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(54) **A GAS-LIQUID SEPARATOR FOR HEAT MEDIUM CIRCULATION SYSTEM**

(57) The current invention relates to a gas-liquid separator for a heat medium circulation system, which device permits safe operation of the heat medium circulation system even in the event of a refrigerant leak.

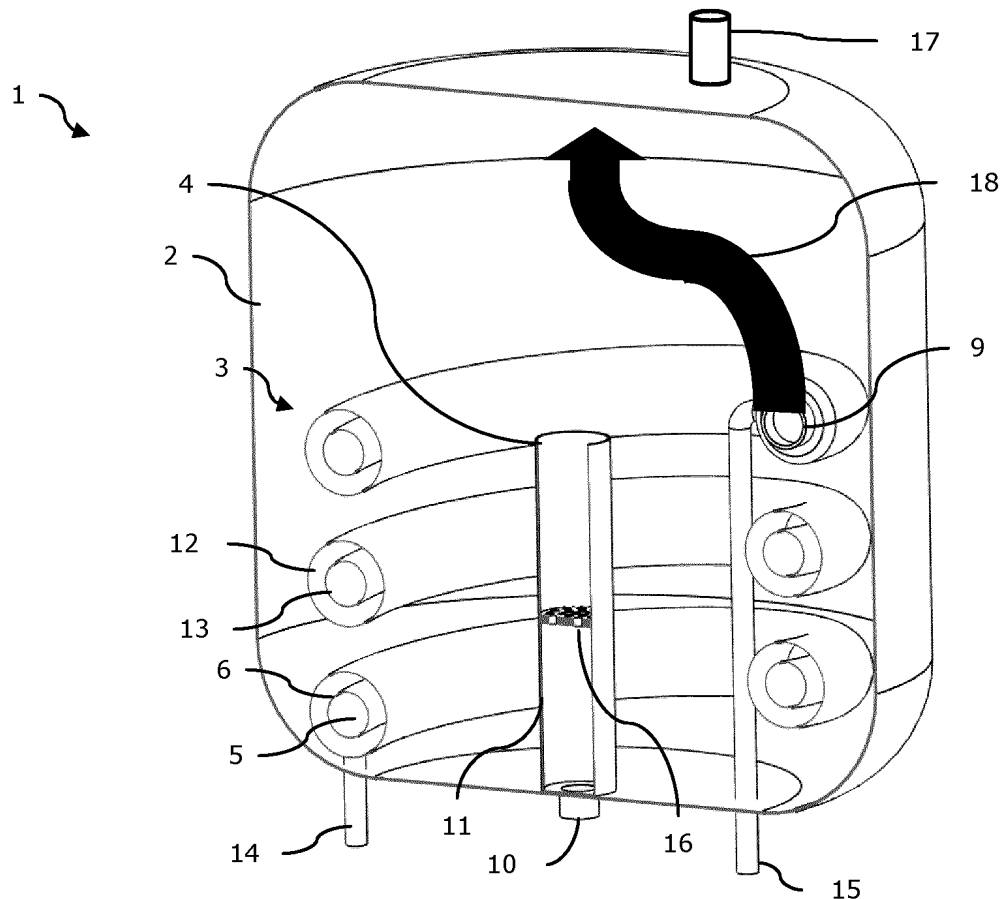


FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heat medium storage device. More in particular, the invention relates to safety improvements to heat medium storage devices having heat exchanging elements.

BACKGROUND

[0002] EP2080975A1 in the name of ATLANTIC CLIMATISATION ET VENT, discloses a device for heat exchange between fluids belonging to two circuits. The device has a reservoir to receive heat medium e.g., water, and a heat medium inlet equipped at a lower part of the reservoir. A heat medium outlet is equipped at an upper part of the reservoir. A coaxial heat pipe is arranged at inside of the reservoir, and is immersed in the heat medium. An inner tube of the pipe is connected to the heat medium inlet at an end of the reservoir, and opens at another end of the reservoir. The inner tube is provided as a passage for the heat medium. An outer tube of the pipe is provided as a passage for refrigerant.

[0003] EP1965164A1 in name of ATLANTIC CLIMATISATION ET VENT, discloses a device for heat exchange between fluids belonging to two circuits. The device has a reservoir to receive heat transfer fluid. The reservoir is equipped with a heat transfer fluid inlet arranged in a lower part of the reservoir and an outlet of a heat transfer fluid arranged in an upper part. An exchanger with coaxial tubes is arranged inside the reservoir, and is immersed in the heat transfer fluid. An inner tube is connected to the heat transfer fluid inlet at an end, and is opened in the reservoir at another end. The tube has a section between the inlet and the exchanger, where the section is uncovered by an outer tube in which leakage opening is arranged.

[0004] These known devices, like any other devices having refrigerant using heat exchanger are susceptible to develop refrigerant leakages. None of the devices disclosed in EP '975 nor in EP '164 include any leak remediation or prevention features. Furthermore, none of the disclosed devices include elements or features to prevent the passage of any leaked refrigerant to any user-side element.

SUMMARY OF THE INVENTION

[0005] The present invention aims to resolve at least some of the problems and disadvantages mentioned above.

[0006] The invention thereto aims to provide gas-liquid separator for a heat medium circulation system, said gas-liquid separator having improved gas-liquid separation which prevent the spreading of any leaked refrigerant to any user-side elements e.g., heat exchangers.

[0007] The present invention thereof serve to provide

a solution to one or more of above-mentioned disadvantages. To this end, the present invention relates to a gas-liquid separator for a heat medium circulation system according to claim 1.

[0008] In a first aspect, the invention relates to a gas-liquid separator for a heat medium circulation system, comprising;

a tank to receive and store the heat medium,
a heat medium inlet that allows the heat medium returning from a usage-side heat exchanger to flow into the tank,
a heat medium outlet that allows the heat medium inside the tank to flow out of the tank to the usage-side heat exchanger,
an internal heat exchanger having a heat medium passage and an adjoining refrigerant passage, which is immersed in the heat medium in the tank and exchanges heat between a refrigerant flowing in the refrigerant passage and the heat medium flowing in the heat medium passage,
a first inlet of the internal heat exchanger configured as an inlet of the heat medium passage, the first inlet being connected to the heating medium inlet;
a first outlet of the internal heat exchanger configured as an outlet of the heat medium passage, the first outlet being open inside the tank; and
an outlet tube having a proximal end and a distal end, the outlet tube being located inside the tank, the distal end of the outlet tube being connected to the heat medium outlet.

[0009] The outlet tube comprises flow reduction means configured for reducing the flow velocity of the heat medium through the outlet tube. Refrigerants used in heat pumps, air-conditioning or other similar refrigerant using installations have lower densities than water or other heat mediums with which said refrigerants are expected to exchange heat (e.g., mineral oil). The device of the present invention is particularly suited, though not exclusively, to the use of water as a heat medium. Water has a higher density than refrigerants, even when said refrigerants are compressed above normal operating pressures expected in heat pumps or air conditioning installations. The present invention takes advantage of the difference of density between refrigerant and heat medium, in particular the buoyancy effects produced by said difference. In this way, any refrigerant making its way to the inside of the tank along with the heat medium via the first outlet will naturally have the tendency to separate from the heat medium and float upwards and pool over the heat medium. By including means for reducing the flow of the heat medium through the outlet tube, any refrigerant leaking into the tank is allowed to rise to the top of the tank before the heat medium with which it enters the tank reaches the outlet tube. By preference, the flow reduction means includes at least one fluid passage, the total cross-sectional area of which at least one passage

is smaller than the internal cross-sectional area of the outlet tube. In this way, the risk of passing refrigerant to any user-side element downstream of the outlet tube is substantially reduced.

[0010] In an embodiment, the flow reduction means is provided at the proximal end of the outlet tube. By preference, the flow reduction means is provided in an intermediary section of the outlet tube between its distal and proximal end. In this way the fluid passage for the heat medium is progressively narrowed, contributing to a more efficient separation of the gaseous refrigerant from the liquid heat medium.

[0011] In an embodiment, the flow reduction means includes a first plate having at least one hole, said hole being smaller than the inner diameter of the outlet tube. By preference, the aperture of the hole is adjustable, for example, by means of a smaller second plate with a hole identical to the hole of the first plate, said second plate being mounted eccentrically relative to the center of the first plate. In another example, the aperture of the hole of the first plate may be adjusted by means of a butterfly valve. In this way the flow of heat medium can be advantageously regulated as necessary.

[0012] In an embodiment, the first plate of the flow reduction means is equipped with a plurality of holes. In a further embodiment, a second identical plate is provided overlapping the first plate, said second plate being rotatable about the common center of both plates. In this way the flow of heat medium can be advantageously regulated as necessary. For example, if the refrigerant flow into the tank increases, the flow of heat medium can be reduced by rotating one of the plates so as to reduce the alignment of the holes of both plates. In another example, the holes of the plates may be aligned, causing the flow of heat medium to increase, should the volume of refrigerant leaked into the tank diminish or even cease.

[0013] In an embodiment, a heat medium outlet port is provided on the bottom of the tank. In this way, the heat medium outlet is located as far away from any source of leaked refrigerant as possible. Furthermore, by being located at the bottom of the tank, the outlet port is located directly opposite to the path and pooling volume of any leaked refrigerant. This advantageously makes it impossible for the any refrigerant to ingress into the outlet port and into any user-side elements connected to said port.

[0014] In an embodiment, the distal end of the outlet tube is connected to a heat medium outlet port, the proximal end of the outlet tube extending, preferably proximally, in the direction of the height of the tank. This configuration of the outlet tube advantageously permits extracting heat medium from the upper, warmer layer of heat medium inside the tank. By preference, the height of the proximal end of the outlet tube is lower than the height of the first outlet. In this way, ingress of any leaked refrigerant into the user side and any user heat exchangers is advantageously avoided. In an embodiment, the outlet tube may be telescopic and comprise at least two sections, the height of the heat medium outlet being au-

tomatically adjustable by means of a buoy in connection to the upper section of the outlet tube. Said connection being, for example a length of cable, a rod or chain, said length being longer than the distance of the first outlet to the top inner surface of the tank. In this way, the device is able to operate even if the tank is not completely full, while still keeping the heat medium outlet below the first outlet of the heat exchanger.

[0015] In an embodiment, the flow reduction means is oriented substantially concentric with the heat medium outlet tube and with the direction of the height of the tank. In this way, each fluid path of the flow reduction means is also oriented in a substantially vertical direction, thereby avoiding the occurrence of any substantial lateral acceleration in the heat fluid as it flows into and through the outlet tube. Lateral acceleration in fluids, such as water or oil, when said fluid flow through a passage are known in the art promote the formation of bubbles of some gaseous substance which may be in contact said fluid. By avoiding said lateral accelerations, leaked refrigerant is advantageously kept out of the outlet tube, and thus, the user side. In order to further control said lateral acceleration of the heat medium as it passes through the outlet tube, the inner walls of the outlet tube may be equipped with lengthwise grooves or helical grooves. The pitch of said grooves being preferably less than one turn per 0.4m, more preferably one turn per 0.6m, one turn per 0.8m, most preferably less than one turn per 1 meter.

[0016] In an embodiment, the internal heat exchanger is a double tube heat exchanger. By preference, the tubes of the double tube heat exchanger are substantially coaxial. In this way, the heat exchange between the refrigerant and the heat medium is advantageously made more uniform along the length of the heat exchanger. By preference, the inner tube of the heat exchanger is configured as a heat medium passage and the space between the inner and outer tube is configured as a refrigerant passage. In this way, both the heat medium inside the tank and the heat medium inside the heat exchanger are, advantageously, able to simultaneously exchange heat with the refrigerant flowing through the refrigerant passage of the heat exchanger.

[0017] In an embodiment, the double tube heat exchanger is formed in a spiral shape, wherein the central axis of the spiral extends in the height direction of the tank. In this way the heat exchanger advantageously has a larger heat exchange area, said heat exchange area being defined by both the inner and outer sides of the refrigerant passage. The larger heat exchange area permits more heat to be exchanged between the refrigerant and the heat medium before the refrigerant returns to the compressor side of the refrigerant circuit. Furthermore, the helical shape of the internal heat exchanger permits a more efficient use of the internal space of the tank, advantageously allowing, for example, for smaller tanks to be used.

[0018] In an embodiment, the outlet tube and the flow reduction means are oriented towards the bottom of the

tank, such that the heat medium flows downward in the outlet tube. This permits taking advantage of the difference in the densities of the refrigerant and the heat medium, as the lower density of the refrigerant gas will tend to rise in the heat medium. By having a vertical outlet tube, any traces of refrigerant gas will be allowed to leave the exiting heat medium as the latter travels down the outlet tube. This effect is further enhanced by the slowing of the heat medium outflow due to the perforated plate.

DESCRIPTION OF FIGURES

[0019] The following description of the figures of specific embodiments of the invention is merely exemplary in nature and is not intended to limit the present teachings, their application or uses. Throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

Figure 1 shows a section view of the gas-liquid separator equipped with a lateral heat medium outlet port.

Figure 2 shows a section view of the gas-liquid separator equipped with a bottom heat medium outlet port.

Figure 3 shows a complete coaxial heat exchanger.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The invention is further described by the following non-limiting examples which further illustrate the invention, and are not intended to, nor should they be interpreted to, limit the scope of the invention.

[0021] The present invention concerns a gas-liquid separator for a heat medium circulation system. The heat medium circulation system comprises of the gas-liquid separator, a pump, a controller that controls at least the pump and at least one usage-side heat exchanger like a radiator. The gas-liquid separator comprises a tank, a heat medium inlet, a heat medium outlet, an internal heat exchanger and an outlet tube. The tank is to receive and store the heat medium. The internal heat exchanger has a heat medium passage and an adjoining refrigerant passage, which is immersed in the heat medium in the tank and exchanges heat between a refrigerant flowing in the refrigerant passage and the heat medium flowing in the heat medium passage. The heat medium passage of the internal heat exchanger, the pump, the at least one usage-side heat exchanger are connected by heat medium pipes, and the heat medium circulates inside the heat medium pipes. The refrigerant passage of the internal heat exchanger, an expansion valve, a heat source-side heat exchanger and a compressor are connected by refrigerant pipes, and the refrigerant circulates inside the refrigerant pipes. In this embodiment, propane can be used as a refrigerant. Also, R32 refrigerant can be also

used. The heat medium inlet allows heat medium returning from a usage-side heat exchanger to flow into the tank. The heat medium outlet allows the heat medium inside the tank to flow out of the tank to the at least one usage-side heat exchanger. The gas-liquid separator includes the heat medium outlet equipped with the outlet tube leading to at least one user-side heat exchanger, which outlet tube is further equipped with flow reduction means. The flow reduction means permit delaying the ingress of heat medium into the heat medium outlet, which advantageously allows any refrigerant leaking into the tank to float to the upper most fraction of the inner volume of said tank. In this way, any refrigerant leaking into the tank is advantageously prevented from migrating to any user-side element along with the heat medium.

[0022] A first inlet of the internal heat exchanger is configured as an inlet of the heat medium passage and is connected to the heating medium inlet. A first outlet of the internal heat exchanger is configured as an outlet of the heat medium passage and is open inside the tank. The outlet tube has a proximal end and a distal end and is located inside the tank. The distal end of the outlet tube is connected to the heat medium outlet.

[0023] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present invention.

[0024] As used herein, the following terms have the following meanings:

"A", "an", and "the" as used herein refers to both singular and plural referents unless the context clearly dictates otherwise. By way of example, "a compartment" refers to one or more than one compartment.

"Comprise", "comprising", and "comprises" and "comprised of" as used herein are synonymous with "include", "including", "includes" or "contain", "containing", "contains" and are inclusive or open-ended terms that specifies the presence of what follows e.g., component and do not exclude or preclude the presence of additional, non-recited components, features, element, members, steps, known in the art or disclosed therein.

[0025] Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order, unless specified. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

[0026] The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within that range, as well as the recited endpoints.

[0027] Whereas the terms "one or more" or "at least one", such as one or more or at least one member(s) of a group of members, is clear per se, by means of further exemplification, the term encompasses inter alia a reference to any one of said members, or to any two or more of said members, such as, e.g., any ≥ 3 , ≥ 4 , ≥ 5 , ≥ 6 or ≥ 7 etc. of said members, and up to all said members.

[0028] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, definitions for the terms used in the description are included to better appreciate the teaching of the present invention. The terms or definitions used herein are provided solely to aid in the understanding of the invention.

[0029] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment, but may do so. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to a person skilled in the art from this disclosure, in one or more embodiments. Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination. With a goal illustrating better the properties of the invention the following presents, as an example and limiting in no way other potential applications, a description of a number of embodiments of the gas-liquid separator based on the invention, wherein:

[0030] FIG. 1 shows a section view of the gas-liquid separator (1) equipped with a lateral heat medium outlet port (10). The gas-liquid separator (1) includes a tank (2), which tank encloses a coaxial heat exchanger (3). The figure shows the heat exchanger (3) having an inner tube (12) placed inside an outer tube (13). The inner tube (12) defines a heat medium passage (5), while the space between the inner tube (12) and the outer tube (13) defines a refrigerant passage (6). A refrigerant inlet tube (14) near the proximal end of the heat exchanger (3), and refrigerant outlet tube (15) located near the distal end of the heat exchanger (3) provide fluid connection with a refrigerant circuit (not shown). An outlet tube (11) is shown connected to the lateral wall of the tank (2). The outlet tube (11) provides fluid connection between a heat

medium outlet (4) on the inside of the tank (2) and a heat medium outlet port (10). The figure shows a perforated plate (16) placed inside the outlet tube (11) before the heat medium outlet port (10). Leaking refrigerant gas coming out of the first outlet (9) gathers and is stored at the top of the inside of the tank (2), said leaked refrigerant gas following a trajectory (18) as shown in the figure. A pressure valve (17) on top of the tank (2) is pre-set to open and release refrigerant gas once the pressure inside the tank (2) reaches predetermined pressure limit, the pre-set pressure at which said valve (17) opens being the same or lower than said predetermined pressure limit. Alternatively or in a complimentary manner, a solenoid valve (not shown) may be provided to the top of the tank (2). A pressure sensor (not shown) may be provided to the top or sides of the tank (2) providing a controller (not shown) with information related to the pressure inside the tank (2), said controller comparing said information with a predetermined pressure limit. If the pressure inside the tank (2) meets or exceeds said pressure limit, the controller sends instructions related to the opening of the solenoid valve to said valve, causing refrigerant gas to be released.

[0031] FIG. 2 shows a section view of the gas-liquid separator (1) equipped with a bottom heat medium outlet port (10). The gas-liquid separator (1) includes a tank (2), which tank encloses a coaxial heat exchanger (3). The figure shows the heat exchanger (3) having an inner tube (12) placed inside an outer tube (13). The inner tube (12) defines a heat medium passage (5), while the space between the inner tube (12) and the outer tube (13) defines a refrigerant passage (6). A refrigerant inlet tube (14) near the proximal end of the heat exchanger (3), and refrigerant outlet tube (15) located near the distal end of the heat exchanger (3) provide fluid connection with a refrigerant circuit (not shown). An outlet tube (11) is shown connected to the bottom wall of the tank (2) and oriented in substantial alignment with the axis of the tank (2). The outlet tube (11) provides fluid connection between a heat medium outlet (4) on the inside of the tank (2) and a heat medium outlet port (10), said heat medium outlet (4) having a larger diameter than the heat medium outlet port (10). The figure shows the heat medium outlet (4) placed at a height lower than that of the first outlet of the heat exchanger (3). The figure also shows a perforated plate (16) inside the outlet tube (11). Leaking refrigerant gas coming out of the first outlet (9) gathers and is stored at the top of the inside of the tank (2), said leaked refrigerant gas following a trajectory (18) as shown in the figure. A pressure valve (17) on top of the tank (2) is pre-set to open and release refrigerant gas once the pressure inside the tank (2) reaches predetermined pressure limit, the pre-set pressure at which said valve (17) opens being the same or lower than said predetermined pressure limit. Alternatively or in a complimentary manner, a solenoid valve (not shown) may be provided to the top of the tank (2). A pressure sensor (not shown) may be provided to the top or sides of the tank (2) providing a controller (not

shown) with information related to the pressure inside the tank (2), said controller comparing said information with a predetermined pressure limit. If the pressure inside the tank (2) meets or exceeds said pressure limit, the controller sends instructions related to the opening of the solenoid valve to said valve, causing refrigerant gas to be released.

[0032] FIG. 3 shows the coaxial heat exchanger (3). The figure shows the heat exchanger (3) of FIG. 1-2 in more detail. A first inlet (7) of the heat exchanger (3) is shown. This first inlet (7) extends out of the tank (2, not shown), in order to accept heat medium and pass it to the heat medium passage (5) of the heat exchanger (3). The heat medium leaves the heat exchanger and enters the tank (2) via the first outlet (9).

List of numbered items:

[0033]

- 1 gas-liquid separator
- 2 tank
- 3 coaxial heat-exchanger
- 4 heat medium outlet
- 5 heat medium passage
- 6 refrigerant passage
- 7 first inlet
- 8 heat medium inlet
- 9 first outlet
- 10 heat medium outlet port
- 11 outlet tube
- 12 inner tube
- 13 outer tube
- 14 refrigerant inlet tube
- 15 refrigerant outlet tube
- 16 perforated plate
- 17 pressure valve
- 18 trajectory of refrigerant gas leaking from the first outlet

[0034] The present invention is in no way limited to the embodiments shown in the figures. On the contrary, methods according to the present invention may be realized in many different ways without departing from the scope of the invention.

Claims

1. A gas-liquid separator for a heat medium circulation system, comprising;

a tank to receive and store the heat medium,
a heat medium inlet that allows the heat medium returning from a usage-side heat exchanger to flow into the tank,
a heat medium outlet that allows the heat medium inside the tank to flow out of the tank to the

usage-side heat exchanger,
an internal heat exchanger having a heat medium passage and an adjoining refrigerant passage, which is immersed in the heat medium in the tank and exchanges heat between a refrigerant flowing in the refrigerant passage and the heat medium flowing in the heat medium passage,

a first inlet of the internal heat exchanger configured as an inlet of the heat medium passage, the first inlet being connected to the heating medium inlet;

a first outlet of the internal heat exchanger configured as an outlet of the heat medium passage, the first outlet being open inside the tank; and
an outlet tube having a proximal end and a distal end, the outlet tube being located inside the tank, the distal end of the outlet tube connected to the heat medium outlet;

characterized in that, the outlet tube comprises flow reduction means configured for reducing the flow velocity of the heat medium through the outlet tube.

2. The gas-liquid separator according to claim 1, **characterized in that**, the flow reduction means is provided at the proximal end of the outlet tube.
3. The gas-liquid separator according to claim 1, **characterized in that**, the flow reduction means is provided in an intermediary section of the outlet tube between the distal and proximal end.
4. The gas-liquid separator according to any one of the claims 1-3, **characterized in that**, the flow reduction means includes a first plate having at least one hole, said hole being smaller than the inner diameter of the outlet tube.
5. The gas-liquid separator according to claim 4, **characterized in that**, the first plate of the flow reduction means is equipped with a plurality of holes.
6. The gas-liquid separator according to previous claims 1-5, **characterized in that**, a heat medium outlet port is provided on the bottom of the tank.
7. The gas-liquid separator according to previous claims 1-6, **characterized in that**, the distal end of the outlet tube is connected to a heat medium outlet port, the proximal end of the outlet tube extending in the direction of the height of the tank.
8. The gas-liquid separator according to previous claim 6, **characterized in that**, the flow reduction means is oriented concentric with the heat medium outlet tube and with the direction of the height of the tank.

9. The gas-liquid separator according to any one of the previous claims, **characterized in that**, the internal heat exchanger is a double tube heat exchanger with the heat medium passage in which the heat medium flows and the refrigerant passage in which the refrigerant flows defining the tubes of the double tube heat exchanger. 5
10. The gas-liquid separator according to claim 9, **characterized in that**, the tubes of the double tube heat exchangers are coaxial. 10
11. The gas-liquid separator according to any one of the claims 9-10, **characterized in that**, the double tube heat exchanger is formed in a spiral shape, wherein the central axis of the spiral extends in the height direction of the tank. 15
12. The gas-liquid separator according to any one of the claims 1 to 11, wherein the outlet tube and the flow reduction means are oriented towards the bottom of the tank, such that the heat medium flows downward in the outlet tube. 20

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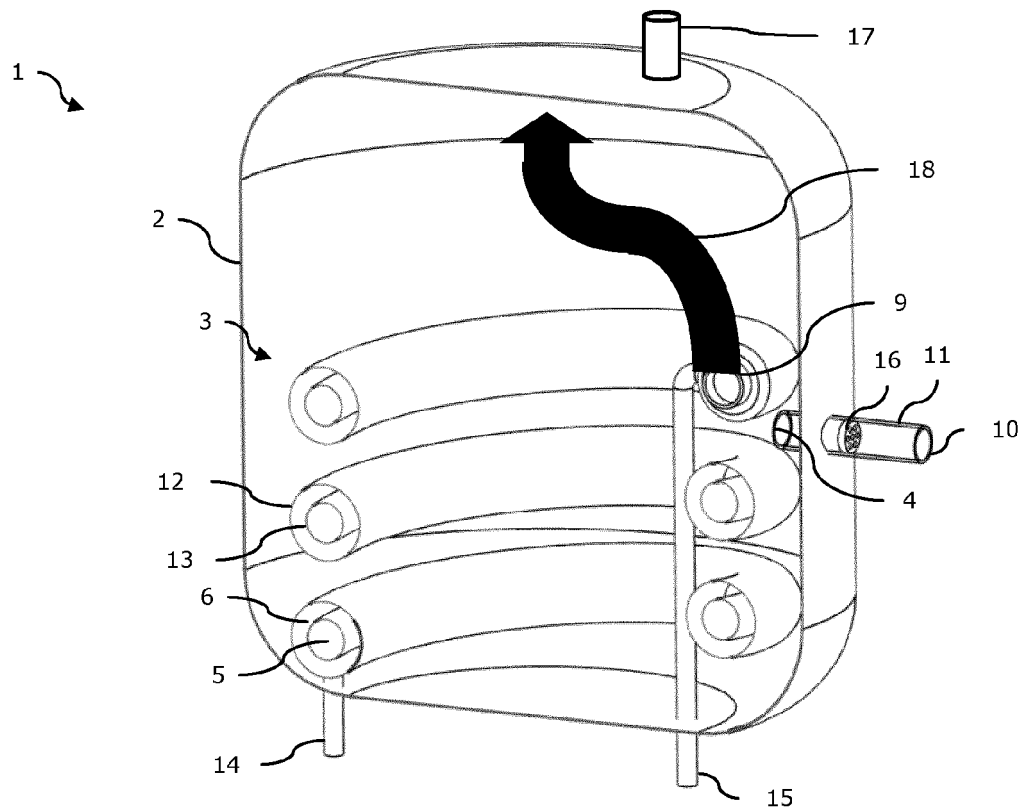


FIG. 1

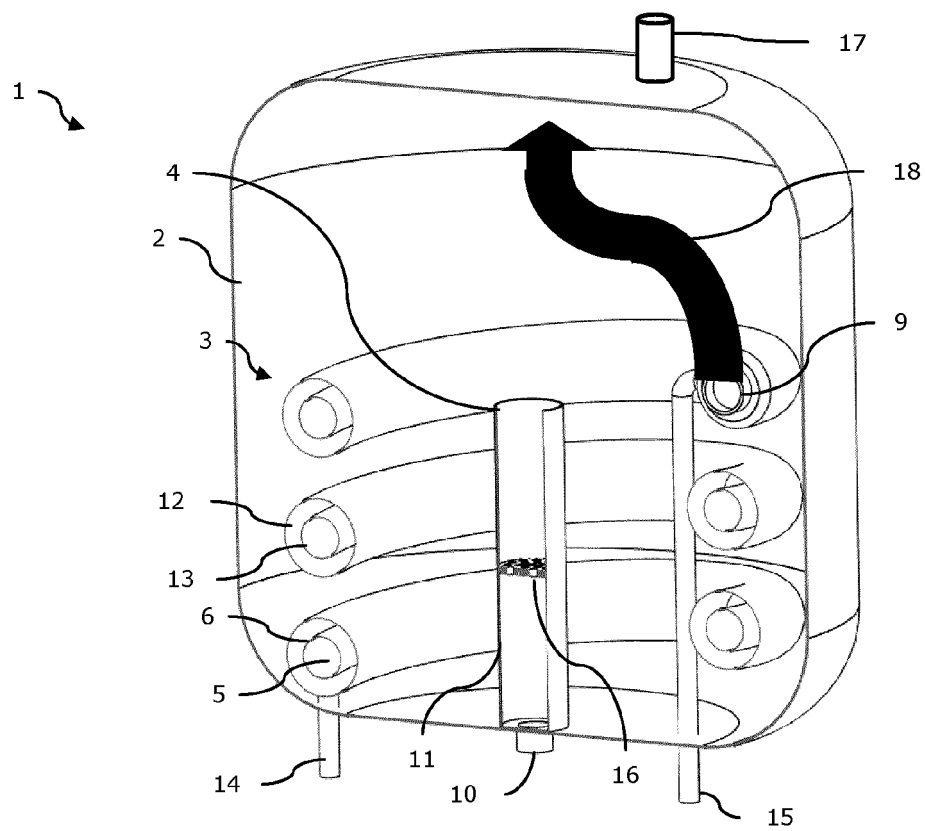


FIG. 2

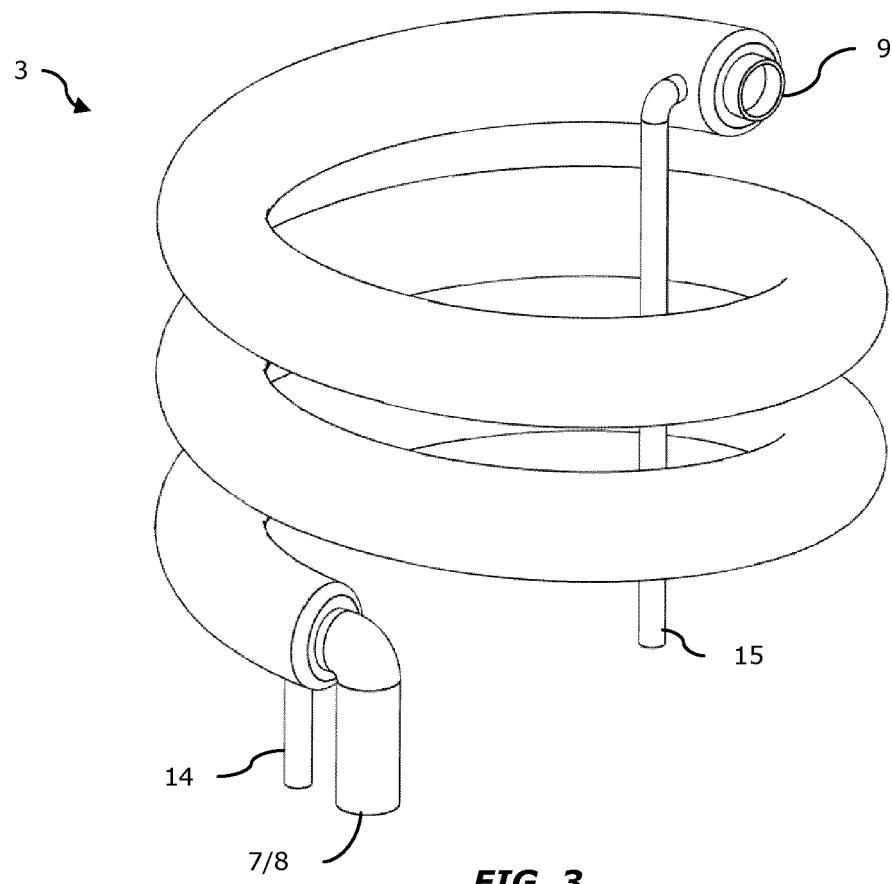


FIG. 3



EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C01)

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The present search report has been drawn up for all claims			
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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	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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