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

(11) EP 3 091 203 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.11.2016 Bulletin 2016/45

(51) Int Cl.:
***F01K 25/08** (2006.01)* ***F01K 9/02** (2006.01)*

(21) Application number: **16167519.4**

(22) Date of filing: **28.04.2016**

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

(30) Priority: **29.04.2015 IT UB20150142**

(71) Applicant: **Kaymacor S.r.l.**
37045 Legnago (VR) (IT)

(72) Inventor: **FLORIS, Marco Giuseppe Francesco**
I-37045 Legnago (Verona) (IT)

(74) Representative: **De Bonis, Paolo**
Buzzi, Notaro & Antonielli d'Oulx S.r.l.
Via Maria Vittoria, 18
10123 Torino (IT)

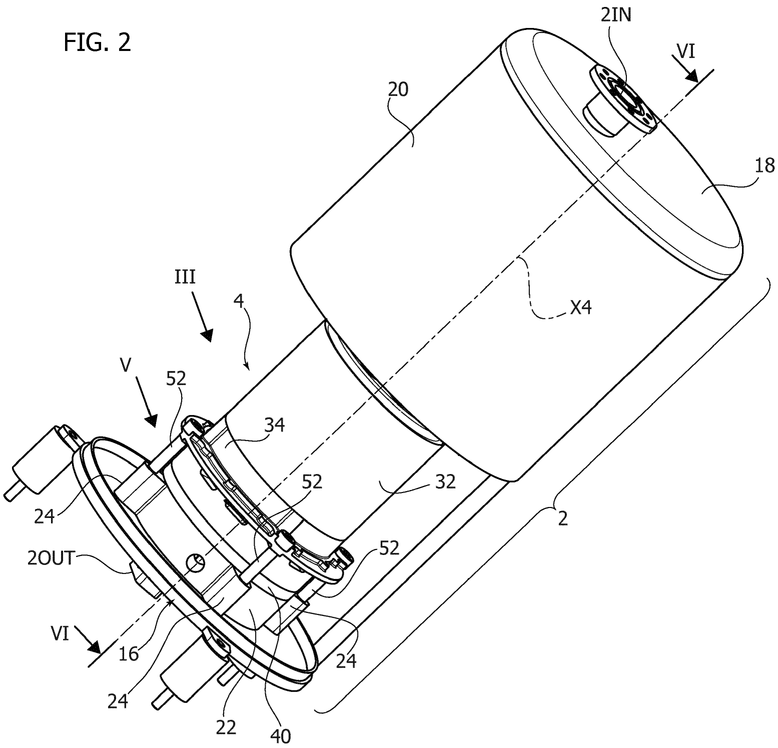
(54) **A RESERVOIR FOR THE RECEPTION OF A CONDENSED WORKING FLUID OF AN ORGANIC RANKINE CYCLE SYSTEM**

(57) Described herein is a reservoir (2; 2') for the reception of a condensed working fluid of an organic Rankine cycle system, the reservoir including an internal volume, an inlet port (2IN) for the intake of condensed working fluid into the internal volume, and an outlet port (20UT) for the condensed working fluid.

The reservoir (2; 2') includes a pump (4) housed in said internal volume, said pump (4) having an intake port (4IN, I34, I36, I38, I22) for the withdrawal of said condensed working fluid from said internal volume and a delivery port (40UT, D34, D36, D38, D22) for the delivery of said working fluid through said outlet port (20UT) of the reservoir.

Moreover described is an organic Rankine cycle system (1) including the reservoir (2; 2'; 2") referred to above.

FIG. 2



EP 3 091 203 A1

Description

Field of the invention

[0001] The present invention relates to organic Rankine cycle (ORC) systems, in particular to reservoirs for receiving a condensed working fluid, which are commonly known as "receivers". An organic Rankine cycle uses a working fluid of an organic nature, unlike a common Rankine cycle with superheated steam.

Prior art and general technical problem

[0002] With reference to Figure 1A, the reference number 1* designates as a whole an example of organic Rankine cycle system of a known type. The system 1* includes a receiver 2*, a pump 4*, a heat exchanger 6, an evaporator 8, an expander 10, an electric generator 12 mechanically connected to the expander 10, and a condenser unit 14. The receiver 2* includes an inlet port 2IN* configured for receiving condensed working fluid from the condenser unit 14, and a discharge port 2OUT* in fluid communication with the intake port of the pump 4*. A delivery port of the pump 4* is, instead, in fluid communication with a first inlet port 6LIN of the heat exchanger 6, whereas a first outlet port 6LOUT of the heat exchanger 6 is in fluid communication with a first inlet port 8LIN of the evaporator 8.

[0003] A first outlet port of the evaporator 8, designated by the reference 8LOUT, is in turn in fluid communication with an intake port 10IN of the expander 10, whereas a discharge port 10OUT of the expander 10 is in fluid communication with a second inlet port 6GIN of the heat exchanger 6. A second outlet port 6GOUT of the heat exchanger 6 is in turn in fluid communication with an inlet port 14IN of the condenser unit 14, whereas a discharge port 14OUT of the unit 14 is in fluid communication with the inlet port 2IN*.

[0004] The two pairs of inlet and outlet ports of the heat exchanger 6 and of the evaporator 8 constitute the ends of two flow paths. In particular, in the heat exchanger 6 the first flow path develops between the ports 6LIN and 6LOUT, whereas the second flow path develops between the ports 6GIN and 6GOUT. The two flow paths are in relation of heat exchange with one another.

[0005] In a similar way, the first flow path within the evaporator 8 is defined between the ports 8LIN and 8LOUT, whereas the second flow path is defined between a second inlet port 8HSIN and a second outlet port 8HSOUT, which are traversed by a thermovector fluid HS. The two flow paths are in relation of heat exchange with one another.

[0006] The working fluid in the liquid phase processed by the pump 4* enters the first flow path of the heat exchanger 6 through the port 6LIN, where it is pre-heated thanks to the heat exchange with the fluid that flows in the second flow path of the heat exchanger 6.

[0007] The pre-heated fluid then exits from the heat exchanger 6 in the liquid phase through the outlet port 6LOUT and enters the first flow path of the evaporator 8 through the port 8IN. Here, thanks to the heat exchanges with the thermovector fluid that flows in the second flow path, the working fluid passes into the gaseous phase, and exits through the port 8OUT. It should be noted, in this connection, that in the diagram of the system 1* of Figure 1A the reference L identifies the stretches of the system 1* in which working fluid in the liquid phase flows, whereas the reference G identifies the stretches of the system 1* in which working fluid in gaseous phase flows. Furthermore, the letters G and L appearing in the references that designate the working ports of the components of the system in which biphasic fluid flows or two monophasic fluids flow indicate the physical state of the fluid at the port in question.

[0008] From the port 8OUT, the working fluid in the gaseous phase is sent through the port 8OUT to the inlet 10IN of the expander 10 for conversion of the thermal energy of the fluid into mechanical energy, and hence into electrical energy via the generator 12.

[0009] The flow rate of gaseous working fluid discharged by the expander 10 through the port 10 OUT then enters the second flow path of the heat exchanger 6 through the port 6GIN, pre-heats the working fluid in the liquid phase in the first flow path of the heat exchanger 6, and exits through the port 6GOUT. From here, the working fluid (still in the gaseous phase) enters the condenser unit 14, by which it is condensed and brought back into the liquid phase, after which, at outlet from the unit 14, the condensed working fluid, which is hence in the liquid phase, is accumulated within the receiver 2, which constitutes a safe intake environment for the pump 4 in so far as the accumulation of fluid therein prevents phenomena of cavitation at intake.

[0010] The configuration of the system 1* presents, however, a drawback that cannot be eliminates and consists in leakage of working fluid in the liquid phase through the pump 4*. In fact, the organic fluids used as working fluid in systems of this type are generally characterized by very low values of viscosity, and are hence very liable to infiltrate through the gaps that are inevitably present in the pump 4*.

[0011] This thus imposes the need to produce pumps with devices and systems that are fluid-tight in regard to the working fluid and very precise and efficient in so far as leakage of fluid constitutes a phenomenon that is highly undesirable on account of the danger for the environment. The need to provide seals that are so precise and efficient consequently entails a considerable increase in the costs and complexity of production of the pump, without on the other hand eliminating the problem completely.

Object of the invention

[0012] The object of the present invention is to solve the technical problems mentioned previously.

[0013] In particular, the object of the present invention is to simplify production of the pump that takes in the condensed working fluid of the receiver, at the same time eliminating the problem of leakage of working fluid.

Summary of the invention

[0014] The object of the invention is achieved by a reservoir, or receiver, for the reception of a condensed working fluid of an organic Rankine cycle system, the reservoir including an internal volume, an inlet port for the intake of condensed working fluid into the internal volume, and an outlet port for the condensed working fluid, the reservoir being characterized in that it includes a pump housed in said internal volume, said pump having an intake port for the withdrawal of said condensed working fluid from said internal volume and a delivery port for the delivery of said working fluid through said outlet port of the reservoir.

[0015] Furthermore, the object of the invention is achieved by an organic Rankine cycle system including a reservoir according to the invention like the one just been described.

Brief description of the drawings

[0016] The invention will now be described with reference to the annexed drawings, which are provided purely by way of non-limiting example and in which:

- Figure 1A, which has already been described, is a schematic illustration of an organic Rankine cycle system of a known type;
- Figure 1B is a schematic illustration of an organic Rankine cycle system according to the invention;
- Figure 2 is a partially exploded perspective view of a receiver according to the invention;
- Figure 3 is a partially exploded perspective view of an ensemble of components indicated by the arrow III in Figure 2;
- Figure 4 is an exploded perspective view of an ensemble of components indicated by the arrow IV in Figure 3;
- Figure 5 is a perspective view of a set of components indicated by the arrow V in Figure 2;
- Figure 6 is a cross-sectional view according to the trace VI-VI of Figure 2;
- Figures 7A and 7B are, respectively, an orthogonal view according to the arrow VII/A of Figure 7B and a cross-sectional view according to the trace VII/B-VII/B of Figure 7A;
- Figure 8 is a schematic cross-sectional view of an alternative embodiment of the invention; and
- Figures 9 and 10 are cross-sectional views of yet a further embodiment of the invention, where the view of Figure 10 corresponds to a cross section according to the trace X-X in Figure 9.

Detailed description

[0017] With reference to Figure 1B, where the reference numbers that are identical to the ones adopted in Figure 1A designate the same components, number 1 designates as a whole an organic Rankine cycle system according to various preferred embodiments of the invention. In particular, the system 1 differs from the system 1* in that it comprises a reservoir (receiver) 2 for receiving a condensed working fluid, which includes an internal volume, an inlet port 2IN for entry of the condensed working fluid into the internal volume and an outlet port for exit of the condensed working fluid, and houses a pump 4 within the internal volume. The pump 4 includes an intake port 4IN configured for intake of condensed working fluid from the internal volume of the reservoir and a delivery port 4OUT, which is configured for sending condensed working fluid through the outlet port 2OUT of the reservoir 2.

[0018] With reference to Figure 2, a preferred embodiment of the reservoir 2 that houses the pump 4 will now be described in detail. The reservoir 2 includes a first end plate 16, a second end plate 18, and a wall 20, the latter having a cylindrical shape and preferably being made integral with the second end plate 18 (this hence means that the end plates 16, 18 are circular and that the shape of the reservoir 2 is as a whole cylindrical). The internal volume of the reservoir 2 is delimited by the end plates 16, 18 and by the wall 20.

[0019] The inlet port 2IN is provided in the end plate 18, whereas the outlet port 2OUT is provided in the end plate 16.

[0020] With reference to Figures 2, 3, and 6, the end plate 16 includes a central relief 22 having a circular shape and preferably provided with radial lobes 24A, which have a respective threaded hole configured for receiving a corresponding fixing screw, as will be described hereinafter.

[0021] Provided moreover in the central relief 22 are two distribution ports of the pump 4, in particular an intake port 122 (not visible in the cross-sectional view of Figure 6) in communication with the internal volume of the reservoir 2, and a delivery port D22, which is in direct fluid communication with the outlet port 2OUT. The intake and delivery ports 122, D22 on the central relief 22 of the end plate 18 form part of a distribution assembly of the pump 4, as will be described hereinafter.

[0022] Preferentially provided at the outlet port 2OUT is a manifold 28 from which there departs a tube 30 (Figure 6), which functionally prolongs the outlet port 2 beyond the top of the end plate 18. It should be noted in fact that the orientation of the reservoir 2 as installed within the system 1 is the one illustrated in Figure 6.

[0023] With reference to Figures 2, 3, and 4, the pump 4 includes an electric motor 32 having a rotor that turns about an axis of rotation X4 and is connected in rotation to an output shaft 33, which also is coaxial to the axis X4.

[0024] The pump 4 moreover includes a plurality of distribution plates, which, together with the end plate 16 (in particular, at the central relief 22) define a distribution assembly of the pump 4, which enables management of intake and delivery of the condensed working fluid coming from the internal volume of the reservoir 2.

[0025] The plurality of distribution plates includes a first distribution plate 34, a second distribution plate 36, and a third distribution plate 38. The distribution plate 34 is received in a seat having a complementary shape provided on the plate 34 and designated by the reference 39.

[0026] Set between the plates 36 and 38 is an eccentric annular plate 40 that includes a hole 40A, which is coaxial to the axis X4 and with respect to which the plate is positioned eccentrically.

[0027] The hole 40A houses inside it a rotor assembly 42 of the pump 4. The rotor assembly 42 is of the internal-gear type and includes an external rotor 44, which has a diameter that is substantially the same as that of the hole 40A (except for the clearance necessary for assembly and operation) and is set in an eccentric position with respect to the axis X4, an internal rotor 46, which is set sharing the axis X4, and a crescent-shaped element 48 between the (internal and external) toothings of the two rotors 44, 46. The internal rotor 46 is connected in rotation to the shaft 33 of the motor 32.

[0028] The latter is received within the distribution plate 34, which is this purpose for substantially cup-shaped. A closing cup 50 (possibly provided with radial openings) is coupled to the plate 34 so as to enclose the motor 32 and secure it on the plate 34. The cup 50 is preferentially secured to the plate 34 by means of a threaded joint between the two or a plurality of radial threaded grub-screws that engage in coinciding radial holes on the two plates.

[0029] Each of the distribution plates 34, 36, 38 carries a respective intake port I34, I36, I38, and a respective delivery port D34, D36, D38. As regards the plate 34, both of the intake and delivery ports 134 and D34 are "false ports", i.e., they are blind ports. The plate 34 moreover includes a ring of radial holes 34IN configured for establishing a fluid communication between the internal volume of the reservoir and the inside of the plate 34 itself so as to carry the organic working fluid in an optimal way towards the motor 32.

[0030] Furthermore, all the distribution plates have a hole, which is coaxial tos the axis X4, for receiving the shaft 33.

[0031] Figure 5 and Figure 6 illustrate the set of distribution plates in the assembled condition. In particular, it will be noted that:

- the eccentric annular plate 40 is mounted between the second distribution plate 34 and the third distribution plate 38 with the rotor assembly 42 housed within the hole 40A thereof; and
- the second distribution plate 36 and the third distribution plate 38 are mounted between the first distribution plate 34 and the central relief 22; in this connection, the plate 38 is preferably housed in a shaped seat on the relief 22, altogether similar to the seat on the plate 34.

[0032] At the moment of assembly, the shaft 33 traverses all the distribution plates, and all the distribution ports 134, 136, 138 and D34, D36, D38 are aligned (and collimated) with respect to one another.

[0033] The ensemble constituted by the distribution plates 34, 36, 38, the rotor assembly 42 (and plate 40), and the electric motor 32 packed between the plate 34 and the cup 50 is then fixed to the central relief 22 of the end plate 16 by means of screws 52 that engage in radial grooves on a flange F34 of the plate 34 and within the threaded holes provided in the lobes 24. In this way, the intake ports 134 (which is blind), 136, and 138 are to be aligned and collimated with the intake port 122, whereas the delivery ports D34 (which is blind), D36, and D38 are aligned and collimated with the delivery port D22: in this way, as anticipated, it is the end plate 16 itself that forms part of the pump 4; in particular, it forms part of the distribution assembly thereof by means of the central relief 22. In other words, it may be noted how the integration of the pump 4 with the reservoir 2 is not limited to the mere insertion of the former into the latter, but there is a true functional integration.

[0034] Operation of the reservoir 2 and of the pump 4 will now be described.

[0035] With reference to Figure 1B and Figures 3 to 6, the organic working fluid in the liquid phase at outlet from the condenser unit 14 through the port 14OUT is received within the reservoir 2 through the inlet port 2IN. In this way, the working fluid in the liquid phase flows into the internal volume of the reservoir 2 and submerges the ensemble constituted by the distribution plates and the electric motor 32 to an extent variable as a function of the accumulation of fluid in the internal volume. The working fluid penetrates into the plate 34 through the holes 34IN, thus lapping the motor 32, guaranteeing optimal cooling thereof. It is to be noted that the holes 34IN co-operate only for the purposes of cooling of the motor 32 and do not co-operate with the distribution ports of the pump 4.

[0036] Furthermore, the working fluid laps the relief 22 and flows into the intake environment of the pump, i.e., the set of intake ports 122, 136, 138, 134, through the intake port 122, and likewise flows into the volume of the compartments of the rotors 44, 46 that faces the set of intake ports and is not occupied by teeth of one or other of the rotors.

[0037] The modalities with which the working fluid in the liquid phase is sent from the intake environment to the delivery environment are those common to operation of any internal-gear pump. In particular, driving of the internal rotor 46 in rotation via the electric motor 32 also causes the external rotor 44 to be driven in rotation with respect to the hole 40A. The working fluid that occupies the intake environment is moved by means of rotation of the rotors 44 and 46, occupying a free volume of the compartments of the rotors 44, 46 that faces the set of intake ports (which functionally constitutes the intake port 4IN), this free volume progressively increasing in the direction of rotation. As rotation of the rotors 44, 46 continues, the working fluid is hence confined between the crescent-shaped element 48, the compartments between the teeth of the rotors 46 and 44 that are located in a position corresponding to the crescent-shaped element 48, and the plates 36, 38.

[0038] When the volume of fluid moved by the rotors 44, 46 exceeds the crescent-shaped element 48, it is sent towards the delivery environment, i.e., the set of delivery ports D34, D36, D38, D22 and the volume of the compartments of the rotors 44, 46 that faces the set of delivery ports and is not occupied by teeth of one or other of the rotors.

[0039] Via the set of delivery ports (which functionally constitutes the delivery port 4OUT) the fluid is then sent on to the outlet port 2OUT of the reservoir 2, in particular through the port D22.

[0040] Provision of the blind delivery port D34 enables equalization of the pressure at the opposite faces of the rotors 44, 46 that face the delivery environment. The delivery pressure (imposed by the circuit of the system 1) is applied on both faces of the rotors 44, 46, hydraulically balancing the system.

[0041] As regards the blind intake port 134, it mainly has the function of rendering uniform distribution of the fluid at the intake of the pump 4 straddling the rotors 44, 46 so as to prevent as much as possible onset of cavitation phenomena.

[0042] From the outlet port 2OUT the working fluid in the liquid phase follows the same cycle that has already been described with reference to Figure 1A: in particular, it enters, in the liquid phase, the first flow path of the heat exchanger 6 (entry at 6LIN), exits therefrom in pre-heated conditions (but still in the liquid phase) from the port 6LOUT, and enters the first flow path of the evaporator 8 (entry at 8LIN). From here, the fluid exits in the gaseous phase through the port 8LOUT thanks to the heat exchange with the thermovector fluid HS that flows in the second flow path (entry at 8HSIN, exit at 8HSOUT).

[0043] From here the working fluid in the gaseous phase proceeds towards the inlet 10IN of the expander 10, exits through the discharge port 10OUT, and enters the second flow path of the heat exchanger 6 (entry at 6GIN, exit at 6GOUT) yielding heat to the fluid that flows in the first flow path, so pre-heating it. Expansion of the working fluid in the expander 10 enables conversion of the mechanical energy transferred to the shaft of the expander 10 into electrical energy by means of the generator 12.

[0044] From here the fluid, still in the gaseous phase, is then sent to the condenser unit 14 (entry at 14IN), by which it is condensed in the liquid phase and sent on, through the port 14OUT, to the reservoir 2 through the port 2IN.

[0045] The reservoir 2 according to the present invention hence enables solution of the technical problems of the systems and pumps of a known type, even introducing further advantages.

[0046] In the first place, the problem of ensuring tightness in the pump 4 is solved since, with the configuration according to the invention, the need for fluid-tightness in regard to the working fluid ceases, in so far as the pump is completely immersed in the condensed working fluid within the reservoir 2. Hence, the problem of any leakage of fluid between the gaps of the pump 4 no longer exists.

[0047] It thus becomes necessary only to guarantee fluid-tightness at the ports of the reservoir, namely the inlet port 2IN, the outlet port 2OUT, and possibly the join between the end plate 16 (or end plates 16, 18 in the case where the reservoir is made up of three distinct pieces) and the wall 20; however, this can be obtained in an effective way with extreme simplicity and at a low cost.

[0048] As regards further advantages, the electric motor 32 that drives in rotation the rotor assembly of the pump 4 is free from problems of cooling, even in conditions of high power absorbed by the pump 4, in so far as the condensed fluid within the reservoir 2 functions as coolant for the motor 32, which is itself immersed in the fluid in the liquid phase.

[0049] Notwithstanding this, penetration of the fluid through the holes 34IN favours filling of the gaps present between the motor and the distribution assembly of the pump 4, thus rendering uniform the amount of liquid that laps the motor itself and favouring cooling of the motor 32.

[0050] It should moreover be noted how, even though in principle the volume of fluid in the reservoir 2 may vary continuously as a function of the workload to which the system 1 is subjected, given the small dimensions of the reservoir 2, which are typical of systems of this sort, especially if they are portable ones (the so-called "micro-ORCs"), optimal cooling of the motor is in any case guaranteed, even in the event of variations of level of high intensity, in so far as the time for reintegration of the level of liquid in the reservoir is in general rather short.

[0051] Not only this, but cooling of the motor 32 by means of the working fluid in the liquid phase enables recovery of thermal energy, which would otherwise be dissipated, and reduction of the workload of the heat exchanger 6 in so far as the fluid that laps the motor 32 is already to a certain extent pre-heated.

[0052] Of course, the details of construction and the embodiments may vary widely with respect to what has been described and illustrated herein, without thereby departing from the sphere of protection of the present invention, as defined by the annexed claims.

[0053] In particular, with reference to Figures 7A and 7B, a further embodiment of the reservoir according to the invention is designated by the reference number 2'. All the reference numbers that are identical to the ones already used previously functionally designate the same components.

[0054] As concerns the reservoir 2', the inventors have advantageously noted that, for some systems, there may exist a particular convenience in arranging both the inlet port 2IN and the discharge port 2OUT at the end plate 16 of the reservoir 2', which, in addition to performing the functions of distribution plate for the pump 4, also functions as intake manifold for the condensed working fluid at inlet to the reservoir 2'.

[0055] Furthermore, in alternative embodiments, it is possible to obtain the end plate 16 by means of a common commercially available disk element or cup-shaped element welded to the wall 20. In this case, the relief 22 would be absent, and the delivery and intake ports of the pump obtained thereon would be provided on the distribution plate 38 (ports 4IN and 4OUT). The latter may be in turn fixed (for example with O-rings) on an internal flange welded on the end plate of a commercial type. On the flange there must of course be provided at least one hole for delivery of the working fluid.

[0056] In yet a further alternative embodiment, illustrated schematically in Figure 8, in addition to the modifications just described that are consequent to adoption of an end plate 16 of a commercial type, the following further modifications are envisaged:

i) the distribution plate 36 is integrated with the eccentric plate 40 (thus forming the plate 36+40) and is made of a material that is able to receive the rotors of the pump 4, i.e., withstand sliding of the rotors of the pump 4 (for example, cast iron); the plate 34 loses its function of distribution plate and becomes simply an element for housing the windings of the motor 32 and for mechanical coupling between the motor 32 and the plate 36; in this case, moreover, the plate 34 is without the blind distribution ports, which are integrated in the element 36+40;

ii) the distribution plate 38 integrating the delivery and intake ports of the pump (ports 4IN and 4OUT) is welded or fixed on an end plate 16 of a commercial type; also in this case, the plate 38 is made of a material capable of withstanding sliding of the rotors 44, 46 of the pump 4, for example cast iron.

[0057] The latter solution, albeit preserving all the advantages described, proves particularly advantageous in the case where the application imposes a stringent ceiling on the overall production cost. In this case, the pump 4 is in effect completely independent; i.e., it could hypothetically function also taken by itself, without having any need of the end plate 16 for defining the distribution ports. The only integration between the pump and the end plate envisaged in this case is fixing of the former to the latter.

[0058] The distribution plate of the pump 4 is in this case single (only the plate 38 is present) in so far as the plates 36 and 40 are integrated and perform the function that was performed by the plate 40 alone, whereas the plate 34, as described, becomes a pure and simple receptacle. Consequently, all the distribution ports on the plate 38 are functional; i.e., there is no blind port as on the plate 34 of the embodiments illustrated in Figures 1 to 7.

[0059] Finally, with reference to Figures 9 and 10, yet a further embodiment of the reservoir according to the invention is designated by the reference number 2".

[0060] The reservoir 2" includes a first end plate 16", a second end plate 18", and a wall 20", the latter having a cylindrical shape and being provided integral with the second end plate 18 or else carried thereon (this hence means that the end plates 16, 18 are circular and the shape of the reservoir 2" is as overall cylindrical). The internal volume of the reservoir 2" is delimited by the end plates 16", 18" and by the wall 20".

[0061] The distribution assembly of the pump 4" is here provided entirely in the end plate 16". In particular, the first end plate 16" includes the following, all obtained therein:

- an intake port 116" and a delivery port D16" of the pump 4";
- the intake port 4IN and the delivery port 4OUT of the pump 4", which are in fluid communication, respectively, with the intake port 116" and the delivery port D16"; and
- the outlet port 2OUT of the reservoir 2", in fluid communication with the delivery port 4OUT of the pump 4", and the inlet port 2IN, in fluid communication with the internal volume of the reservoir 2" and with the intake port 4IN of the pump 4".

[0062] The intake port 116" is moreover in communication with the internal volume of the reservoir 2, whereas the delivery port D16" is in direct fluid communication with the delivery environment of the pump 4".

[0063] For the intake port 116" of the pump 4" to be in fluid communication with the internal volume of the reservoir 2, the intake port 4IN is provided by means of a first hole 4IN_1, which develops preferably in an axial direction within the end plate 16, without traversing it completely, and then intersects a second hole 4IN_2 with radial orientation, which finally intersects an axial hole 4IN_3, which in turn gives out into the intake port 116". Basically, the intake port is provided by means of a U-shaped channel within the end plate 16" that sets the intake port 116" in fluid communication with the internal volume of the reservoir 2".

[0064] Furthermore, as may be seen in Figure 10, the intake port 4IN of the pump 4", and in particular the hole 4IN_2, is in fluid communication with the inlet port 2IN of the reservoir 2, here provided by means of an external channel obtained on the end plate 16. In this way, as anticipated, also the inlet port 2IN of the reservoir 2" is in effect provided in the end plate 16.

[0065] In this way, the port 2IN is functionally connected to a bifurcation that departs both in the direction of the intake port 116" and in the direction of the internal volume of the reservoir 2".

[0066] Fluid communication between the port 2OUT and the delivery port D16" of the pump 4" is ensured, instead, by means of a single radial hole 2OUT_ that gives out, at one end, into the port 2OUT and intersects, at the opposite end, an axial hole corresponding to the delivery port 4OUT, which in turn gives out into the port D16".

[0067] The pump 4" includes an electric motor 32 having a rotor that turns about an axis of rotation X4" and is connected in rotation to an output shaft 33", which also is coaxial to the axis X4". The output shaft 33" is connected in rotation to a bushing H" (for example, by means of a shape coupling with a spline), which is in turn connected in rotation - once again preferably by means of a shape coupling - to an output shaft S42" of a rotor assembly 42" of the pump 4. The rotor assembly 42" is of the type with internal lobed rotors, commonly designated by the term "gerotor". The rotor assembly 42" is housed within a bushing B42", in particular within a cylindrical seat thereof, which develops about an axis X42" parallel to the axis X4". Moreover fixed to the bushing B42" is a double hollow flange F" that is coaxial to the axis X4", which receives the shaft 33" and located in which is the bushing H".

[0068] The rotor assembly 42" includes an external rotor 44", which has a diameter substantially similar to that of the cylindrical seat on the bushing B42" and turns with respect thereto about the axis X42"; i.e., it is eccentric with respect to the axis X4". The rotor assembly 42" moreover includes an internal rotor 46" sharing the axis X4", which is connected in rotation to the shaft S42". In this way, the rotor 46" is eccentric with respect to the rotor 44".

[0069] The internal rotor 46" and the external rotor 44" both present a trocoidal geometry, and the internal rotor 46" has a number of external lobes that is smaller by one than the number of internal lobes of the external rotor 44". The external lobes of the internal rotor 46" mesh with the internal lobes of the external rotor 44": driving of the rotors of the pump in rotation is thus obtained by the electric motor 32", which drives the rotor 46" in rotation about the axis X4" (shafts 33" and S42"), which in turn drives the rotor 44" in rotation about the axis X42" by meshing therewith.

[0070] Defined between the two rotors 44" and 46" is a series of variable spaces that define the intake environment (in fluid communication with the port 116") and the delivery environment (in fluid communication with the port D16") of the pump 4".

[0071] Also in this embodiment, integration of the pump 4" with the reservoir 2" is not limited to a mere juxtaposition, i.e., to the mere insertion of the former into the latter, but there is a real functional integration between the two.

[0072] Operation of the reservoir 2", both in terms of operation of the pump 4" and in terms of operation within the organic Rankine cycle system, is similar to what has already been described.

[0073] In this embodiment the reservoir 2" functions also as steam separator: since the inlet port 2IN and the outlet port 2OUT are provided on the end plate 16, which is set in a lower position, and hence, since it is at a lower geometrical height than, for example, the port 2IN on the reservoir 2, the pump 4" is prevented from drawing in working fluid in the vapour phase. This is a problem frequently encountered in this type of systems in so far as a mere widening of cross section of a duct for passage of the fluid is sufficient for the latter to evaporate. In the case of the reservoir 2", the working fluid in the vapour phase remains confined in the top part of the internal volume of the reservoir, in the proximity of the end plate 18", whereas on the bottom (end plate 16") only the working fluid in the liquid phase remains thanks to the higher density.

Claims

1. A reservoir (2; 2’) for the reception of a condensed working fluid of an organic Rankine cycle system, the reservoir including an internal volume, an inlet port (2IN) for the intake of condensed working fluid into the internal volume, and an outlet port (2OUT) for the condensed working fluid, the reservoir (2; 2’) being **characterized in that** it includes a pump (4) housed in said internal volume, said pump (4) having an intake port (4IN, I34, I36, I38, I22) for the withdrawal of said condensed working fluid from said internal volume and a delivery port (4OUT, D34, D36, D38, D22) for the delivery of said working fluid through said outlet port (2OUT) of the reservoir.

2. The reservoir (2; 2’) according to claim 1, wherein said pump (4) includes an electric motor (32), a rotor assembly (42) operable in rotation by said electric motor (32), and a distribution assembly (34, 36, 38, 16, 22, 134, 136, 138, 122, D34, D36, D38, D22) for governing the intake and the delivery of the condensed working fluid.

3. The reservoir (2, 2’) according to claim 1 or 2, including a first end plate (16), a second end plate (18) and a casing (20), said internal volume being delimited by said first and second end plates (16, 18) and said casing (20).

4. The reservoir (2, 2’) according to claim 3, wherein said first end plate (16) is part of said distribution assembly (34, 36, 38, 16, 22, 134, 136, 138, 122, D34, D36, D38, D22) of said pump (4).

5. The reservoir (2, 2’) according to claim 4, wherein said distribution assembly (34, 36, 38, 16, 22,134,136,138,122, D34, D36, D38, D22) includes:

   - a first distribution plate (34) configured for housing said electric motor (32),
   - a second distribution plate (36),

- a third distribution plate (38),
- an annular eccentric plate (40) housing said rotor assembly (42),
- a central relief (22) of said first end plate (16),

wherein said annular eccentric plate (40) is mounted between said second (34) and third (38) distribution plates with said rotor assembly (42) housed therein, and
wherein said second (36) and third (38) distribution plates are mounted comprised between said first distribution plate (34) and said central relief (22).

6. The reservoir (2, 2') according to claim 5, wherein said second distribution plate (36) is housed in a seat (39) on said first distribution plate (34) and said third distribution plate (38) is housed in a seat on said central relief (22).

7. The reservoir (2, 2') according to any of claims 4 to 6, wherein said first, second and third distribution plates (34, 36, 38) and said central relief (22) each include an intake opening (134, 136, 138, 122) and a delivery opening (D34, D36, D38, D22), wherein all the intake openings (134, 136, 138, 122) are aligned and collimated with each other and all the delivery openings are aligned and collimated with each other (D34, D36, D38, D22).

8. The reservoir (2, 2') according to any of claims 4 to 7, wherein said first distribution plate (34) includes a plurality of radial holes (34IN) configured for enabling a penetration of the working fluid that is in the internal volume of the reservoir (2, 2') so that it impinges upon the electric motor (32) that is received in said first distribution plate (34).

9. An organic Rankine cycle system (1) including a reservoir (2; 2') according to any of claims 1 to 8.

10. The system (1) according to claim 9, further including:

- a heat exchanger (6),
- an evaporator (8),
- an expander (10) mechanically coupled to an electric generator (12),
- a condenser unit (14), wherein:
    - the outlet port (2OUT) of the reservoir (2; 2') is in fluid communication with a first inlet port (6LIN) of said heat exchanger (6),
    - a first outlet port (6LOUT) of said heat exchanger (6) is in fluid communication with a first inlet port (8LIN) of said evaporator (8),
    - a first outlet port (8GOUT) of said evaporator (8) is in fluid communication with an inlet port (10IN) of said expander (10),
    - a discharge port (10OUT) of said expander (10) is in fluid communication with a second inlet port (6GIN) of said heat exchanger (6),
    - a second outlet port (6GOUT) of said heat exchanger (6) is in fluid communication with an inlet port (14IN) of the condenser unit (14),
    - an outlet port (14OUT) of the condenser unit (14) is in fluid communication with the inlet port (2IN) of the reservoir (2, 2').

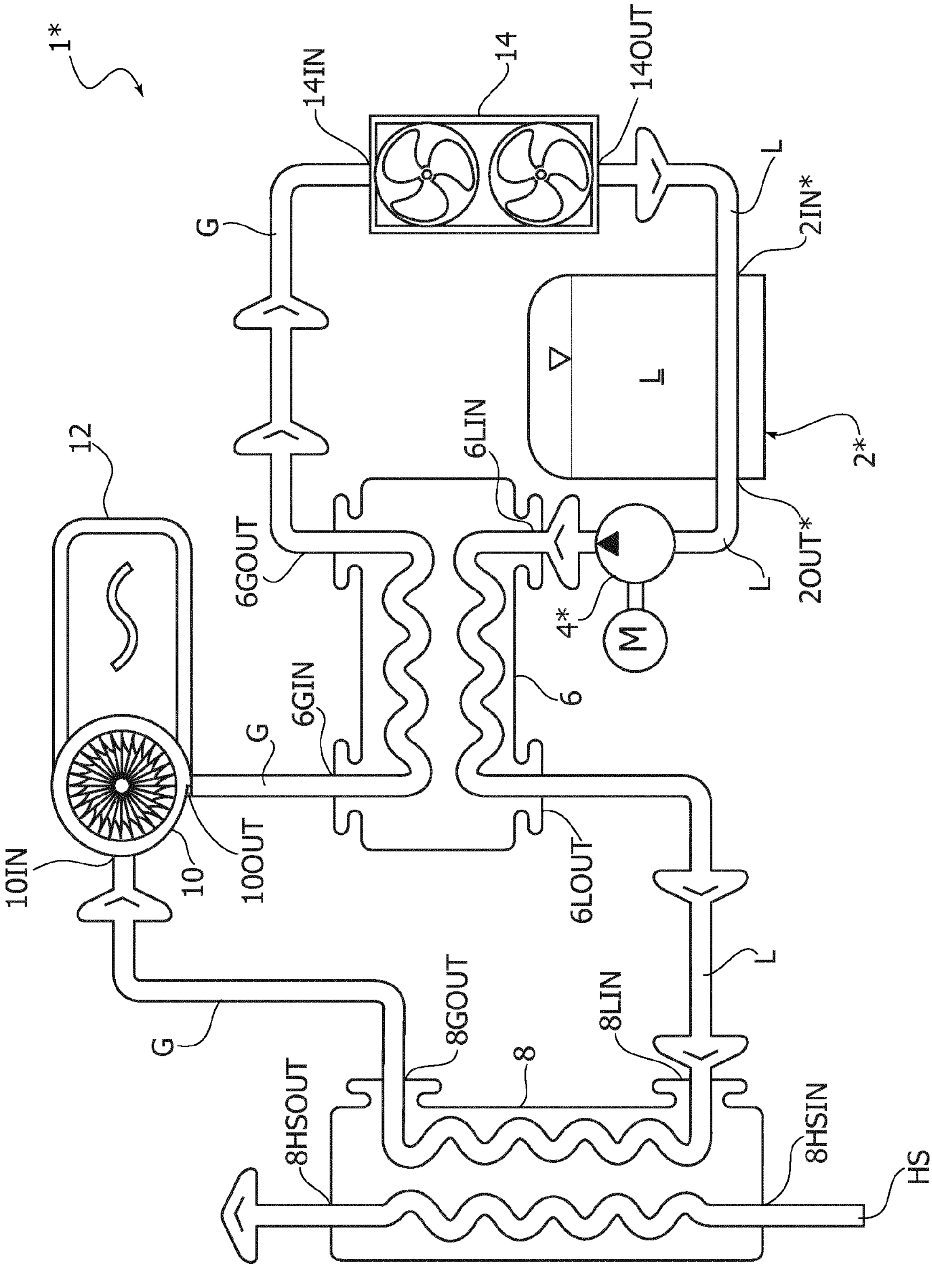
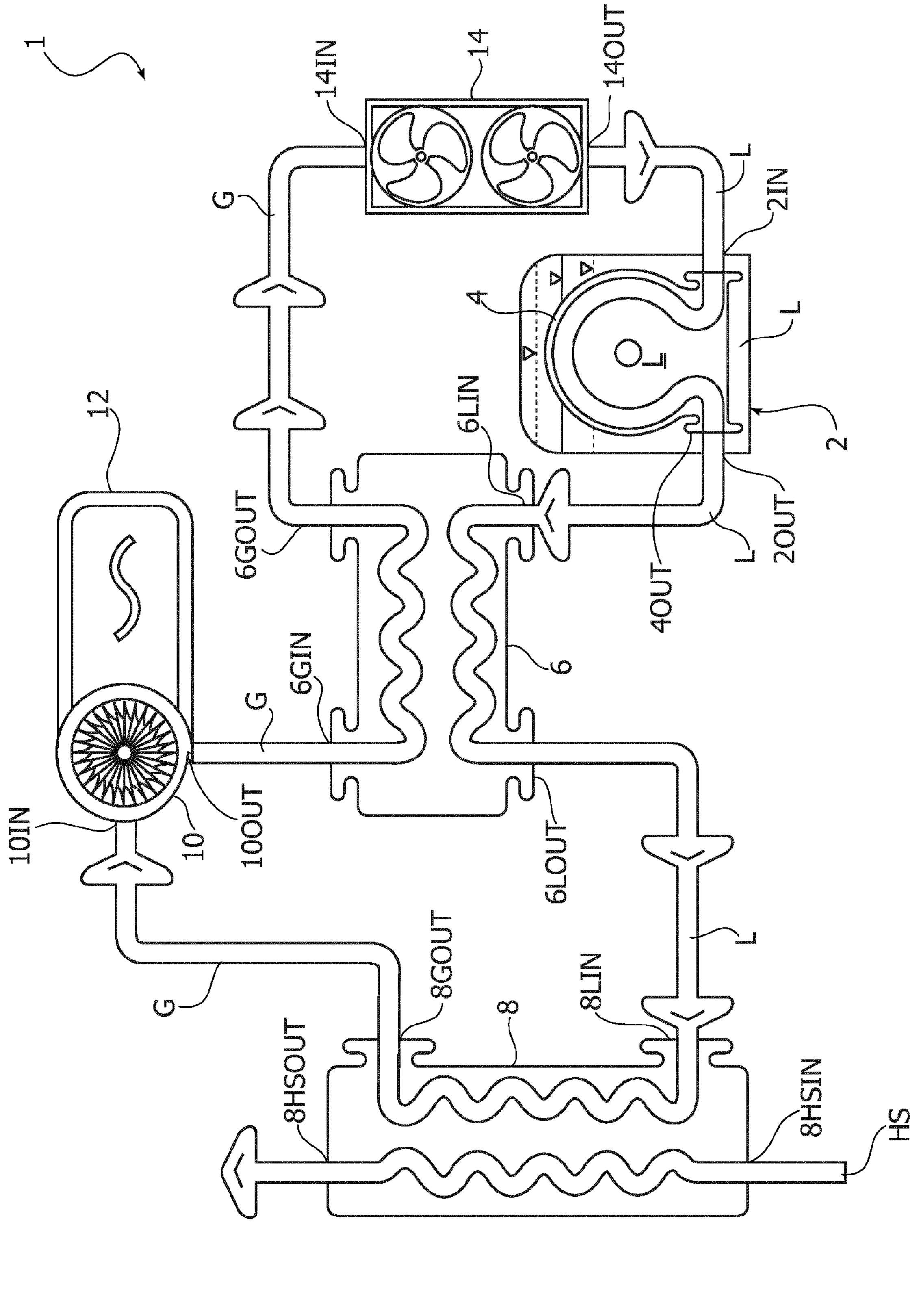

1*
14IN
14
14OUT
G
L
2IN*
L
2*
12
6LIN
6GOUT
2OUT*
L
4*
M
6
6GIN
G
10IN
10
10OUT
6LOUT
L
G
8GOUT
8LIN
8
8HSOUT
8HSIN
HS

FIG. 1A

FIG. 1B


1
14
14IN
14OUT
G
L
2IN
4
L
6LIN
2
2OUT
4OUT
6GOUT
12
6GIN
G
6
10IN
10
10OUT
6LOUT
L
G
8GOUT
8LIN
8
8HSOUT
8HSIN
HS

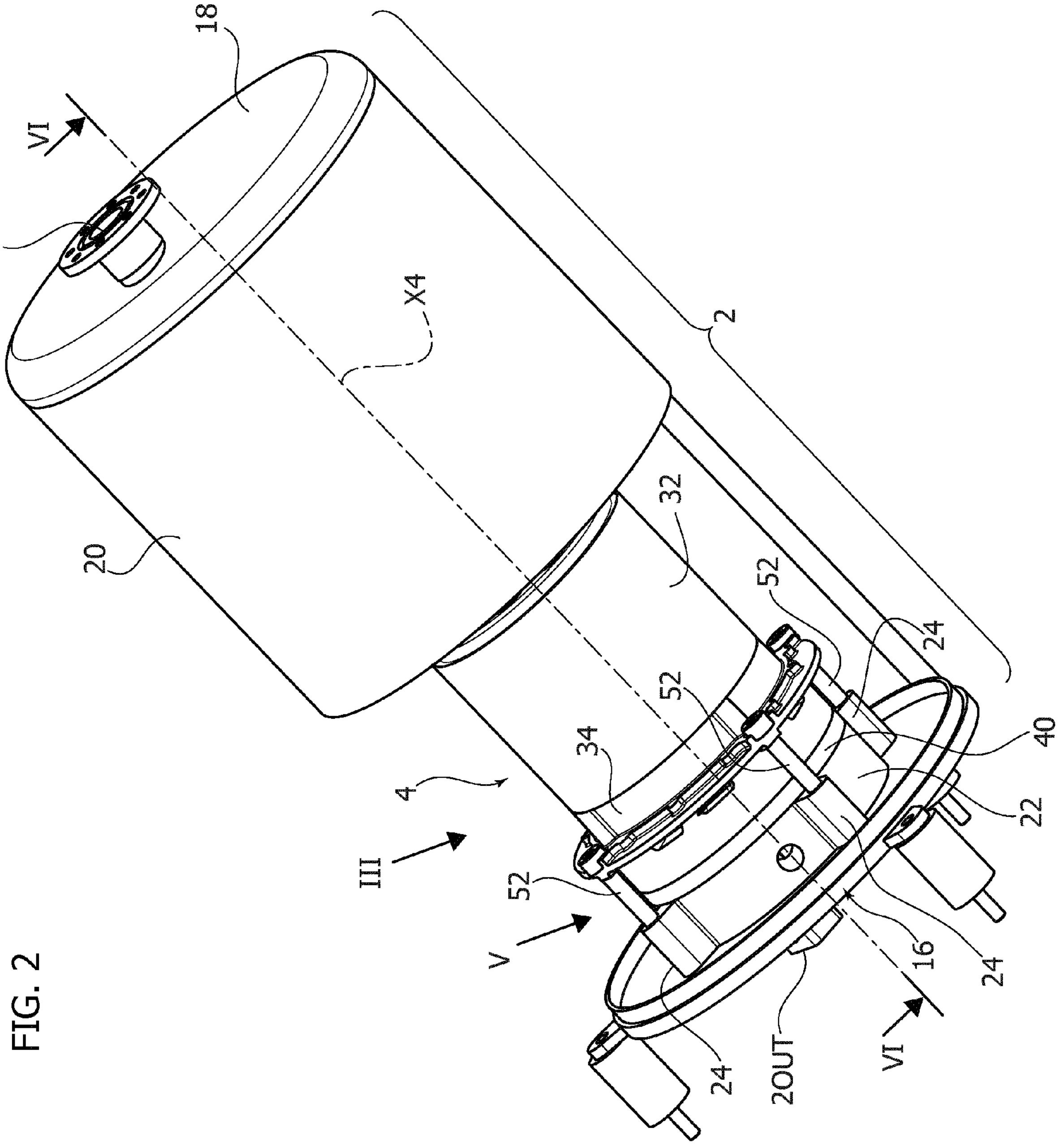


FIG. 2

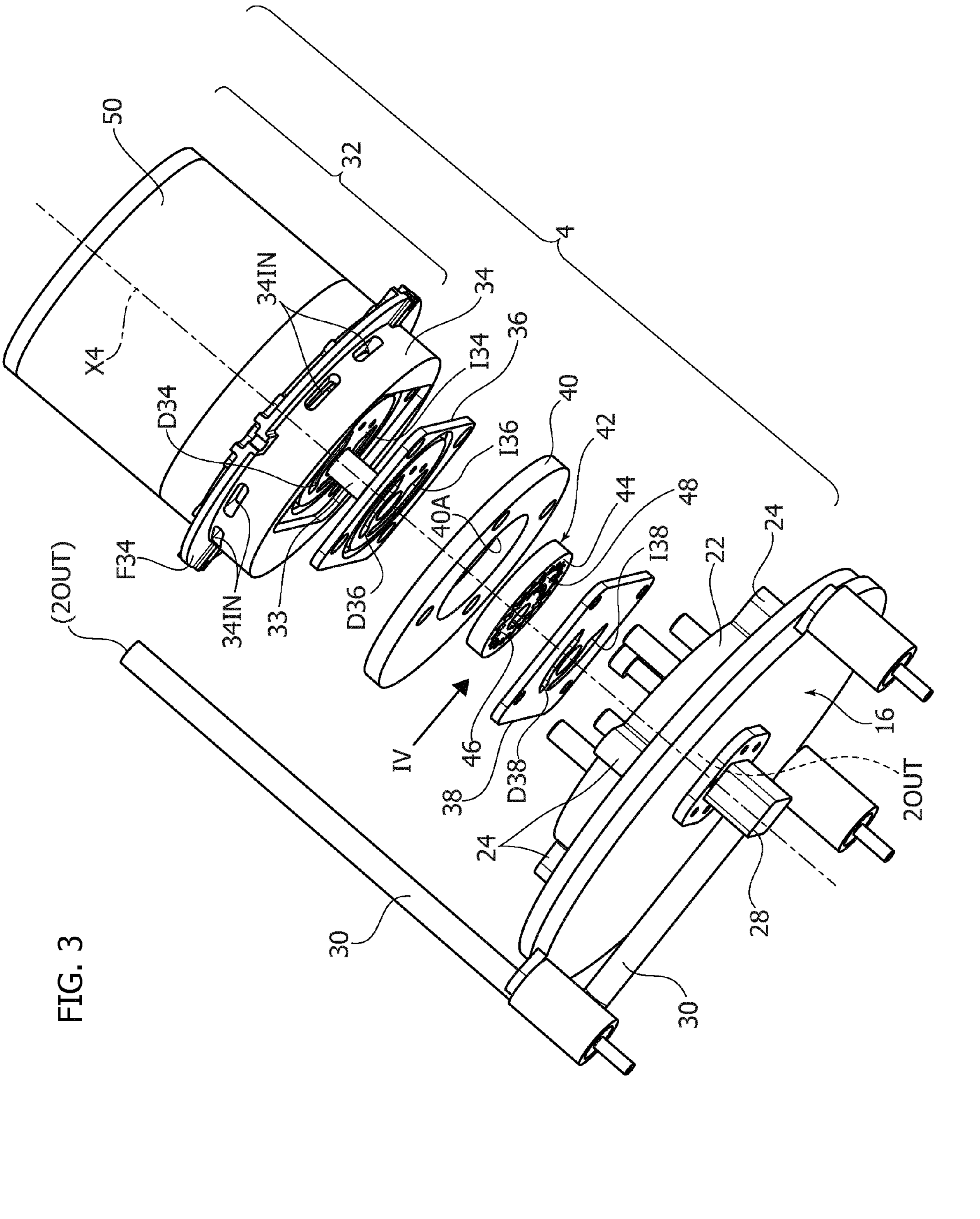

50
32
4
34IN
34
36
X4
I34
40
D34
I36
42
44
48
40A
I38
22
24
(2OUT)
F34
34IN
33
D36
16
IV
46
38
D38
2OUT
24
28
30
30

FIG. 3

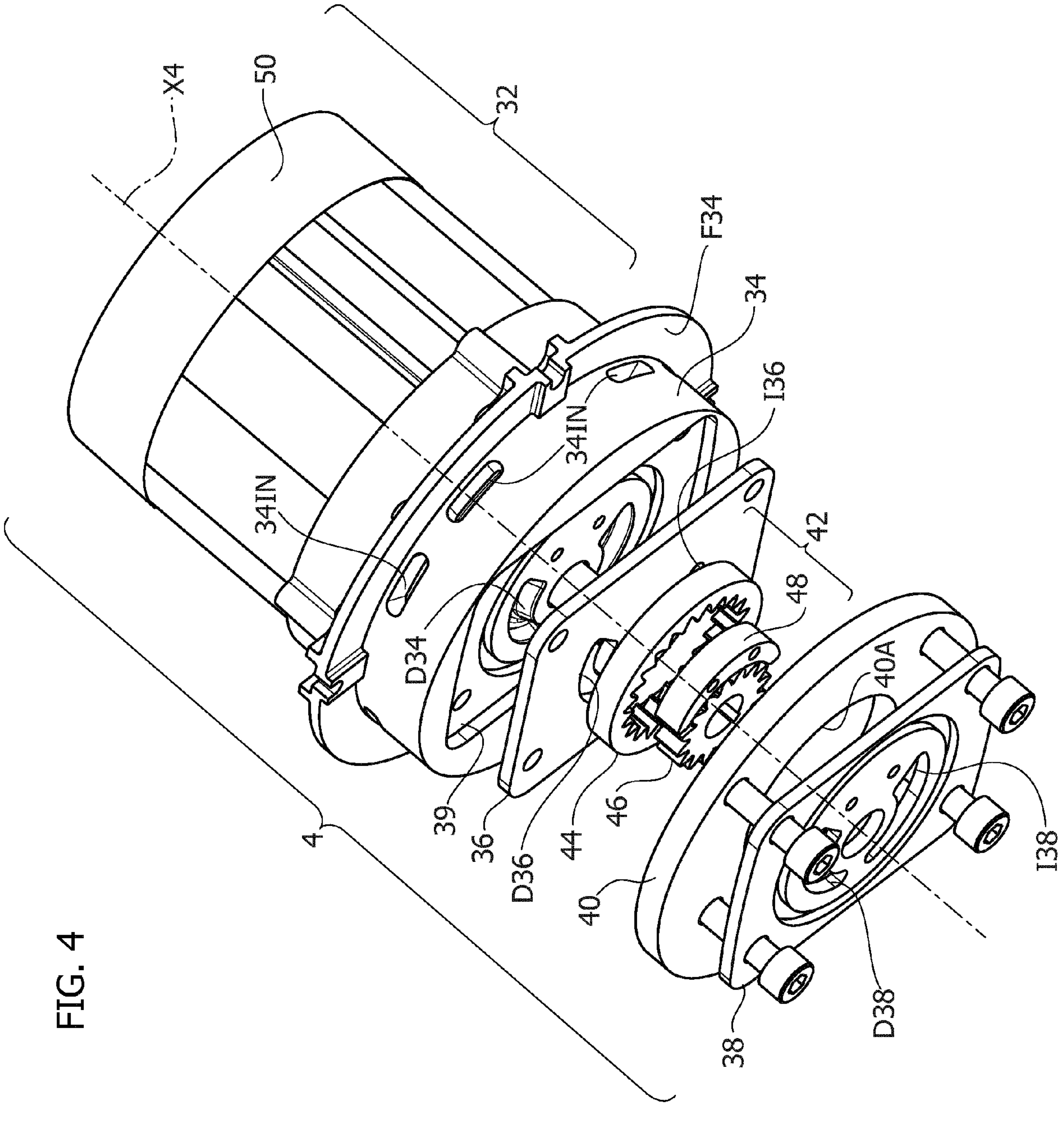

X4
50
32
F34
34
I36
34IN
34IN
34IN
42
48
D34
40A
39
36
D36
44
46
I38
40
D38
38
4

FIG. 4

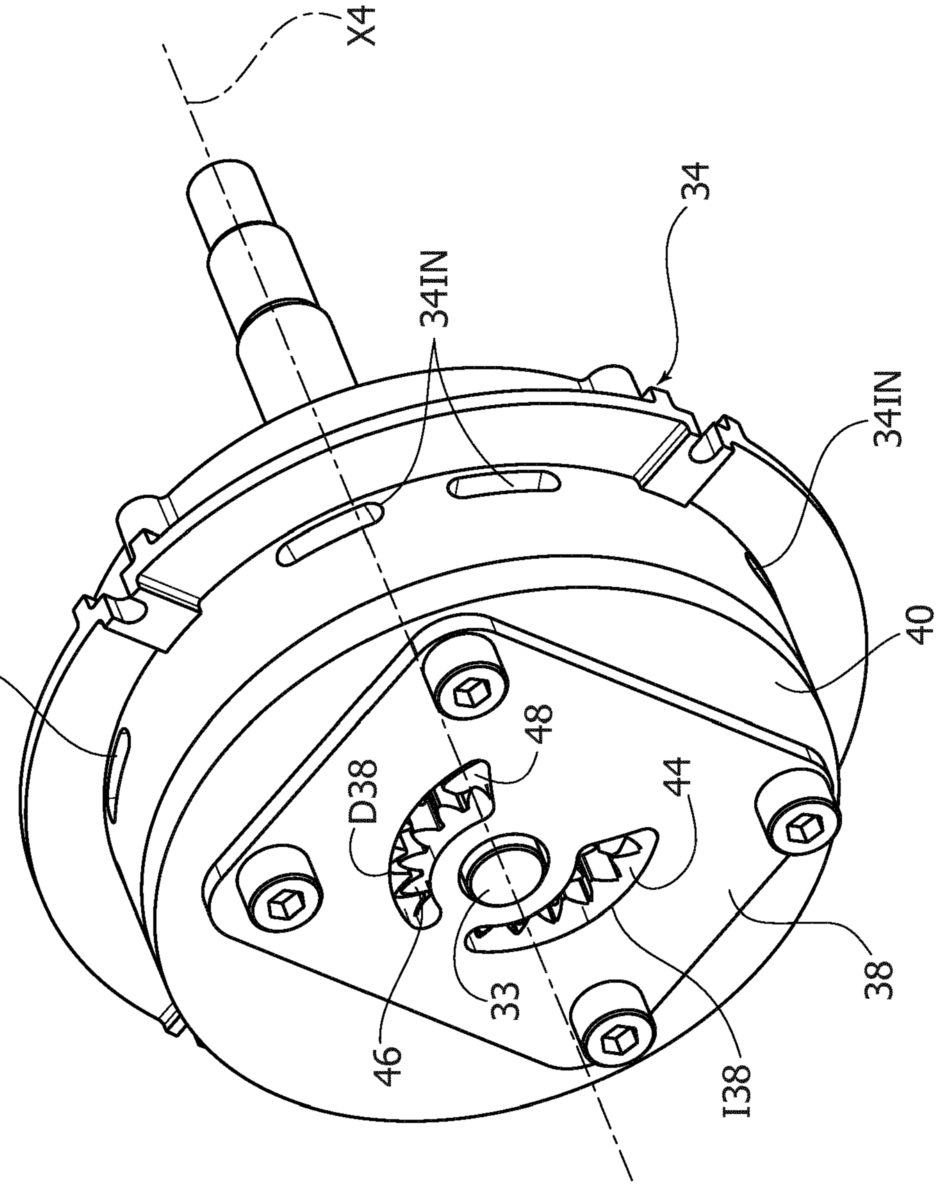


FIG. 5

FIG. 6

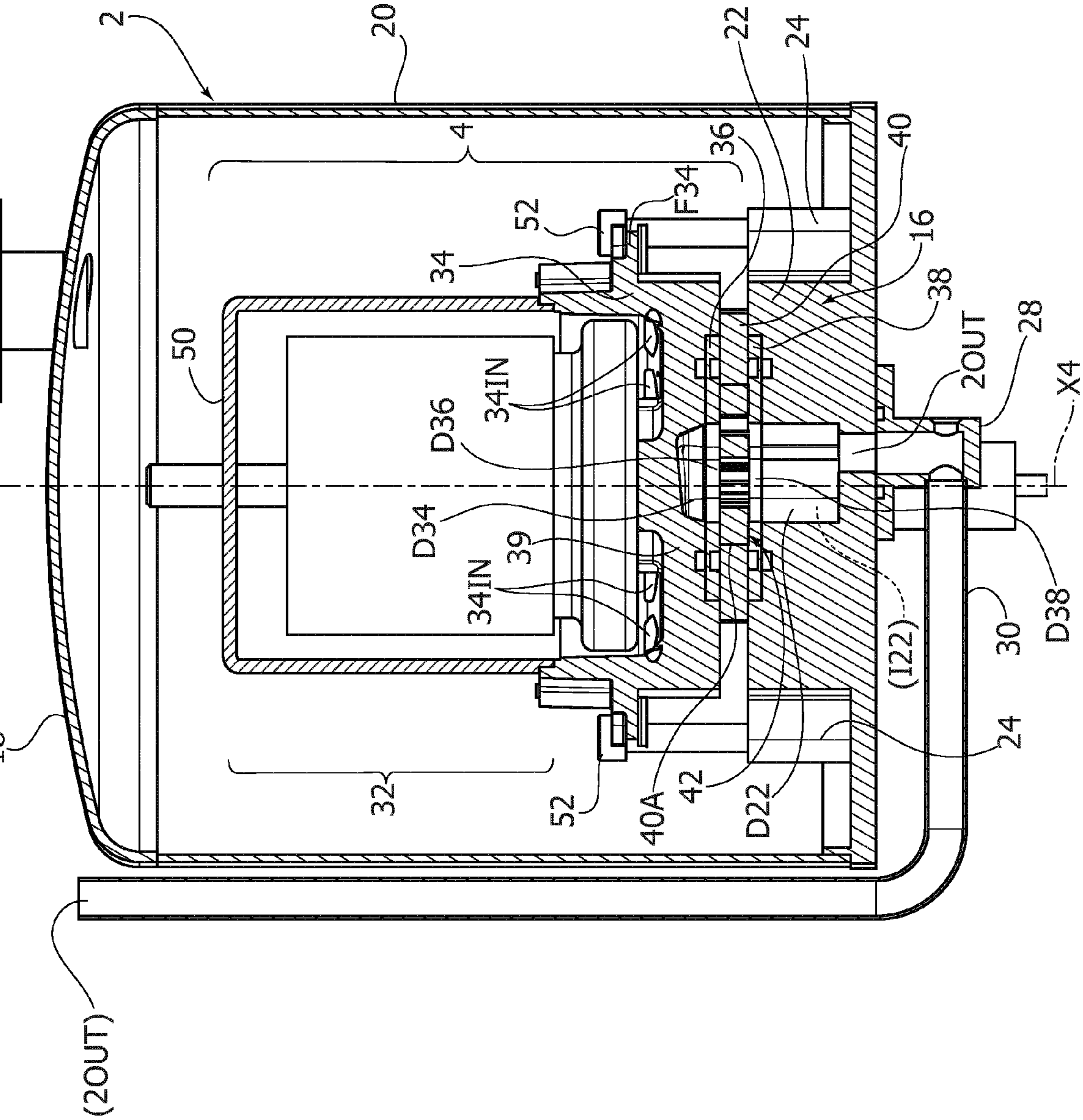

2
2IN
20
4
22
24
36
40
16
38
2OUT
28
X4
52
F34
34
50
34IN
D36
D34
39
34IN
18
32
52
40A
42
D22
(I22)
24
30
D38
(2OUT)

FIG. 7B

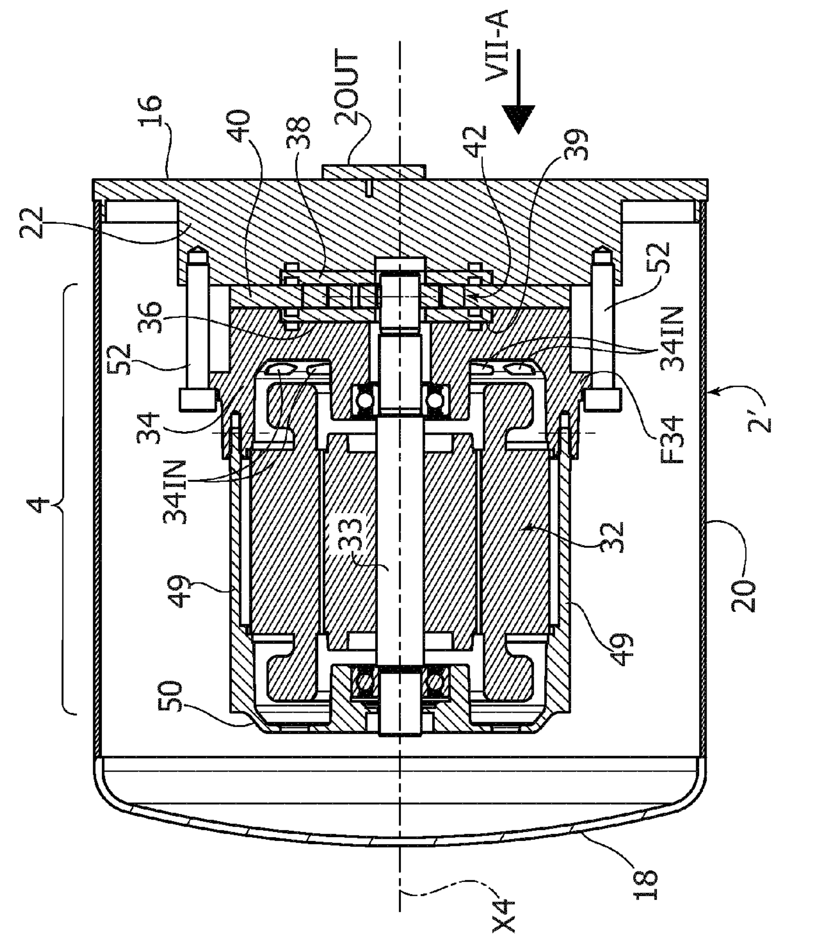

16
22
40
38
2OUT
VII-A
42
39
52
36
34IN
52
34
F34
2'
4
34IN
33
32
49
20
49
50
18
X4

FIG. 7A

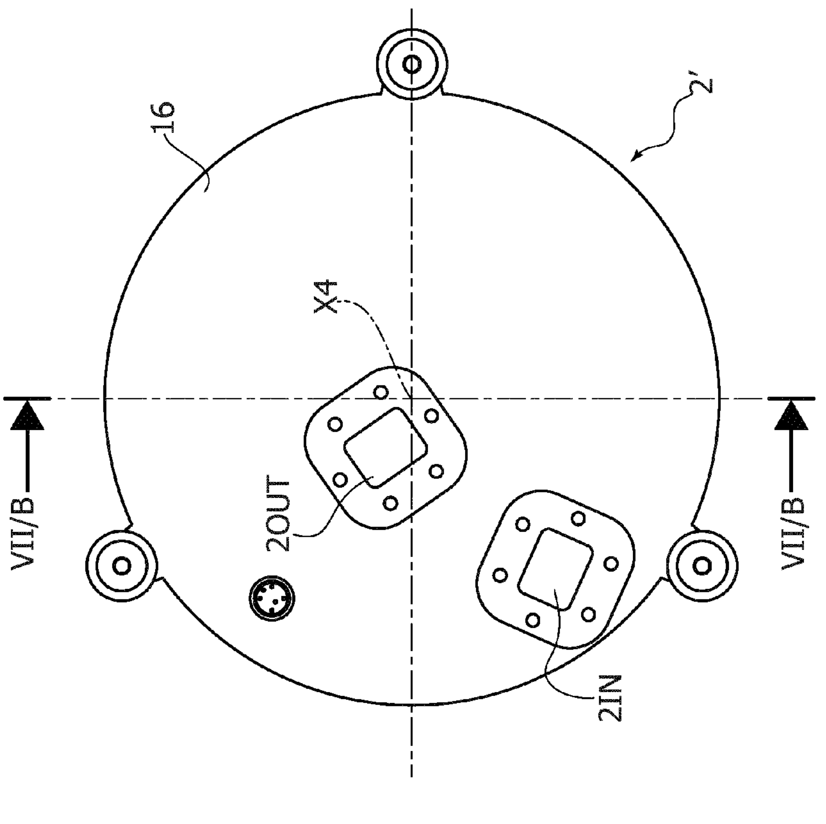

16
2'
X4
VII/B
2OUT
VII/B
2IN

FIG. 8

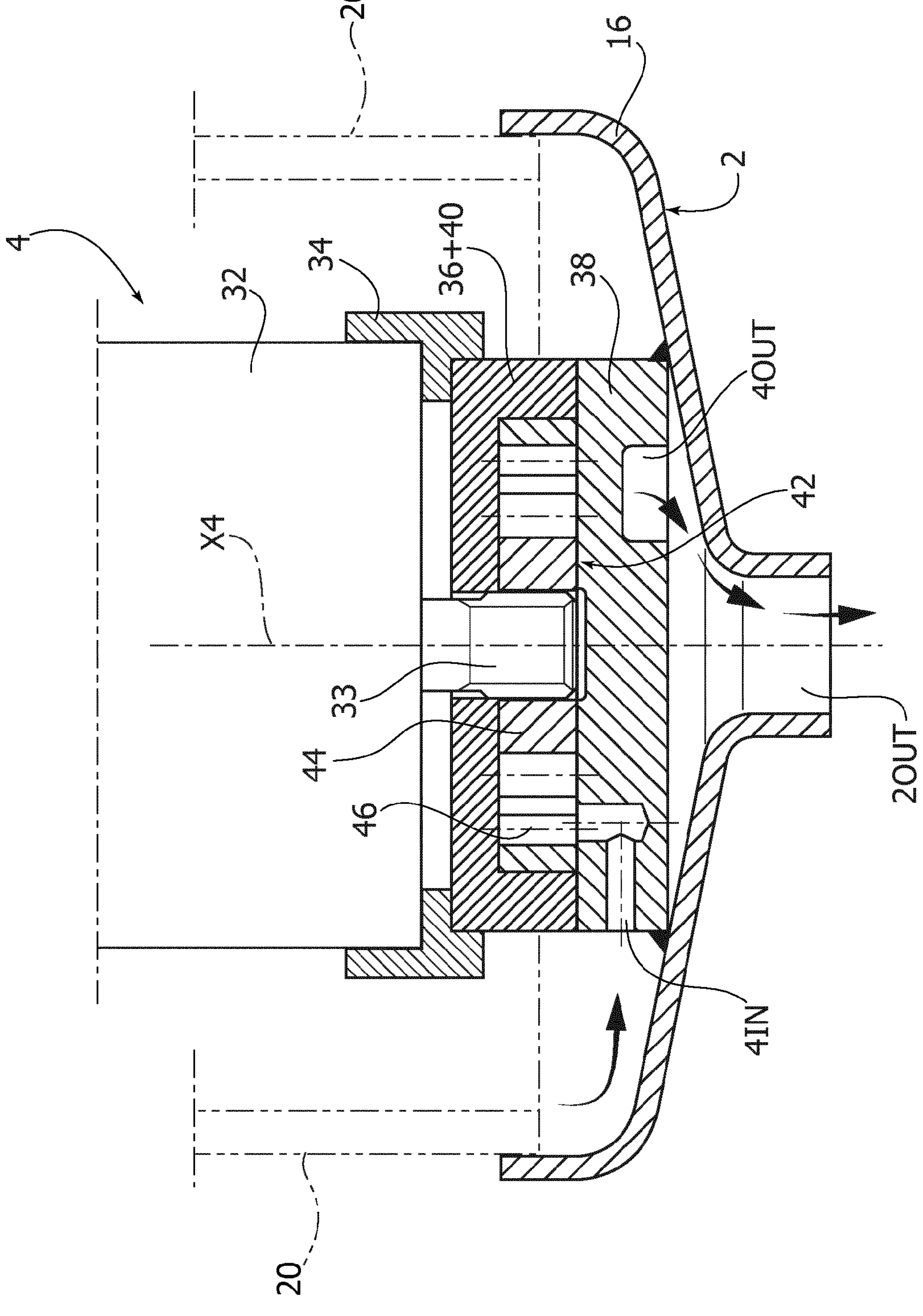


FIG. 10

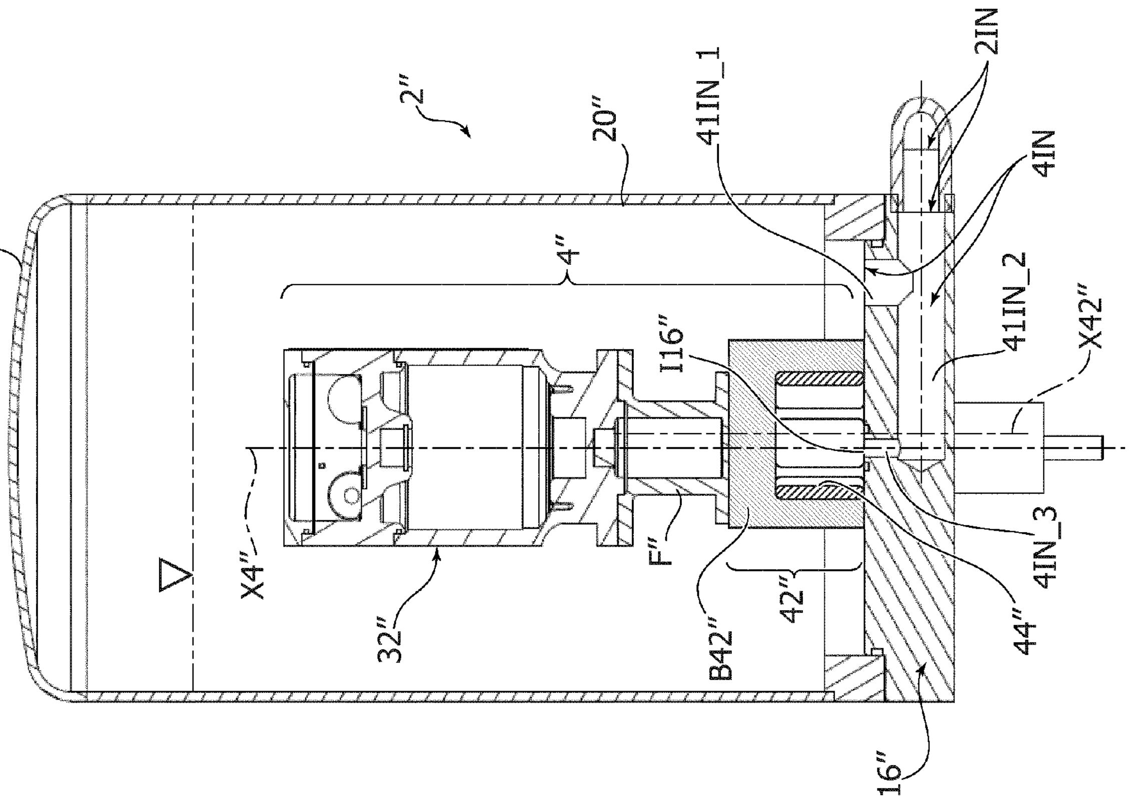
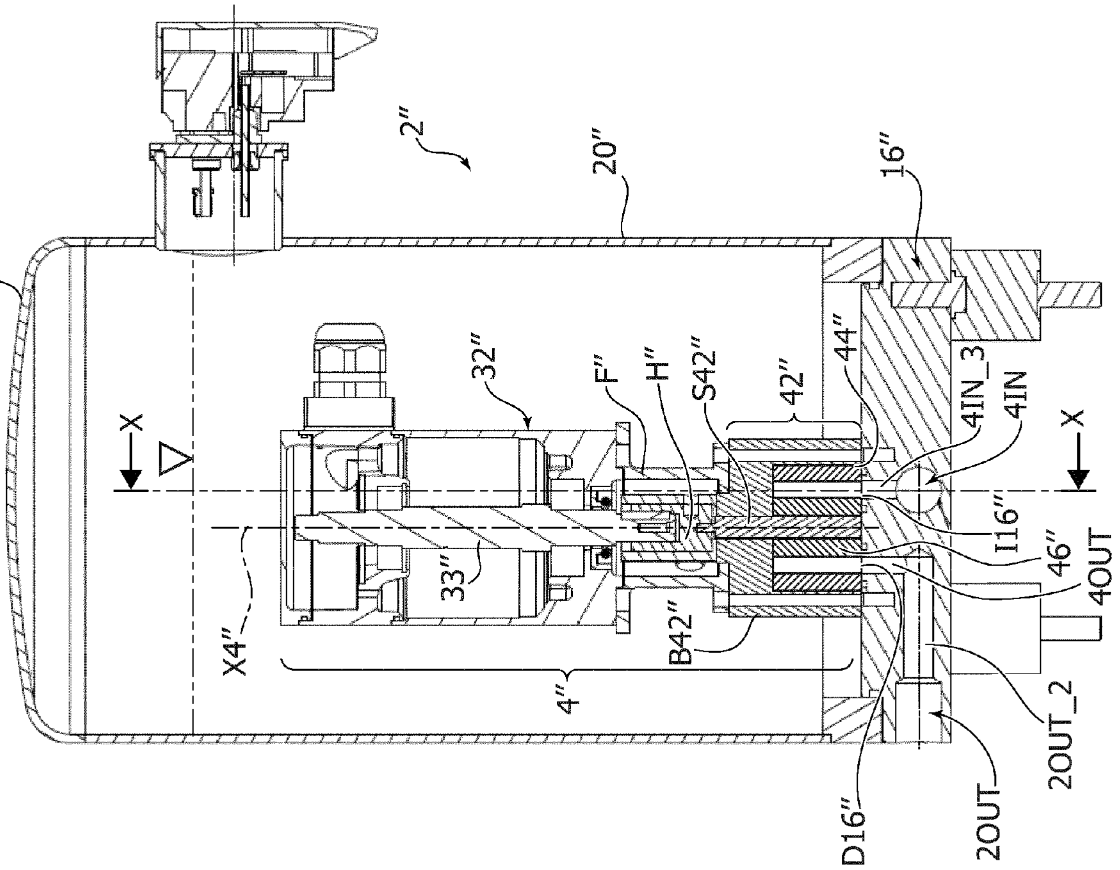

2"
18"
20"
41IN_1
2IN
4IN
4"
41IN_2
X42"
I16"
4IN_3
44"
16"
42"
B42"
F"
32"
X4"

FIG. 9


2"
18"
20"
16"
32"
F"
H"
S42"
42"
44"
4IN_3
4IN
X
X
I16"
46"
4OUT
2OUT_2
2OUT
D16"
B42"
4"
X4"
33"

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 16 7519

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	GB 2 401 396 A (AUTOMOTIVE MOTION TECH LTD [GB]) 10 November 2004 (2004-11-10) * page 5, line 3 - page 20, line 9; claims; figures * * abstract * -----	1-10	INV. F01K25/08 F01K9/02
A	EP 2 846 009 A1 (PANASONIC CORP [JP]) 11 March 2015 (2015-03-11) * paragraph [0051] - paragraph [0131]; claims; figures * * abstract * -----	1-10	
A	DE 10 2010 042068 A1 (BEHR GMBH & CO KG [DE]) 12 April 2012 (2012-04-12) * paragraph [0032] - paragraph [0041]; claims; figures * * abstract * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01K

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 September 2016	Zerf, Georges

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 16 16 7519

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.

27-09-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2401396 A	10-11-2004	NONE	
EP 2846009 A1	11-03-2015	CN 104420903 A	18-03-2015
		EP 2846009 A1	11-03-2015
		JP 2015078685 A	23-04-2015
		US 2015068208 A1	12-03-2015
DE 102010042068 A1	12-04-2012	CN 203421998 U	05-02-2014
		DE 102010042068 A1	12-04-2012
		EP 2625483 A1	14-08-2013
		JP 2013543575 A	05-12-2013
		KR 20130132427 A	04-12-2013
		RU 2013120280 A	20-11-2014
		US 2013219880 A1	29-08-2013
		WO 2012045845 A1	12-04-2012

EPO FORM P0459

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