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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 October 2016 (13.10.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/163873 A1

(51) International Patent Classification:
F03G 7/05 (2006.01)

(21) International Application Number:
PCT/NL2015/050234

(22) International Filing Date:
10 April 2015 (10.04.2015)

(25) Filing Language: Dutch

(26) Publication Language: English

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(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, 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, 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, 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))*

[Continued on next page]

(54) Title: SYSTEM FOR CONVERTING HEAT TO KINETIC ENERGY

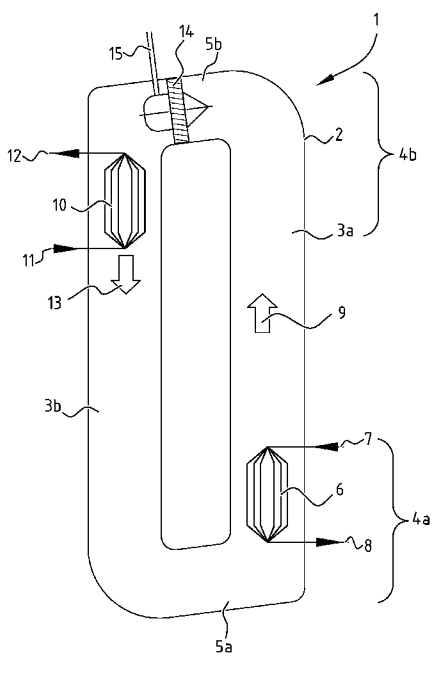

FIG. 1

(57) Abstract: The invention relates to a system for converting heat to kinetic energy, comprising: -a vertically disposed elongate body which is at least partially filled with a working fluid, which body comprises two channels which are mutually separated in longitudinal direction and which are in fluid-throughflow contact with each other in the area of a first lower longitudinal end zone of the body and in the area of a second upper longitudinal end zone of the body; a first heat exchanger for exchanging heat between the working fluid in the body and an external heat source relative to the body, which first heat exchanger is disposed in the area of the first longitudinal end zone of the body in or close to the one channel; a second heat exchanger for exchanging heat between the working fluid in the body and an external cold source relative to the body, which second heat exchanger is disposed in the area of the second longitudinal end zone of the body in or close to the other channel; and a turbine disposed in the body, wherein the turbine is disposed between the first heat exchanger and the second heat exchanger as seen in flow direction of the working fluid. The invention also relates to the use of such a system and to an assembly of a system according to the invention and a ship, buoy, platform or the like. The invention can be applied particularly, though not exclusively, for the purpose of utilizing heat flows with small differences in temperature available in large quantities such as occur between the higher and deeper layers in the ocean.

WO 2016/163873 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

SYSTEM FOR CONVERTING HEAT TO KINETIC ENERGY

The invention relates to a system for converting heat to kinetic energy, comprising:

- a vertically disposed gas-tight and/or liquid-tight elongate body which is at least partially filled with a working fluid, which body comprises two channels which are mutually separated in longitudinal direction and which are in fluid-throughflow contact with each other in the area of a first lower longitudinal end zone of the body and in the area of a second upper longitudinal end zone of the body;

- a first heat exchanger for exchanging heat between the working fluid in the body and an external heat source relative to the body, which first heat exchanger is disposed in the area of the first longitudinal end zone of the body in or close to the one channel;

- a second heat exchanger for exchanging heat between the working fluid in the body and an external cold source relative to the body, which second heat exchanger is disposed in the area of the second longitudinal end zone of the body in or close to the other channel; and

- a turbine disposed in the body.

The system of the type stated in the preamble is configured in use to cause the working fluid to change to a substantially gaseous state by supplying heat to the working fluid via the first heat exchanger, so that the working fluid is substantially in a gaseous state in the one channel and will displace upward from the first longitudinal end zone to the second longitudinal end zone of the body;

wherein the system is configured in use to cause the working fluid to change to a substantially liquid state by discharging heat from the working fluid via the second heat exchanger, so that the working fluid is substantially in a liquid state in the other channel and wherein under the influence of gravitational force a pressure is built up on the working fluid in the liquid state and the working fluid will displace downward from the second longitudinal end zone to the first longitudinal end zone of the body,

and wherein due to the upward and downward displacement of the working fluid in the body the working fluid will circulate in the body, by which circulation of the working fluid the turbine is driven rotatably.

Supplying heat to the working fluid in the area of the lower longitudinal end zone of the body close to the one channel causes the temperature of the working fluid to increase there, whereby the density of the working fluid decreases and the working fluid changes to the gas phase. Heat is conversely discharged from the working fluid at the other upper longitudinal end zone of the body close to the other channel, whereby the local temperature of the working fluid decreases and the density increases and the working fluid changes to the liquid phase. The gaseous working fluid will easily displace upward in the one channel and the liquid working fluid will easily displace downward in the other channel, wherein, because the weight of the liquid working fluid in the one channel is greater than that of the gaseous working fluid in the other channel, the power of the system can increase. The pressure in the other channel with the working fluid in the liquid phase increases under the influence of gravitational force. The upward displacement and downward displacement of the working fluid results in circulation of the working fluid in the body. The working fluid circulating in the body drives the turbine disposed in the body for the purpose of generating kinetic energy.

In contrast to the per se known Organic Rankine Cycle (ORC), wherein the working liquid is brought to pressure in the liquid phase by a pump, the pressure buildup takes place here due to the force which gravity exerts on the liquid column. This reduces the complexity of the installation and is energetically more favourable because this ‘gravity pump’ has a high efficiency. A pump need moreover not be provided for the purpose of building up the pressure in the liquid phase, whereby there are no pump losses. The system of the type stated in the preamble is however less compact than the ORC because a relatively great length of the body is necessary to exert sufficient pressure on the liquid column using gravitational force.

US application number US 2012/0240576 A1 shows a system of the type stated in the preamble.

It is an object of the invention to improve the system referred to in the preamble. It is a particular object of the invention to improve the system of US 2012/0240576 A1.

This object is achieved with a system of the type stated in the preamble wherein according to the invention the turbine is disposed between the first heat exchanger and the second heat exchanger as seen in flow direction of the working fluid.

The turbine is disposed here according to the invention in the gas phase of the working fluid and is therefore driven by the working fluid in gas phase. In the system of US 2012/0240576 A1 the turbine is in contrast disposed between the second heat exchanger and the first heat exchanger as seen in flow direction of the working fluid so that the turbine is driven by the working fluid in liquid phase. An advantage of driving the turbine in the gas phase of the working fluid is that the system can be given a more compact form and particularly the body can have a shorter length compared to the system of US 2012/0240576 A1. Because of its compact form and relatively short length the system according to the invention can be embodied relatively inexpensively compared to the system of US 2012/0240576 A1, and a pump for the purpose of building up the pressure in the liquid phase is not required as in the case of the ORC.

It is noted that it is self-evident to have the turbine driven by the working fluid in liquid phase, whereby the pressure of the liquid column can be used to drive the turbine and the efficiency of the system is relatively high. Wholly contrary to expectations however, it is found that the efficiency of the system according to the invention, wherein the turbine is driven by the working fluid in gas phase instead of in liquid phase, is only slightly lower. This is because the volume of the working fluid in gas phase is relatively large compared to the working fluid in liquid phase. The system according to the invention can therefore be readily applied in situations where the compact and therefore relatively inexpensive system provides more advantages than the limited loss in efficiency.

Applicant has found that in the system according to the invention only small temperature differences of the working fluid in the body are required to cause the circulation of the working fluid and thereby the driving of the turbine. It has particularly been found by applicant that a temperature difference in the order of magnitude of about 10°C can be sufficient. The difference in temperature between the heat source and the cold source can hereby amount to about 15°C to 20°C, depending on the efficiency of the first and second heat exchangers. Owing to this relatively small difference in temperature between the heat source and cold source diverse heat and cold sources can be employed in the system according to the invention, which heat and cold sources would otherwise for instance remain unused because of their relatively small temperature difference. It is noted that the system is not limited to such temperature differences in the working fluid and between the heat and cold sources.

It is noted that the first and second heat exchangers can be coupled directly to the heat source and cold source, wherein media coming from the heat source and cold source are carried to the first and second heat exchanger. It can alternatively be the case that the first and second heat exchangers are coupled indirectly to the heat source and cold source, for instance via an additional set of heat exchangers.

The heat source can for instance be selected from the group comprising ocean or sea water, terrestrial heat, volcanic spring water, industrial residual heat, fluid heated by a solar collector, air, water from a hot water spring on land or at sea, and a combination thereof.

The cold source can for instance be selected from the group comprising ocean or sea water, groundwater, water optionally evaporating in forced manner, air and a combination thereof.

It is noted that any type of heat source can be combined with any type of cold source. It is also noted that said heat and cold sources are heat and cold sources suitable for the system according to the invention, but that the invention is not limited to said heat and cold sources. It is further noted that the body can be disposed both in and on water and on land, optionally elevated or sunken.

In an embodiment of the system according to the invention the working fluid is selected from the group comprising gases, for instance carbon dioxide, refrigerants, for instance hydrofluorocarbons, a mixture of water and ammonia, and combinations thereof.

Because the body is a gas-tight and/or liquid-tight body it is possible to fill the body with any suitable working fluid. A working fluid can for instance particularly be selected which has a boiling and/or condensation temperature which, at the prevailing pressures in the body, lies between the temperatures of the cold source and the heat source. The working fluid particularly has a boiling and/or condensation temperature lying at the prevailing pressures between -10 and 100°C, preferably between -10 and 50°C, still more preferably between 0 and 25°C. According to the invention such a working fluid can be gaseous in the one channel and a liquid in the other channel, wherein the working fluid undergoes a phase change each time at the heat exchangers. The prevailing pressures lie for instance between 0 and 10 bar.

The working fluid preferably has an optimal ratio of the expansion at the transition from liquid to gas and the evaporation heat per cubic metre at the pressure prevailing in the system at the location of the first heat exchanger.

Said hydrofluorocarbons can for instance be R134a or R1234, but are not limited thereto.

The turbine can be disposed at any random location between the first and the second heat exchanger. When the system is disposed in the sea or ocean or in sunken arrangement on land, a high arrangement of the turbine has the advantage of better accessibility.

In yet another embodiment of the system according to the invention the body is suitable for arranging on, in or close to a body of water, such as a sea or ocean, wherein the system comprises a first conduit which is coupled on one side to the first heat exchanger and on the other side debouches by means of an inlet opening in the sea or ocean close to the water surface thereof, wherein the system comprises a second conduit which is coupled on one side to the second heat exchanger and on the other side debouches by means of an inlet opening in the sea or ocean close to a bottom thereof, and comprising pump means for pumping sea or ocean water via the first conduit and second conduit to the first and second heat exchanger. If there is sufficient height difference between the two locations where the first conduit and the second conduit debouch, there is in the sea or ocean a sufficiently great temperature difference between the water present there. The water surrounding the inlet opening of the first conduit has for instance a temperature of about 25°C to 30°C and the water surrounding the inlet opening of the second conduit has a temperature of about 3°C to 6°C. The deeper the second conduit debouches, the lower the local temperature can be of the water which will be pumped upward in the second conduit via the inlet opening. Close to the bottom is in any case understood here to mean that the second conduit debouches deeper in the sea than the first conduct. Because the sea or ocean has a substantially continuous difference in water temperature, it is possible with the device according to this embodiment to produce energy almost continuously, particularly for instance both during the day and at night, as well as for instance during any season. Owing to the required small temperature difference at which the device according to the invention can function, the device can be disposed at diverse locations in or close to the sea or ocean, even at locations where the temperature difference is relatively small.

It is noted that the pump means can comprise any suitable type of pump means.

In this embodiment of the system a third conduit can optionally be provided which for ecological reasons discharges at lower depth sea or ocean water cooled in the first heat exchanger.

In this embodiment of the system a fourth conduit can optionally also be provided which for ecological reasons discharges at lower depth sea or ocean water heated in the second heat exchanger The fourth conduit preferably has a length here such that it debouches in an area of the sea or ocean where the local temperature of the sea or ocean water is substantially equal to the temperature of the sea or ocean water heated in the second heat exchanger. The fourth conduit preferably has at least the same length as the third conduit.

The system can comprise any suitable combination of and any suitable number of heat exchangers and/or conduits. The terms “first”, “second”, “third” and “fourth” used serve only to distinguish the different heat exchangers and/or conduits. Not all of the stated conduits therefore need be present in the system. Said third conduit may for instance not be present, while said fourth conduit is present. The system will in that case therefore comprise a total of three conduits despite the reference to the fourth conduit.

A particular embodiment is possible when the heat source is a volcanic lake or a hot source in the sea or ocean bed, or when use is made of geothermics. The first heat exchanger can then be coupled to a heat pipe which carries the heat from the volcanic lake, the hot source or the earth to the heat exchanger so that the heat is extracted as optimally as possible. The heat pipe serves here both as collector and heat transport means.

The system can comprise a generator connected to the turbine for the purpose of converting the kinetic energy to electrical energy. When the system is placed on the sea or ocean, the electrical energy generated with the system can for instance be transported to land via cables or other transport means.

In yet another embodiment of the system according to the invention the system or components thereof are accommodated in a shared housing or a housing of their own.

The heat exchangers, the body, the turbine, the generator and optional pumps can for instance each be accommodated in a housing of their own. The diverse components can in this way be easily transported in their housings to the location of use and be coupled on-site for the purpose of assembling the system according to the invention. Determined components or all components can alternatively be accommodated in a shared housing. It is thus practical for instance to accommodate the turbine and generator in a shared housing. It will be apparent that this choice can be made as desired.

The invention also relates to the use of a system according to any of the claims 1-8, wherein the system is used such that:

- the working fluid changes to a substantially gaseous state by supplying heat to the working fluid via the first heat exchanger, so that the working fluid is substantially in a gaseous state in the one channel and will displace upward from the first longitudinal end zone to the second longitudinal end zone of the body;

- the working fluid changes to a substantially liquid state by discharging heat from the working fluid via the second heat exchanger, so that the working fluid is substantially in a liquid state in the other channel and wherein under the influence of gravitational force a pressure is built up on the working fluid in the liquid state and the working fluid will displace downward from the second longitudinal end zone to the first longitudinal end zone of the body,

wherein due to the upward and downward displacement of the working fluid in the body the working fluid will circulate in the body, by which circulation of the working fluid the turbine is driven rotatably,

wherein the turbine is disposed between the first heat exchanger and the second heat exchanger as seen in flow direction of the working fluid so that the turbine is driven by the working fluid in gaseous state.

The advantages of using the system in this way have already been elucidated above with reference to the system itself.

In an embodiment of the use of the system according to the invention the system is disposed on, in or close to a body of water such as an ocean or sea.

When the system is disposed in or on the water, the system can be connected to a ship, buoy, platform or the like. The system can for instance be suspended from the ship, buoy, platform or the like, for instance using suspending means, or be disposed on or in the ship, buoy, platform or the like. The system can alternatively be disposed onshore close to the water.

The system is preferably disposed such that the second longitudinal end zone of the body extends a maximum of 10 metres above the water level.

The pumping force with which water from said body of water is guided to the second heat exchanger can in this way be relatively limited. If the system has a greater length than 10 m, or is placed on an elevated surface such as a fjord or dune adjacently of a body of water, the system can for instance then be disposed sunk in a recess in the ground.

The invention also relates to an assembly of a system according to any of the claims 1-8 and a ship, buoy, platform or the like, wherein the system is suspended from the ship, buoy, platform or the like, for instance using suspending means, or disposed on or in the ship, buoy, platform or the like.

An advantage hereof is that the system is easily displaceable by displacing the ship, buoy, platform or the like. It can also be relatively complex to place an installation on the bed of the sea or ocean, whereby it is easier to suspend the system according to the invention from the ship or the like or dispose it thereon or therein.

The invention will be further elucidated with reference to figures shown in a drawing, in which:

- figure 1 is a schematic view of a first embodiment of the system according to the invention; and
- figure 2 shows the system of figure 1 in a situation where it is suspended from a ship.

Figure 1 shows a system 1 for converting heat to kinetic energy as according to a first embodiment of the invention. System 1 comprises a vertically disposed gas-tight and/or liquid-tight elongate body 2 which is at least partially filled with a working fluid. Body 2 comprises two channels 3a, 3b which are mutually separated in longitudinal direction and which, via connecting pieces 5a, 5b, are in mutual contact for fluid throughflow in the area of a first lower longitudinal end zone 4a of body 2 and in the area of a second upper longitudinal end zone 4b of body 2. Body 2 has a substantially annular form here. A first heat exchanger 6 is disposed in the one channel 3a of body 2 in the area of the first longitudinal end zone 4a. A relatively warm medium coming from a suitable heat source is supplied via inlet 7 to first heat exchanger 6, wherein the heat from the medium is transferred to the working fluid in body 2. Relatively warm is understood here to mean that the warm medium has a higher temperature than the working fluid in the area of the first longitudinal end zone 4a. The thus cooled medium is discharged via outlet 8. Heating the working fluid in body 2 will cause the density of the working fluid in the one channel 3a to decrease, whereby the working fluid will displace upward in direction 9. The flow direction of the medium in first heat exchanger 6 is opposite here to the direction 9 of the upward displacing working fluid in order to obtain the best possible heat transfer. First heat exchanger 6 is here a so-called counter-flow heat exchanger. A second heat exchanger 10 is disposed in the other channel 3b of body 2 in the area of the second longitudinal end zone 4b. A relatively cold medium coming from a suitable cold source is supplied via inlet 11 to second heat exchanger 10, wherein heat from the working fluid in body 2 is transferred to the medium. Relatively cold is understood here to mean that the cold medium has a lower temperature than the working fluid in the area of the second longitudinal end zone 4b. The thus heated medium is discharged via outlet 12. Cooling of the working fluid in body 2 will cause the density of the working fluid in the other channel 3a to increase, whereby the working fluid will displace downward in direction 13. The flow direction of the medium in second heat exchanger 10 is opposite here to the direction 13 of the downward displacing working fluid in order to obtain the best possible heat transfer. Second heat exchanger 10 is here a so-called counter-flow heat exchanger. A turbine 14 is disposed between the first and second heat exchanger 3b as seen in the flow direction of the medium, which turbine 14 is driven by the circulating working fluid in gas phase. Turbine 14 is coupled via a coupling 15 to for instance a generator for converting kinetic energy generated by the turbine to electrical energy.

It is noted that, although first heat exchanger 6 and second heat exchanger 10 are embodied as counter-flow heat exchangers in figure 1, they can be any suitable type of heat exchanger.

Body 2 of figure 1 can have any suitable length. Body 2 has for instance a length lying between 5 and 25 m. The process imposes limitations on the length: in the other channel 3b the pressure in the vicinity of heat exchanger 10 must be so high that the fluid condenses, which results in a higher pressure at heat exchanger 6, i.e. as high as the weight of the column of gas in the one channel 3a plus the pressure drop over the turbine. The available heat source must have a temperature high enough to cause the fluid to evaporate at this increased pressure, and so a higher boiling temperature. Applicant has found that, when system 1 is disposed in or close to a sea or ocean, said length of between 5 and 25 m is a practical length at which evaporation is possible with the temperature differences present in practice in the ocean. Applicant has further found that a reasonable efficiency is achieved with the embodiment as described. The efficiency lies for instance between 0.5 and 10%, more particularly around 0.7 - 2%. Such an efficiency is relatively low, but the system according to the invention is suitable for generating usable energy when there is relatively little difference in temperature between the heat source and the cold source, which energy would not otherwise be utilized. Depending on the selected heat source and cold source, the system according to the invention can also operate substantially continuously.

The diameter of each channel 3a, 3b lies for instance between 0.3-10 m, preferably between 0.5-2 m, this being dependent on the power to be realized.

As described above, body 2 is gas-tight and/or liquid-tight. The system is hereby a closed gas and/or liquid system. The working fluid can hereby be any suitable working fluid. For the purpose of exchanging heat the system is not a closed system.

It is noted that in the exemplary embodiment of figure 1 the first heat exchanger 6 and second heat exchanger 10 are disposed in body 2. Heat exchangers 6, 10 can alternatively be disposed on an outer side of body 2, wherein the heat can be transferred via the outer wall of body 2.

Figure 2 shows system 1 of figure 1, wherein body 2 is suspended from a ship 16. The heat source is formed here by relatively warm sea or ocean water situated close to the water surface 19. The cold source is formed here by relatively cold sea or ocean water situated close to the sea or ocean bed 20. Provided for the purpose of supplying the relatively warm water to first heat exchanger 6 is a first conduct 17 debouching in the sea or ocean close to the water surface 19 thereof or having an inflow opening disposed close to water surface 19. Provided for supplying the relatively cold water to second heat exchanger 10 is a second conduit 18 debouching in the sea or ocean close to the bed 20 thereof or having an inflow opening disposed close to bed 20. The absolute distance between the inlet opening of second conduit 18 and bed 20 can be chosen as desired, for instance subject to the local sea or ocean depth. Close to is for instance understood to mean that second conduit 18 debouches close to the first end zone 4 of body 2 or deeper, and in any case that conduit 18 debouches deeper than first conduit 17. Conduits 17, 18 are shown schematically, wherein the direction in which the sea or ocean water is pumped is shown schematically with respective arrows 21 and 22. Conduit 17 can for instance have a diameter lying between 1-10 m, more preferably between 3-7 m. Conduit 18 can for instance have a diameter lying between 1-10 m, more preferably between 5-8 m. The length of conduit 17 can be substantially equal to the length of body 2. Second conduit 18 in particular can optionally have a greater length than body 2 so that conduit 18 debouches below body 2, where the temperature of the sea water is relatively low.

The sea water close to the inflow opening of first conduit 17 has for instance a temperature of about 302 K, and the sea water leaving first heat exchanger 6 has for instance a temperature of about 292 K. The sea water close to the inflow opening of second conduit 18 has for instance a temperature of about 277 K, and the sea water leaving second heat exchanger 10 has for instance a temperature of about 284 K. The temperature of the working fluid varies here between about 283 and 292 K. The pressure in the body varies between about 0-10 bar, wherein the pressure, in addition to the temperature, influences the phase of the working fluid. Particularly the pressure in the one channel 3a, where the medium is in gas phase, is lower than the pressure in the other channel 3b where the medium is in liquid phase. The power generated with system 1 lies for instance between 0.1-50 MW, wherein the efficiency lies between for instance 0.5-4%.

It is noted that the invention is not limited to the shown embodiments but also extends to variants within the scope of the appended claims.

It will thus be apparent to the skilled person that, although the system is shown in a situation suspended from a ship, the system can be disposed at a random suitable location.

Claims

1. System for converting heat to kinetic energy, comprising:

- a vertically disposed gas-tight and/or liquid-tight elongate body which is at least partially filled with a working fluid, which body comprises two channels which are mutually separated in longitudinal direction and which are in fluid-throughflow contact with each other in the area of a first lower longitudinal end zone of the body and in the area of a second upper longitudinal end zone of the body;

- a first heat exchanger for exchanging heat between the working fluid in the body and an external heat source relative to the body, which first heat exchanger is disposed in the area of the first longitudinal end zone of the body in or close to the one channel;

- a second heat exchanger for exchanging heat between the working fluid in the body and an external cold source relative to the body, which second heat exchanger is disposed in the area of the second longitudinal end zone of the body in or close to the other channel; and

- a turbine disposed in the body,

wherein the system is configured in use to cause the working fluid to change to a substantially gaseous state by supplying heat to the working fluid via the first heat exchanger, so that the working fluid is substantially in a gaseous state in the one channel and will displace upward from the first longitudinal end zone to the second longitudinal end zone of the body;

wherein the system is configured in use to cause the working fluid to change to a substantially liquid state by discharging heat from the working fluid via the second heat exchanger, so that the working fluid is substantially in a liquid state in the other channel and wherein under the influence of gravitational force a pressure is built up on the working fluid in the liquid state and the working fluid will displace downward from the second longitudinal end zone to the first longitudinal end zone of the body,

wherein due to the upward and downward displacement of the working fluid in the body the working fluid will circulate in the body, by which circulation of the working fluid the turbine is driven rotatably,

characterized in that

the turbine is disposed between the first heat exchanger and the second heat exchanger as seen in flow direction of the working fluid.

2. System as claimed in claim 1, wherein the heat source is selected from the group comprising ocean or sea water, terrestrial heat, volcanic spring water, industrial residual heat, fluid heated by a solar collector, air, water from a hot water spring on land or at sea, and a combination thereof.

3. System as claimed in claim 1 or 2, wherein the cold source is selected from the group comprising ocean or sea water, groundwater, water optionally evaporating in forced manner, air and a combination thereof.

4. System as claimed in any of the foregoing claims, wherein the working fluid is selected from the group comprising gases, for instance carbon dioxide, refrigerants, for instance hydrofluorocarbons, a mixture of water and ammonia, and combinations thereof.

5. System as claimed in any of the foregoing claims, wherein the body is suitable for arranging on, in or close to a body of water, such as a sea or ocean, wherein the system comprises a first conduit which is coupled on one side to the first heat exchanger and on the other side debouches by means of an inlet opening in the sea or ocean close to the water surface thereof, wherein the system comprises a second conduit which is coupled on one side to the second heat exchanger and on the other side debouches by means of an inlet opening in the sea or ocean close to a bottom thereof, and comprising pump means for pumping sea or ocean water via the first conduit and second conduit to the first and second heat exchanger.

6. System as claimed in any of the foregoing claims, comprising a heat pipe coupled to the first heat exchanger.

7. System as claimed in any of the foregoing claims, comprising a generator connected to the turbine for the purpose of converting kinetic energy to electrical energy.

8. System as claimed in any of the foregoing claims, wherein the system or components thereof are accommodated in a shared housing or a housing of their own.

9. Use of a system as claimed in any of the claims 1-8, wherein the system is used such that:

- the working fluid changes to a substantially gaseous state by supplying heat to the working fluid via the first heat exchanger, so that the working fluid is substantially in a gaseous state in the one channel and will displace upward from the first longitudinal end zone to the second longitudinal end zone of the body;

- the working fluid changes to a substantially liquid state by discharging heat from the working fluid via the second heat exchanger, so that the working fluid is substantially in a liquid state in the other channel and wherein under the influence of gravitational force a pressure is built up on the working fluid in the liquid state and the working fluid will displace downward from the second longitudinal end zone to the first longitudinal end zone of the body,

wherein due to the upward and downward displacement of the working fluid in the body the working fluid will circulate in the body, by which circulation of the working fluid the turbine is driven rotatably,

characterized in that

the turbine is disposed between the first heat exchanger and the second heat exchanger as seen in flow direction of the working fluid so that the turbine is driven by the working fluid in gaseous state.

10. Use as claimed in claim 9, wherein the system is disposed on, in or close to a body of water such as an ocean or sea.

11. Use as claimed in claim 10, wherein the system is disposed such that the second longitudinal end zone of the body extends a maximum of 10 metres above the water level.

12. Assembly of a system as claimed in any of the claims 1-8 and a ship, buoy, platform or the like, wherein the system is suspended from the ship, buoy, platform or the like, for instance using suspending means, or disposed on or in the ship, buoy, platform or the like.

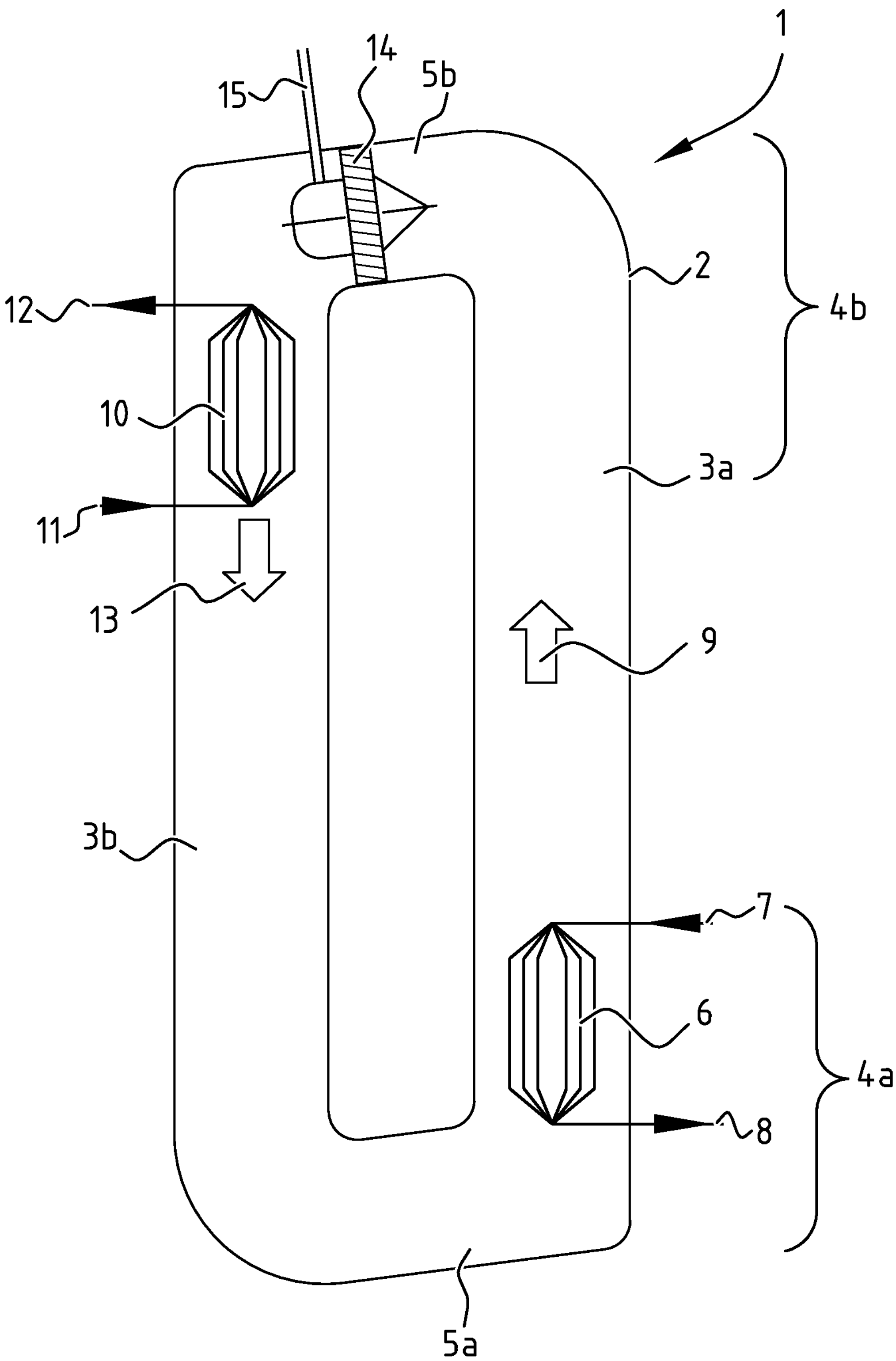

FIG. 1

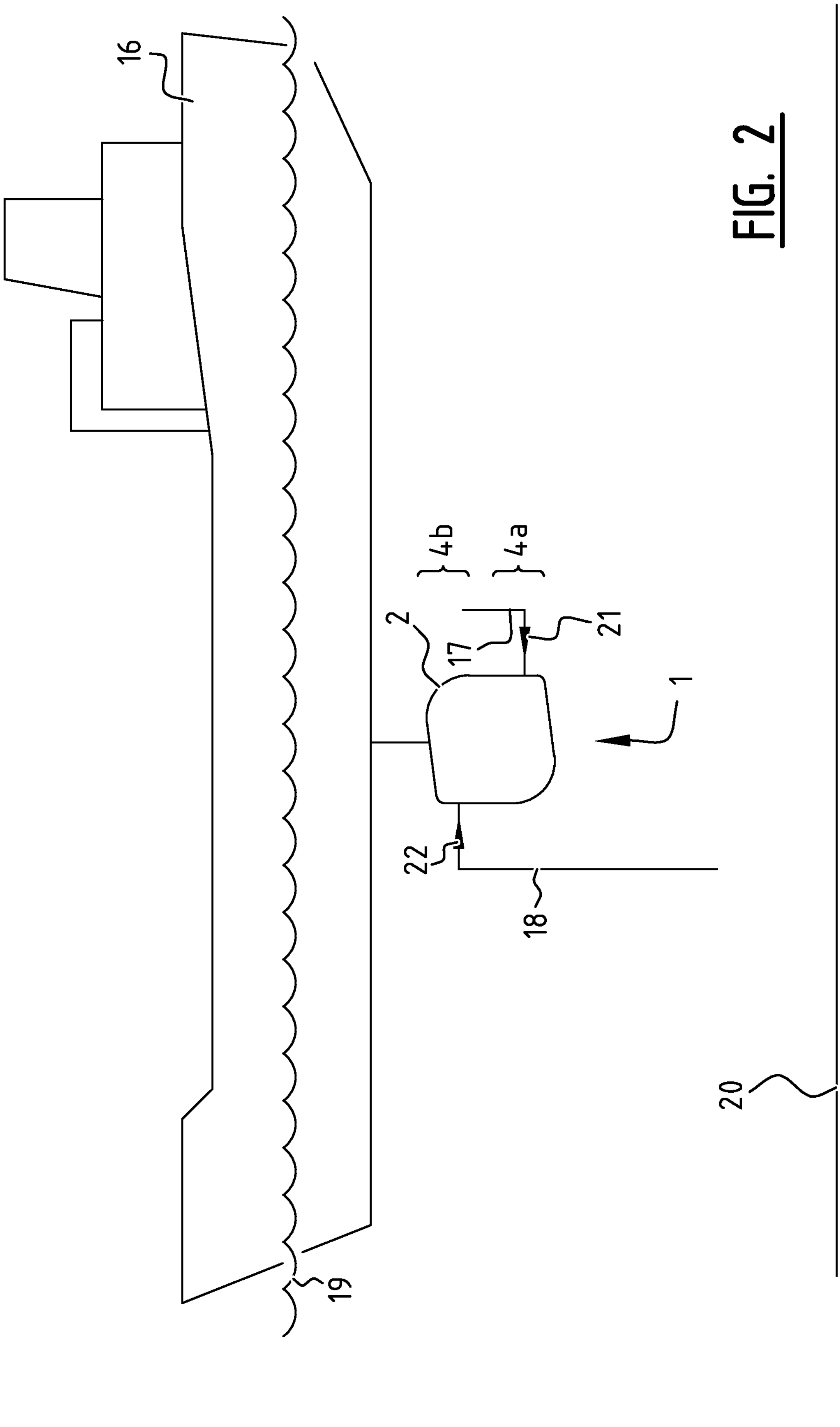

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2015/050234

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03G7/05
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)
F03G

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/036919 A1 (BAIRD JAMES RUSSELL [CA]) 17 February 2011 (2011-02-17) paragraph [0164] - paragraph [0179]; figure 6	1-12
X	US 2011/079375 A1 (NAGURNY NICHOLAS J [US] ET AL) 7 April 2011 (2011-04-07) paragraph [0043] - paragraph [0046]; figure 1	1-12
X	EP 2 395 241 A2 (SRINIVASAN NAGAN [US]) 14 December 2011 (2011-12-14) paragraph [0046] - paragraph [0056]; figures 6,7-9	1-12
X	GB 2 009 388 A (ICEBERG TRANSPORT INT) 13 June 1979 (1979-06-13) page 1 - page 2; figure 1	1-3,5-12

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 September 2016	19/09/2016

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2002/007644 A1 (KELLEY BRUCE T [US]) 24 January 2002 (2002-01-24) paragraph [0032] - paragraph [0033]; figure 3	1-4,7-12
A	US 2012/240576 A1 (JOHNSON ROWLAND XAVIER [US]) 27 September 2012 (2012-09-27) cited in the application the whole document	1-12

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2015/050234

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