(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 April 2017 (27.04.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/068061 A1

(51) International Patent Classification:
F01K 11/00 (2006.01) *F01K 25/08* (2006.01)
F01K 21/02 (2006.01) *F22B 1/16* (2006.01)

(21) International Application Number:
PCT/EP2016/075263

(22) International Filing Date:
20 October 2016 (20.10.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2015638 20 October 2015 (20.10.2015) NL

(71) Applicant: **NIKI ENERJI URETIM A.S.** [TR/TR]; Yukaridudullu Mah. Necip Fazil Bulv., Keyap Sanayi Sitesi E2 Blok No: 86, Umraniye, 34775 Istanbul (TR).

(72) Inventors: **YESIL, Ismet**; Yukaridudullu Mah. Necip Fazil Bulv., Keyap Sanayi Sitesi E2 Blok No: 86, Umraniye, 34775 Istanbul (TR). **MOHAMADE, Qumars**; Yukaridudullu Mah. Necip Fazil Bulv., Keyap Sanayi Sitesi E2 Blok No: 86, Umraniye, 34775 Istanbul (TR).

(74) Agent: **JANSEN, C.M.**; V.O., Carnegieplein 5, 2517 KJ Den Haag (NL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,

[Continued on next page]

(54) Title: A POWER GENERATOR AND A METHOD OF GENERATING POWER

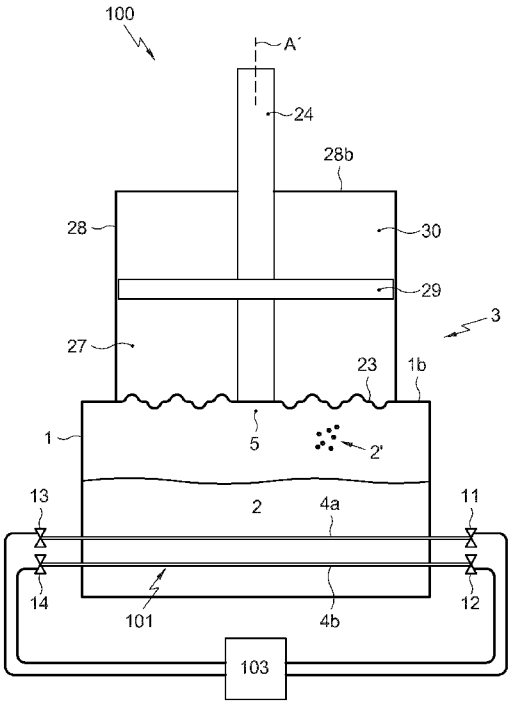

FIG. 3

(57) Abstract: The invention relates to a power generator. The power generator comprises a vessel provided with a heat exchanging unit for alternatingly heating and cooling an organic based working fluid contained in the interior of the vessel during operation of the power generator. Further, the power generator comprises a mechanical unit associated with the vessel and provided with a reciprocating moving element that moves responsive to the heating and cooling process. The heat exchanging unit is arranged for heating the working fluid from below an evaporation temperature and for cooling the working fluid from above the evaporation temperature. Further, the power generator comprises a pressure transferring structure for transferring a pressure exerted by gas in the vessel towards the mechanical unit for driving the reciprocating moving element.

WO 2017/068061 A1

TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Title: A power generator and a method of generating power

The invention relates to a power generator, comprising a vessel provided with a heat exchanging unit for alternatingly heating and cooling an organic based working fluid contained in the interior of the vessel during operation of the power generator, further comprising a mechanical unit associated with the vessel and provided with a reciprocating moving element that moves responsive to the heating and cooling process.

Power generators are generally known for generating electricity, conventionally using an internal combustion engine consuming fossil fuel such as coal, oil or gas. Since the emission of carbon dioxide causes global warming, alternative sources of electrical power are being explored.

Patent publication US 5 916 140 discloses a thermal hydraulic engine providing mechanical and/or electrical energy by alternatingly transmitting heat to and removing heat from an operating fluid so that the fluid periodically expands and contracts. The change in volume of the working fluid is used for driving a piston housed in the interior space of a cylinder.

It is an object of the invention to provide an improved power generator. In particular, it is an object of the invention to provide a power generator having an increased efficiency. Thereto, according to an aspect of the invention, the heat exchanging unit is arranged for heating the working fluid from below an evaporation temperature and for cooling the working fluid from above the evaporation temperature, the power generator further comprising a pressure transferring structure for transferring a pressure exerted by gas in the vessel towards the mechanical unit for driving the reciprocating moving element.

By heating and cooling the working fluid around the evaporation temperature gas evaporates and condenses, thereby causing a gas volume to expand and contract considerably for advantageously alternatingly

generating a pressure cycle inducing the reciprocating moving element to reciprocate accordingly, thereby obtaining an efficient power generator.

It is noted that patent publication US 2004/0060294 discloses a steam engine including an U-shaped fluid container containing water flowing towards a piston for applying a pressure to said piston. It is further noted that patent publication US 2005/0155347 discloses an engine for converting thermal energy to stored fluid energy, using expansion cylinders with expansion chambers and flexible membranes. In addition, it is noted that patent publication FR 2 390 583 discloses a vertical cylinder terminating in a working chamber which is closed by a flexible membrane. In the working chamber a fluid is heated such that the volume of the working chamber expands thereby moving one end of a lever that is attached to said flexible membrane. Then, cold liquid is injected into the cylinder.

Advantageously, the pressure transferring structure may include a barring element barring gas to flow towards the mechanical unit. By counteracting that gas particles from the working fluid contact the mechanical unit, the structure of the vessel and the mechanical unit can be optimized independently for their specific function. As an example, the reciprocating moving element can be lubricated in an optimal way, while a liquid/gas phase transition of the working fluid can be accelerated in the vessel.

In a preferred embodiment, the barring element is a flexible membrane sealing an opening in a top part of the vessel, thereby minimizing a distance between the vessel and the reciprocating moving element so that the overall efficiency of the power generator even further increases.

Also, the invention relates to a method of generating power.

Advantageous embodiments according to the invention are described in the appended claims.

By way of non-limiting example only, embodiments of the present inventions will now be described with reference to the accompanying figures in which:

Figure 1 shows a schematic view of a first embodiment of a power generator according to the invention;

Figure 2 shows a schematic view of a second embodiment of a power generator according to the invention, and

Figure 3 shows a schematic view of a third embodiment of a power generator according to the invention.

The embodiments disclosed herein are shown as examples only and should by no means be understood as limiting the scope of the claimed invention in any way. In this description and in the figures, the same or similar elements have the same or similar reference signs.

Figure 1 shows a schematic view of a first embodiment of a power generator 100 according to the invention. The power generator 100 comprises a vessel 1 implemented as a closed container that is partially filled with an organic based working fluid 2. The vessel is cylindrically shaped having a bottom section 1a, a top section 1b and a side wall 1c with circular cross section. In principle, the vessel may have another geometry, such as a cylinder having a rectangular cross section, a pyramid or a ball. The vessel 1 is provided with a heat exchanging unit 101 for alternatingly heating and cooling the working fluid 2 during operation of the power generator 100. The vessel 1, can be of any form and material with the sidewall 1c having sufficient strength withstanding internal pressures that are generated as described below. The heat exchanging unit 101 is in the shown embodiment arranged in the interior of the closed container 1 for direct contact with the working fluid 2. Alternatively, the heat exchanging unit is arranged on or near the container exchanging heat with the bottom section 1a, top section 1b and/or side wall 1c of the vessel 1.

The power generator 100 further comprises a mechanical unit 3 associated with the vessel 1. The mechanical unit 3 includes a stationary hollow cylinder 7 and a reciprocating moving element 9 received in the hollow cylinder 7. The hollow cylinder has a bottom section 7a, a top section 7b and a sidewall 7c. In the hollow cylinder 7 a lower volume 7' is defined being bounded by the bottom section 7a and a lower surface 9a of the reciprocating moving element 9. The power generator 100 also comprises a pressure transferring structure 102 for transferring a pressure exerted by gas 2' particles in the vessel 1 towards the mechanical unit 3 for driving the reciprocating moving element 9. The reciprocating moving element 9 includes an elongate rigid structure having a first end 9' movably received in the cylinder 7, and a second end 9" mounted to a crank shaft 10 of the power generator 100. A reciprocating motion of the reciprocating moving element 9 rotates the crank shaft 10 thereby driving an electric generator (not shown) for producing electricity.

The working fluid 2 occupies a lower volume in the interior of the vessel 1, while gas particles 2' evaporated from the working fluid 2 are present in an upper volume 1" of the vessel interior, the upper volume 1" being bounded by the surface 2" of the working fluid 2 and the top section 1b of the vessel 1.

In the shown embodiment, the pressure transferring structure 102 includes a tube 6 interconnecting an upper part 1' of the vessel 1 to a lower part 3' of the hollow cylinder 7 so that the lower volume 7' in the hollow cylinder 7 is in fluid communication with the upper volume 1" of the vessel 1, via a continuous channel 6' extending through the tube 6 and through corresponding openings 5, 8 in the vessel sidewall 1c and the cylinder sidewall 7c of the mechanical unit 3.

The heat exchanging unit 101 comprises a tube 4 extending through the interior of the vessel 1, the tube 4 having at least two input

ports 11, 12 and at least two output ports 13, 14 exterior to the vessel 1 for alternatingly flowing the tube 4 with a heating and a cooling fluid.

The tube 4 is arranged for allowing a fluid to pass therethrough. The closed container 1 is provided with two openings 19, 20, one opening for the introduction of the tube and the other opening for leaving thereof. The tube 4 is mounted in a manner to provide a fluid sealing at both openings 19, 20. The tube 6 has two inlets 11,12 outside the container 1, upstream from the introduction opening 19 and two outlets 13, 14 downstream to the leaving opening 20 of the closed container 1. The first inlet 11 is for providing a hot fluid and the second inlet 12 is for providing a cold fluid. Similarly, the first outlet 13 is for leaving the hot fluid and the second outlet 14 is for leaving the cold fluid. Each inlet and outlet is provided with respective valves for selectively controlling the fluid-pass through the tube. Optionally, the power generator 100 is provided with a controller 103 controlling a process of alternatingly heating and cooling the working fluid 2 in the interior of the container 1. However, the inlets and outlets of the tube can also be manually operated.

The hot fluid and the cold fluid are preferably water. The hot water can be obtained from a hot water source which may be naturally available, such as a geothermal water source, or from any other source, such as sea, lake, a water tank etc. which may need to be heated by any heat source based on electricity, fossil fuel, solar energy etc. The cold fluid can be obtained from any source, such as sea, lake, a water tank etc. which is preferably not needed to be cooled for maintaining the efficiency of the overall power generator. It is noted that the hot fluid and the cold fluid may be a type of fluid other than water.

It is also noted that the heat exchanging unit 101 may include an electric based device, including for example a resistance for heating and a Peltier Module for cooling.

The organic based working fluid can be selected from a group containing CFCs, HCFCs, HFCs, HCs and/or PFCs. The fluid may preferably be Chlorodifluoromethane. In a preferred embodiment of the invention, the working fluid, in a liquid phase and prior to operation, is pumped into the closed container 1 under pressure, for instance at 10 bar of pressure. In principle, the container 1 can be pre-pressurized with the working fluid at an over-pressure of circa 10 bar, less than circa 10 bar, e.g. circa 8 bar or circa 6 bar, or more than circa 10 bar, e.g. circa 12 bar or circa 14 bar. In practice, the container 1 can be partially filled with the working fluid in liquid phase, while a working fluid in gas phase contributes to the above-mentioned pressure that is set. The step of pre-pressurizing the working fluid 2 might be needed for balancing a counter load on the reciprocating moving element 9 as described below. Near the top section 1b of the closed container 1 an opening 5 is provided for connecting a first end of the tube 6 described above, the other end of the tube 6 being connected to the hollow cylinder 7 of the mechanical unit 3 at an opening 8 formed near the bottom section 7a of the hollow cylinder 7a. The mechanical unit 3 is preferably implemented as a cylinder-piston mechanism.

The heat exchanging unit 101 is arranged for heating the working fluid 2 from below an evaporation temperature and for cooling the working fluid 2 from above the evaporation temperature of the working fluid 2.

There are at least two modes of operation the heat transfer device 4 can be worked, i.e. the heating mode and the cooling mode. In the heating mode, the heat transfer device 4 is heated up at a temperature changing phase of the working fluid from liquid to gas. In the cooling mode, the heat transfer device 4 is cooled down at a temperature changing phase of the working fluid from gas to liquid.

The operation of the power generator 100 is started by a step of opening the inlet and outlet valves 11, 13 of the hot water, all remaining valves 12, 14 are closed at this moment so that how water flows through the

tube 4 of the heat exchanging unit 101. Assuming the ambient temperature is about 25-30 °C, the temperature of the hot water can be about 80 °C. Within a few seconds, the working fluid 2 starts with changing its phase from liquid to gas thereby increasing the pressure in the closed container 1. With the increased pressure, the gas pressure is also exerted on the lower surface 9a of the reciprocating moving element, also called piston, so that the piston 9 moves from a starting position upwardly up to a top dead center. Before the piston 9 reaches its top dead center, the inlet and outlet valves 11, 13 of the hot water are closed and the inlet and outlet valves 12, 14 of the cold water are opened, so that cold water flows through the tube 4 of the heat exchanging unit 101 providing a phase change of the working fluid 2 from gas to liquid. Assuming the ambient temperature is about 25-30 °C, the temperature of the cold water can be about 30 °C. Than the piston moves downwardly back to its starting position. As a result, the piston 9 moves responsive to the heating and cooling process performed by the heat exchanging unit 101. In experiences, it appears that the pace of return stroke of the piston 9 might take more time than the pace of the forward stroke of the piston 9, in unbalanced circumstances.

In an attempt to make a time period for performing the pace of return closer to the time period for performing the forward strokes of the piston 9, there is provided a counter load on the piston, e.g. mounted at the first end 9' of the piston and exerting a static force on the piston 9 downwardly. The counter load is initially balanced with the working fluid 2 pressure mentioned above. Therefore, in forward stroke of the piston 9 the counter load will have a negative effect in displacing the piston 9 but it will have positive effect in returning the piston to its initial position. The counter load may be implemented as a restoring force such as a spring force or a constantly acting force induced by a mass and so forth.

A pace equalization may be further improved by providing the heat exchanging unit 101 with a further tube extending through the interior

of the vessel for additionally cooling the working fluid. Than, a first tube might be used for flowing hot water while a second tube might be used for flowing cold water. In such a configuration, the first tube might be substantially longer than the second tube assuming the tubes are of same physical properties and have a same or similar fluid flow rate.

Advantageously, the pace equalization might be further improved by flowing the second tube permanently with cold water, while the first tube might be flown intermittently with hot water, e.g. only when an upward stroke of the piston is intended. Then, separate tubes are used for heating and cooling the working fluid, respectively.

Figure 2 shows a schematic view of a second embodiment of a power generator 100 according to the invention. Here, the pressure transferring structure 102 includes a barring element 18 barring gas to flow towards the mechanical unit 3. A separate gas chamber is provided between the barring element 18 and the lower surface 9a of the piston 9, thereby obtaining a hydraulic unit between the closed container 1 and the piston 9. The pressure transferring structure 102 includes a cylindrical housing 15 having two chambers 16, 17 divided by a separator 18 movable along an axial axis A of the housing 15. The separator 18 forms the barring element and is preferably a rigid plate, but can be implemented in another way, e.g. as a more flexible plate. The separator 18 is preferably sealingly and gastight received between sidewalls of the housing 15. A first chamber 16 has a first opening 21 in line with a first end of an interior channel of a first tube 6a of the pressure transferring structure, the second end of the interior channel of the first tube 6a being in line with the above described opening 5 near the top section 1b of the vessel 1. Then, the first chamber 16 is in fluid communication with the interior of the closed container via the first tube 6a. Similarly, the second chamber 17 has a second opening 22 in line with a first end of an interior channel of a second tube 6b of the pressure transferring structure 102, the second end of the interior channel of the

second tube 6b being in line with the above described opening 8 near the bottom section 7b of the hollow cylinder 7. Then, the second chamber 17 is in fluid communication with the lower volume 7' of the hollow cylinder 7 via the second tube 6b. Then, the interior of the vessel 1 is in hydraulic fluid communication with the lower volume 7' of the hollow cylinder 7. The barring element is arranged in the channel of the pressure transferring structure interconnecting the vessel to the mechanical unit. By implementing the barring element as a partitioning module that separates the gas from a further medium contacting the reciprocating moving element, the mechanical features of the mechanical unit 3 and the thermodynamic features of the vessel can advantageously be optimized separately. As an example, the clearance between the piston outer diameter and the inner wall of the hollow cylinder 7 can be continuously lubricated as the piston 9 reciprocates. Further, the working fluid will more rapidly change its phase from gas to liquid and vice versa, since the gas volume has more compact dimensions. The working principle of the power generator is similar to the first embodiment described referring to Fig. 1.

Figure 3 shows a schematic view of a third embodiment of a power generator 100 according to the invention. In this embodiment the closed container 1 is provided with a central opening 5 in the top section 1c of the vessel 1. Further, a flexible membrane 23 is provided covering and sealing the central opening in the container 1, thus forming a barring element barring gas to flow towards the mechanical unit 3. A piston rod 24 is connected to the flexible membrane 23 and extends upwardly, away from the working fluid 1. By rigidly connecting the barring element, implemented as flexible membrane 23, to the reciprocating moving element, implemented as a piston, a pressure force exerted on the membrane is directly transferred to the piston, thereby improving the efficiency of the power generator. Alternatively, said pressure force is indirectly transferred to the piston, e.g. via an intermediate gas chamber as described referring to Fig. 2.

The heat exchanging unit 102 includes a first and a second tube 4a, 4b for separately flowing hot and cold water, respectively, as described above referring to Fig. 2. Each tube 4a, 4b is provided with valves 11, 12, 13, 14 that are manually and/or automatically controllable.

The container 1 is preferably of cylindrical form while the flexible membrane 23 has preferably a circular perimeter and is coaxially secured to the container 1 along its perimeter. Preferably, the inner diameter of the container 1 is larger than the diameter of the flexible membrane 23, obtaining a power generator having an increased efficiency. The top section 1b is formed as an annular element on the upper rim of the sidewall 1c of the container 1. The piston rod 24 is also coaxially secured to the flexible membrane 23 extending upwardly.

On top of the vessel 1, extending from the top section 1b of the container 1, the hollow cylinder 28 of the mechanical unit 3 is mounted. The cylinder 28 has an axial axis A' and receives the piston rod 24 that moves upwardly and downwardly in the hollow cylinder 28 during operation of the power generator 100. The hollow cylinder 28 is closed, at its bottom side, by the flexible membrane 23, and is closed, at its top side by a top section 28b provided with an opening through which opening the piston rod 24 extends upwardly. The piston rod 24 is not only secured to the flexible membrane 23, at a lower end of the rod, but is also coaxially secured, to a sealing member 29 having a disc shaped geometry and sealingly movable along the inner wall of the cylinder 28 in the axial direction A'. The sealing member 29 and the flexible membrane 23 are spaced apart at a fixed distance, thus defining a first chamber 27 between the flexible membrane 23 and the sealing member 29. The first chamber 27 is filled with a gas, e.g. at a pressure higher than 1 atm. The hollow cylinder 28 includes a second chamber 30 defined between the sealing member 29 and the top section 28b of the cylinder 28. The second chamber 30 is also filled with gas, e.g. with an ambient pressure of 1 atm.

By providing a pressure higher than 1 atm in the first chamber 27 the flexible membrane 29 is pre-stressed and subjected to relatively small pressure differences during operation of the power generator, thereby maintaining physical properties of the membrane and extending its life time, counteracting any rupture of the flexible membrane upon exposure to relatively high pressures exerted by the gas in the container 1.

The general working principle of the power generator 100 is similar to the first embodiment described referring to Fig. 1.

As described referring to other embodiments, also the power generator illustrated in Fig. 3 includes a counter load exerting a downwardly oriented force to the piston rod 24. Similarly, the counter load is initially balanced with the working fluid pressure. Initially, the pressure in the closed container 1 is preferably set at the same level as the pressure in the first chamber 27. For the piston rod to perform an advancing forward, upward stroke, the first tube 4a is operated by opening its inlet and outlet valves 11, 13 to flow hot water therethrough. Then, an amount of working fluid changes its phase from liquid to gas forming pressure which in turn moves the flexible membrane 23 upwardly. In a preferred embodiment, the second tube 4b of the heat exchanging unit 101 is permanently operated flowing cold water, i.e. also during a upward movement of the piston rod. Then, the first tube 4a of the heat exchanging unit 101 is in operation only when the piston rod makes a forward, upward stroke flowing hot water.

According to a further aspect of the invention, there is provided a method of generating power. The method includes the step of alternatingly heating and cooling an organic based working fluid contained in the interior of a vessel for moving a reciprocating moving element of a mechanical unit, wherein the working fluid is heated from below an evaporation temperature and wherein the working fluid is cooled from above an evaporation temperature, the method further comprising the step of transferring a

pressure exerted by gas in the vessel towards the mechanical unit for driving the reciprocating moving element.

The invention is not restricted to the embodiments described above. It will be understood that many variants are possible.

These and other variants will be apparent to the person skilled in the art and are considered to fall within the scope of the invention as formulated by the following claims. For the purpose of clarity and a concise description features are described herein as part of the same or separate embodiments. However, it will be appreciated that the scope of the invention may include embodiments having combinations of all or some of the features described.

Claims

1. A power generator, comprising a vessel provided with a heat exchanging unit for alternatingly heating and cooling an organic based working fluid contained in the interior of the vessel during operation of the power generator, further comprising a mechanical unit associated with the vessel and provided with a reciprocating moving element that moves responsive to the heating and cooling process, wherein the heat exchanging unit is arranged for heating the working fluid from below an evaporation temperature and for cooling the working fluid from above the evaporation temperature, the power generator further comprising a pressure transferring structure for transferring a pressure exerted by gas in the vessel towards the mechanical unit for driving the reciprocating moving element.

2. A power generator according to claim 1, wherein the pressure transferring structure includes a barring element barring gas to flow towards the mechanical unit.

3. A power generator according to claim 2, wherein the barring element is a flexible membrane sealing an opening in a top part of the vessel.

4. A power generator according to claim 2, wherein the barring element is a rigid plate movable in a cylindrical housing.

5. A power generator according to of the preceding claims 2-4, wherein the barring element is a partitioning module that separates the gas from a further medium contacting the reciprocating moving element.

6. A power generator according to any of the preceding claims 2-5, wherein the barring element is rigidly connected to the reciprocating moving element.

7. A power generator according to any of the preceding claims, wherein the mechanical unit comprises a hollow cylinder receiving the reciprocating moving element.

8. A power generator according to claim 7, wherein the hollow cylinder is mounted on the vessel.

9. A power generator according to claim 7, wherein the pressure transferring structure includes a tube interconnecting the vessel to the mechanical unit.

10. A power generator according to claim 9, wherein the barring element is arranged in the channel of the pressure transferring structure.

11. A power generator according to any of the preceding claims, wherein the heat exchanging unit comprises a tube extending through the interior of the vessel, the tube having an input port and an output port exterior to the vessel for alternatingly flowing the tube with a heating and a cooling fluid.

12. A power generator according to claim 11, wherein the heat exchanging unit comprises a further tube extending through the interior of the vessel for heating and cooling the working fluid using separate tubes.

13. A power generator according to any of the preceding claims, wherein the reciprocating moving element is provided with a counter load exerting a static force on the moving element.

14. A power generator according to any of the preceding claims, wherein the vessel is pre-pressurized with the working fluid.

15. A power generator according to claim 14, wherein the vessel is pre-pressurized at a pressure of circa 10 bar.

16. A power generator according to any of the preceding claims, wherein the vessel is a closed container.

17. A power generator according to any of the preceding claims, wherein the vessel has an inner diameter that is larger than a diameter of the flexible membrane.

18. A power generator according to any of the preceding claims, further comprising a controller controlling a process of alternatingly heating and cooling the working fluid contained in the interior of the vessel.

19. A power generator according to any of the preceding claims, wherein the working fluid is a CFC, HCFC, HFC, HC or PFC, preferably chlorodifluoromethane.

20. A method of generating power, comprising the step of alternatingly heating and cooling an organic based working fluid contained in the interior of a vessel for moving a reciprocating moving element of a mechanical unit, wherein the working fluid is heated from below an evaporation temperature and wherein the working fluid is cooled from above an evaporation temperature, the method further comprising the step of transferring a pressure exerted by gas in the vessel towards the mechanical unit for driving the reciprocating moving element.

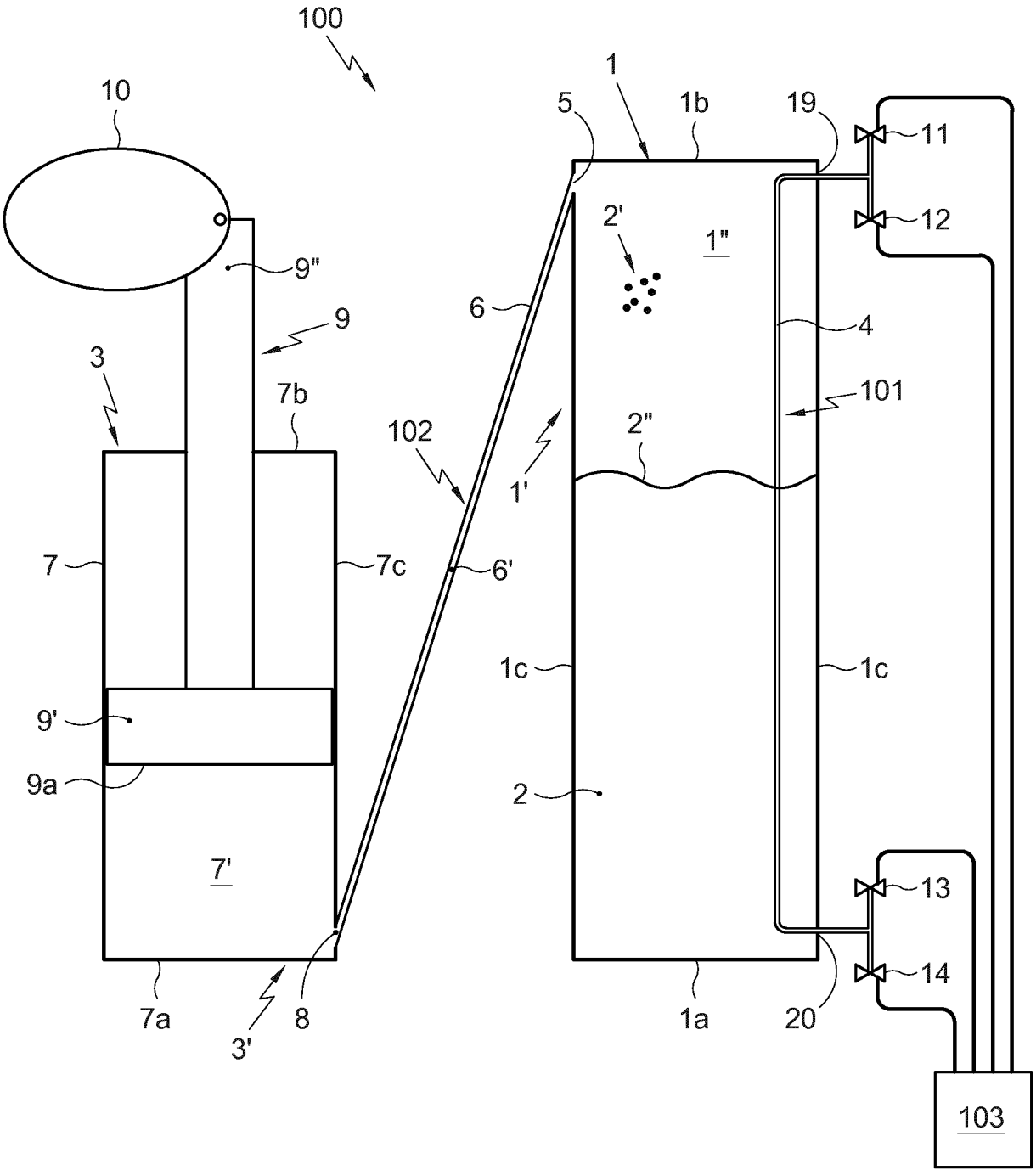
100
10
9"
9
3
7b
7
7c
9'
9a
7'
7a
3'
8
102
6
6'
1
5
1b
19
11
12
2'
1"
4
101
2"
1'
1c
1c
2
13
14
1a
20
103

FIG. 1

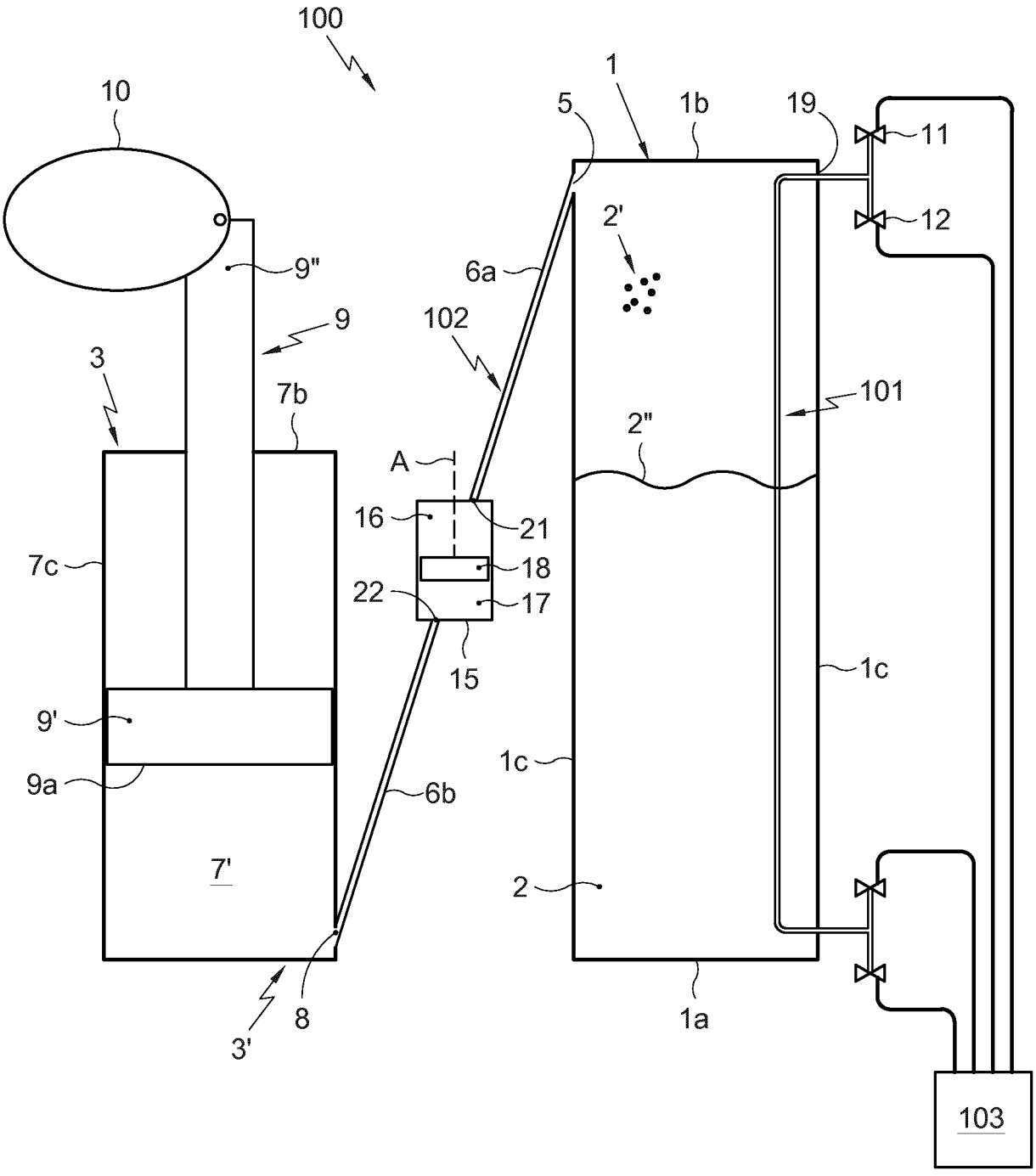
100
10
1
5
1b
19
11
12
2'
6a
9"
9
102
3
7b
101
2"
A
16
21
18
22
17
15
7c
1c
9'
1c
9a
6b
7'
2
3'
8
1a
103

FIG. 2

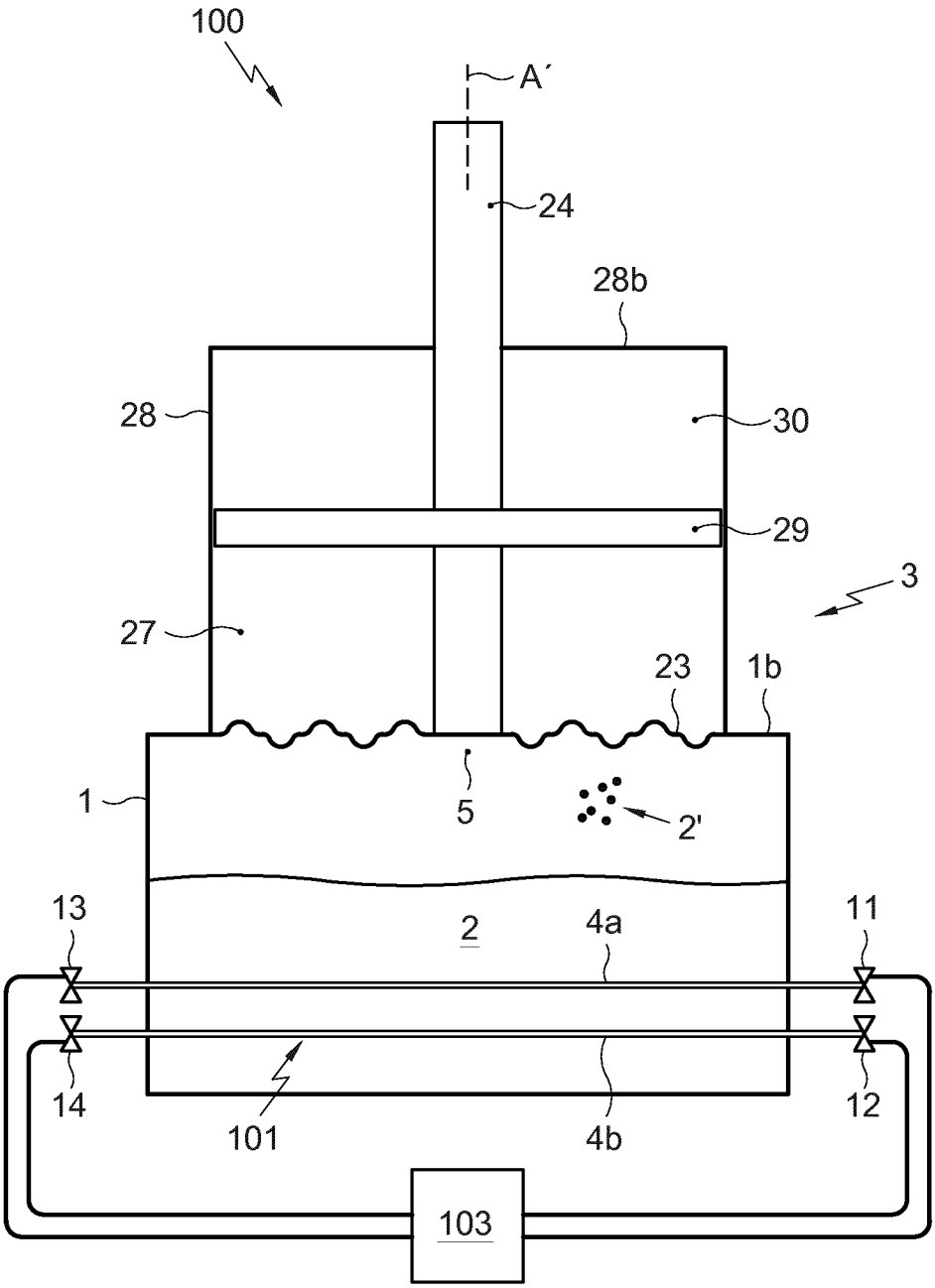

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/075263

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01K11/00 F01K21/02 F01K25/08 F22B1/16
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01K F22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/060294 A1 (YATSUZUKA SHINICHI [JP] ET AL) 1 April 2004 (2004-04-01) figure 6a	1,7-9, 11-13, 16,18,20
Y	US 2005/155347 A1 (LEWELLIN RICHARD L [AU]) 21 July 2005 (2005-07-21) figure 1	1-6,10, 11, 14-16, 18,19
Y	FR 2 390 583 A1 (CYTEC FRANCE [FR]) 8 December 1978 (1978-12-08) figure 1	1-6,10, 11, 14-16, 18,19

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2016	23/12/2016

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

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/075263

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/128898 A2 (GERSHON MACHINE LTD [IL]; HARIF GERSHON [IL]) 20 October 2011 (2011-10-20) figure A	1,7,9, 11,13, 18-20
A	JP S55 60707 A (KIMURA SHINDAI KOGYO KK) 8 May 1980 (1980-05-08) abstract; figure 2a	1,7,9, 11,12, 18,20
A	US 5 927 071 A (ASANUMA NOBUYOSHI [JP] ET AL) 27 July 1999 (1999-07-27) page but, column 3, line 59 - column 4, line 53; figures 1-3	1,2,4,5, 7,9, 14-16
A	US 6 272 855 B1 (LEONARDI JOSEPH [US]) 14 August 2001 (2001-08-14) figure 1	1,7-9, 18-20
A	US 2005/198960 A1 (MARNOCH IAN A [CA]) 15 September 2005 (2005-09-15) figure 1	1,7,9, 11,18
A	EP 2 660 433 A1 (MIND STUDI E PROGETTAZIONE ING VITRI GIUSEPPE E ING LUCHETTI FILIPPO E) 6 November 2013 (2013-11-06) figure 1	1,9,11, 12,18

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/075263

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004060294 A1	01-04-2004	CN 1485526 A	31-03-2004
		DE 10339003 A1	11-03-2004
		FR 2846032 A1	23-04-2004
		JP 4411829 B2	10-02-2010
		JP 2004084523 A	18-03-2004
		US 2004060294 A1	01-04-2004
US 2005155347 A1	21-07-2005	CA 2484615 A1	02-10-2003
		EP 1495224 A1	12-01-2005
		NZ 536084 A	21-12-2007
		US 2005155347 A1	21-07-2005
		WO 03081011 A1	02-10-2003
FR 2390583 A1	08-12-1978	NONE	
WO 2011128898 A2	20-10-2011	AU 2011241835 A1	18-10-2012
		CA 2794348 A1	20-10-2011
		CN 102844529 A	26-12-2012
		EP 2558689 A2	20-02-2013
		JP 5890826 B2	22-03-2016
		JP 2013524101 A	17-06-2013
		KR 20130079335 A	10-07-2013
		RU 2012140040 A	20-05-2014
		WO 2011128898 A2	20-10-2011
JP S5560707 A	08-05-1980	NONE	
US 5927071 A	27-07-1999	DE 19648050 A1	05-06-1997
		US 5927071 A	27-07-1999
US 6272855 B1	14-08-2001	NONE	
US 2005198960 A1	15-09-2005	CA 2558990 A1	22-09-2005
		US 2005198960 A1	15-09-2005
		US 2008127649 A1	05-06-2008
		WO 2005088080 A1	22-09-2005
EP 2660433 A1	06-11-2013	NONE	