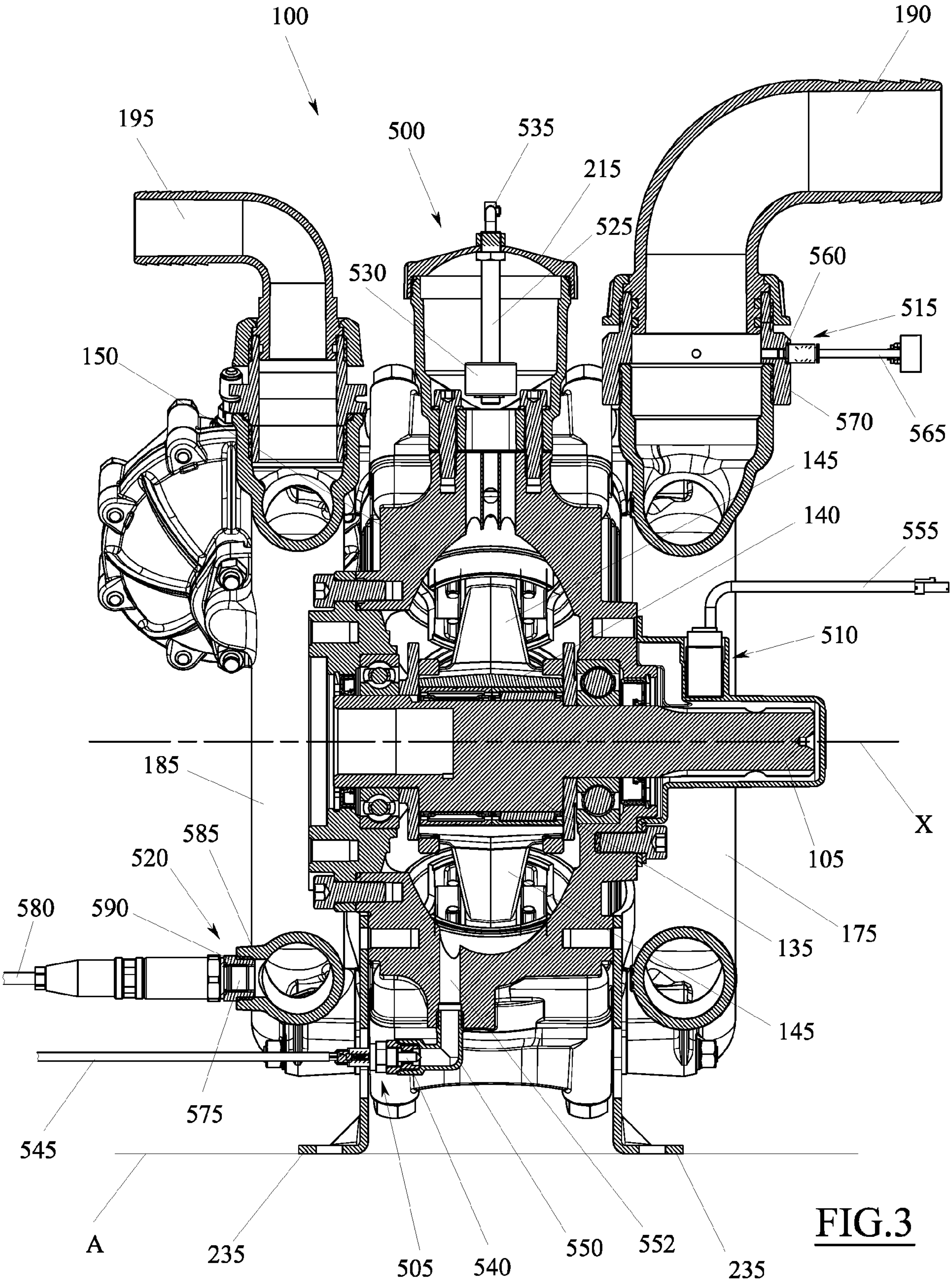
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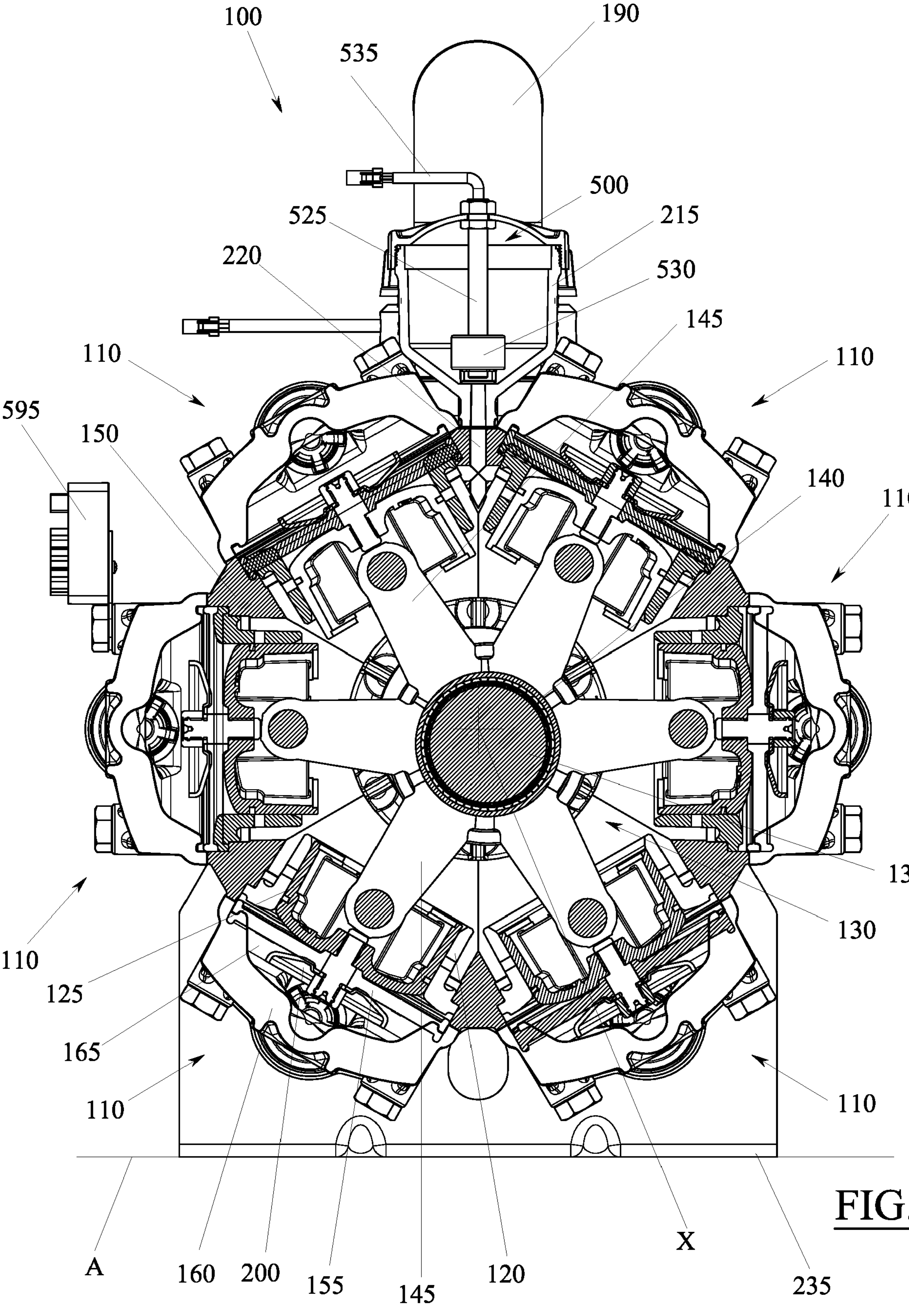
FIG.3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145
120
X
235

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 8828

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	WO 2016/176328 A1 (EMERSON CLIMATE TECHNOLOGIES [US]) 3 November 2016 (2016-11-03) * abstract *paragraphs 81,82,87; figures 3-4 *	1-10	INV. F04B43/02 F04B49/06 F04B49/10 F04B53/16 F04B53/18 F04B53/22
X	US 2008/168898 A1 (HARDIN JOHN W [US] ET AL) 17 July 2008 (2008-07-17) * abstract *paragraphs 37,69; figure 2 *	1-10	
X	US 2006/065012 A1 (KUDO TAKAYUKI [JP]) 30 March 2006 (2006-03-30) * paragraphs [0044] - [0054]; figures *	1-10	
X	US 6 425 293 B1 (WOODROFFE JAIME A [US] ET AL) 30 July 2002 (2002-07-30) * column 6, lines 1-35; claims; figures * * columns 10, 18 *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)
F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	21 December 2018	Pinna, Stefano

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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