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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.

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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 coolant e.g. water, and a coolant inlet equipped at a lower part of the reservoir. A coolant 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 coolant. An inner tube of the pipe is connected to the 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 coolant. 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 coolant fluid. The reservoir is equipped with a coolant fluid inlet arranged in a lower part of the reservoir and an outlet of a coolant fluid arranged in an upper part. An exchanger with coaxial tubes is arranged inside the reservoir, and is immersed in the fluid. An inner tube is connected to the 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 heat medium circulation system according to claim 1.

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

a container that comprises a container main body to receive and store the heat medium;
a heat medium inlet that is located below the container main body and allows the heat medium to return from a usage-side heat exchanger to flow into the container main body;
a heat medium outlet that is located in the upper half of above in the container main body and allows the heat medium to flow out of the container main body to the usage-side heat exchanger; and
an internal heat exchanger having a heat medium passage and an adjoining refrigerant passage, said internal heat exchanger being immersed in the heat medium inside the container main body and permitting exchange of heat between a refrigerant flowing in the refrigerant passage and the heat medium flowing in the heat medium passage, a distal end of the heat medium passage opening into the space inside the container main body.

[0009] The container is further provided with a container subpart at the upper part of the container main body and be in fluid communication with the internal space of the container main body. The container subpart has a width smaller than the width of the container main body, when the gas-liquid separator is viewed from above. By preference, the internal volume of the container subpart is up to 5% of the volume of the container. More preferably, the internal volume of the container subpart is up to 10%, 15%, 20%, most preferably, 25% of the volume of the container. 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 container along with the heat medium via the first outlet will naturally have the tendency to separate from said heat medium and float upwards and pool over the heat medium. By having a container subpart on the top part of the container, any leaked refrigerant will tend to pool and be retained inside the internal volume of said subpart. In this way, the risk of any refrigerant flowing out of the container and into any usage-side heat exchanger is very

nearly removed. By preference, the refrigerant passage of the internal heat exchanger is part of a refrigerant circuit including at least one compressor for compressing said refrigerant.

[0010] In a further embodiment, the container main body and the container subpart are formed with a cylindrical shape, wherein both of the cylindrical central axes are common. The cylindrical shape and its subpart, as well as their substantial concentricity advantageously allow for easier manufacturing. This configuration is particularly efficient in capturing any leaked refrigerant when the distal end of the heat medium of the heat exchanger is located near the axis of the container subpart.

[0011] In an embodiment, the container main body and the container subpart are formed with a cylindrical shape, wherein both of the cylindrical central axes are offset. The cylindrical shape and its subpart, advantageously allow for easier manufacturing. This configuration is particularly efficient in capturing any leaked refrigerant when the distal end of the heat medium of the heat exchanger is located near the central axis of the container subpart. By preference, the minimal distance between the distal end of the heat medium passage and the central axis of the container subpart is smaller than the minimal distance between the heat medium outlet and the central axis of the container subpart, when the gas-liquid separator is viewed from above. More preferably, the heat medium outlet is located near a container wall and diametrically opposite to the container subpart. In this way, the heat medium outlet is advantageously distanced from any refrigerant coming from either the container subpart or the distal end of the heat medium passage of the heat exchanger, thereby eliminating the risk of refrigerant entering the heat medium outlet.

[0012] In an embodiment, 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. 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 container 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.

[0013] In an embodiment, the double tube heat exchanger is formed in a spiral or helical shape, wherein the central axis of the helix or spiral extends in the height direction of the gas-liquid separator. 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 larg-

er 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 or spiral shape of the internal heat exchanger permits a more efficient use of the internal space of the container, advantageously allowing, for example, for smaller containers to be used.

[0014] In an embodiment, the distal end of the heat medium passage of the heat exchanger is located adjacent and is oriented tangential to a wall of the container main body. By preference, the spiral or helical shape of the heat exchanger includes at least two turns, the last of which turns includes the distal end of the heat medium passage of the heat exchanger, the distal end of the heat medium passage being located at least 10mm farther from the axis of the spiral or helix than each preceding turn. In this way, heat medium leaving the heat exchanger is advantageously ejected near the inner lateral walls of the container and in a direction that is substantially tangential to said walls. By locating the distal end of the heat medium passage of the heat exchanger farther from the axis of the spiral or helical heat exchanger, a gap between all but part of the last coil of heat exchanger and the inner walls of the container is left. By virtue of the contact of the heat medium in the container and the outer tube of the spiral or helical heat exchanger, convection currents are created around the heat exchanger. These convection currents, advantageously push the heat medium introduced via distal end of the heat medium passage of the heat exchanger upwards and along the inner walls of the container. In this way, the rise of any leaked refrigerant to the internal volume of the container subpart and away from the heat medium outlet is advantageously accelerated. By preference, the heat medium outlet is located in substantial overlap with the cylindrical axis of the container main body. In this way, the heat medium outlet is shielded by the convection current around the inner and outer perimeter of the heat exchanger which force any leaked refrigerant upwards and away from said outlet. This advantageously makes it impossible for any refrigerant to leave the container via the heat medium outlet.

DESCRIPTION OF FIGURES

[0015] 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 heat medium outlet port on the side.

Figure 2 shows a section view of the gas-liquid sep-

arator equipped with a heat medium outlet port on the side.

Figure 3 shows a double tube heat exchanger having an extended first outlet.

Figure 4 shows a top section view of the gas-liquid separator equipped with the double tube heat exchanger having an extended first outlet.

DETAILED DESCRIPTION OF THE INVENTION

[0016] 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.

[0017] The present invention concerns 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 a usage-side heat exchanger like a radiator. The gas-liquid separator includes a container with an internal heat exchanger for exchanging heat between a heat medium and a refrigerant, the passages for each of these fluids being both inside the container and immersed in heat medium. The heat medium passage of the internal heat exchanger, the pump and the 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 passage includes a first outlet in fluid communication with the internal volume of the container. The container is provided with a container subpart connected to the top of said container. The internal volume of the container subpart is provided in fluid communication with the internal volume of the container. The location of the container subpart above the heat medium outlet allows for superior liquid gas separation, as any refrigerant leaking into the container quickly returns to a gaseous state and floats to the top of the internal volume of the container and into the internal volume of the container subpart. The smaller width of the container subpart in combination with the low buoyancy of the refrigerant contribute to trap the latter and prevent it from leaving the container to any user-side elements.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within that range, as well as the recited endpoints.

[0022] 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.

[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, 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.

[0024] 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. 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. Further-

more, 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.

[0025] With as 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:

FIG. 1 shows a section view of the gas-liquid separator (1) equipped with a heat medium outlet port (10) on the side. The gas-liquid separator (1) includes a container (2), which container encloses a double tube heat exchanger (3). The tubes of the double tube heat exchanger (3) are coaxial. Also the container (2) comprises a container main body (17) and a container subpart (16) at the upper part of the container main body (17) and be in fluid communication with the internal space of the container main body. The container main body (17) and the container subpart (16) are formed with a cylindrical shape, wherein both of the cylindrical central axes are common. 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 disposed to the lateral wall of the container (2). The outlet tube (11) provides fluid connection between a heat medium outlet (4) on the inside of the container (2) and a heat medium outlet port (10). The figure, shows the heat medium outlet (4) placed at a height lower than that of a first outlet (9) (equivalent to the "distal end of the heat medium passage" as used in this document, for instance in the claims) of the heat exchanger. But, the heat medium outlet (4) may be placed at a height higher than that of the first outlet (9) of the heat exchanger. The figure shows the trajectory of any leaked refrigerant in a gaseous state (19) leaked through the first outlet (9). An over-pressure valve (18) is shown on top of the container (2), said over-pressure valve (16) being in fluid communication with the inside of the container (2). The valve (18) is configured to open automatically if the pressure inside the container (2) exceeds a predetermined safety threshold (e.g. 60% of the failure pressure of the container). The valve (18) may be a mechanical or an electro-mechanical valve,

preferably a solenoid valve assembly equipped with a pressure indicator and a controller. The pressure indicator being configured to send a signal with information related to the pressure inside the container (2) to the controller, and the controller being configured to compare the signal received from the pressure indicator with a pre-set safety pressure. The controller is configured to send a signal to the solenoid valve if the pressure inside the container (2) exceeds said pre-set safety pressure, the signal containing instructions to cause the solenoid valve to open and to control the aperture of said valve.

FIG. 2 shows a section view of the gas-liquid separator (1) equipped with the heat medium outlet port (10) on the bottom. The gas-liquid separator (1) includes a container (2), which container encloses a double tube heat exchanger (3) and includes a container subpart (16) in substantial alignment with the axial direction of the container (2). 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). The inner tube (12) and the outer tube (13) are coaxial. 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). A first inlet (7) of the heat exchanger (3) is shown extending out of the container (2), in this way enabling the ingress of heat medium to the heat medium passage (5) of the heat exchanger (3) and into the container (2) via the first outlet (9) of the heat exchanger. An outlet tube (11) is shown disposed to the bottom wall of the container (2) and oriented in substantial alignment with the axis of the container (2). The outlet tube (11) provides fluid connection between a heat medium outlet (4) on the inside of the container (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). But the heat medium outlet (4) may be placed at a height higher than that of the first outlet (9) of the heat exchanger. The figure shows the trajectory of any leaked refrigerant in a gaseous state (19) leaked through the first outlet (9). An over-pressure valve (18) is shown on top of the container (2), said over-pressure valve (16) being in fluid communication with the inside of the container (2). The valve (18) is configured to open automatically if the pressure inside the container (2) exceeds a predetermined safety threshold (e.g., 60% of the failure pressure of the container). The valve (18) may be a mechanical or an electro-mechanical valve, preferably a solenoid valve assembly

equipped with a pressure indicator and a controller. The pressure indicator being configured to send a signal with information related to the pressure inside the container (2) to the controller, and the controller being configured to compare the signal received from the pressure indicator with a pre-set safety pressure. The controller is configured to send a signal to the solenoid valve if the pressure inside the container (2) exceeds said pre-set safety pressure, the signal containing instructions to cause the solenoid valve to open and to control the aperture of said valve.

FIG. 3 shows a double tube heat exchanger (3) having an extended first outlet (9). The shown heat exchanger (3) shares an almost identical construction to those of the embodiments shown in FIG. 1-2, differing only in the longer first outlet (9). The features of this embodiment of the heat exchanger (3) are better appreciated in FIG. 4.

FIG. 4 shows a top section view of the gas-liquid separator (1) equipped with the double tube heat exchanger (3) having an extended first outlet (9). The figure shows the distal end of the first outlet (9) converging towards the wall of the container (2) and away from the axis of the heat exchanger (3) until the axis of the extended first outlet (9) is tangential with the walls of the container (2). The figure shows the container main body (17) and the container subpart (16) are formed with a cylindrical shape, wherein both of the cylindrical central axes are common. The figure shows the heat medium outlet (4) is located in substantial overlap with the cylindrical axis of the container main body (17).

FIG. 5 shows a top section view of the gas-liquid separator (1) equipped with the double tube heat exchanger (3) having an extended first outlet (9). The figure shows the distal end of the first outlet (9) converging towards the wall of the container (2) and away from the axis of the heat exchanger (3) until the axis of the extended first outlet (9) is tangential with the walls of the container (2). The figure shows the container main body (17) and the container subpart (16) are formed with a cylindrical shape, wherein both of the cylindrical central axes (20, 21) are offset. The figure shows the heat medium outlet (4) is located laterally on the container main body (17). The minimal distance (d1) between the distal end of the first outlet (9) and the central axis of the container subpart (20) is smaller than the minimal distance (d2) between the heat medium outlet (4) and the central axis of the container subpart (20).

List of numbered items:

[0026]

- | | |
|----|---|
| 1 | gas-liquid separator |
| 2 | container |
| 3 | double tube 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 | container subpart |
| 17 | container main body |
| 18 | over-pressure valve |
| 19 | trajectory of refrigerant gas leaking from the first outlet |
| 20 | axis of container subpart |
| 21 | axis of container main body |
| d1 | distance between the central axis of the container subpart and the distal end of the first outlet |
| 25 | d2 distance between the central axis of the container subpart and the heat medium outlet |

[0027] 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.

35 Claims

1. A gas-liquid separator for heat medium circulation system comprising;
 - a container that comprises a container main body to receive and store the heat medium;
 - a heat medium inlet that is located below the container main body and allows the heat medium to return from a usage-side heat exchanger to flow into the container main body;
 - a heat medium outlet that is located in the upper half of the container main body and allows the heat medium to flow out of the container main body to the usage-side heat exchanger; and
 - an internal heat exchanger having a heat medium passage and an adjoining refrigerant passage, said internal heat exchanger being immersed in the heat medium inside the container main body and permitting exchange of heat between a refrigerant flowing in the refrigerant passage and the heat medium flowing in the heat medium passage, a distal end of the heat medium passage opening inside the container main

body;

characterized in that, the container comprises a container subpart at the upper side of the container main body, and in fluid communication with the internal space of the container main body, wherein the container subpart has a width smaller than the width of the container main body.

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2. The device according to claim 1, **characterized in that**, the container main body and the container subpart are formed with a cylindrical shape, wherein both of the cylindrical central axes are common.

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3. The device according to claim 1, **characterized in that**, the container main body and the container subpart are formed with a cylindrical shape, wherein both of the cylindrical central axes are offset.

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4. The device according to claim 3, **characterized in that**, the minimal distance between the distal end of the heat medium passage and the central axis of the container subpart is smaller than the minimal distance between the heat medium outlet and the central axis of the container subpart.

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5. The device according to any one of the claims 1-4, **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.

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6. The device according to claim 5, **characterized in that**, the tubes of the double tube heat exchanger are coaxial.

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7. The device according to any one of the claims 5-6, **characterized in that**, the double tube heat exchanger is formed in a spiral or helical shape, wherein the central axis of the spiral or helical extends in the height direction of the gas-liquid separator.

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8. The device according to any of the previous claims 5-7, **characterized in that**, the distal end of the heat medium passage of the heat exchanger is located adjacent and is oriented tangential to a wall of the container main body.

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9. The device according to any of the claim 7 or 8, **characterized in that**, the spiral or helical shape of the heat exchanger includes at least two turns, the last of which turns includes the distal end of the heat medium passage of the heat exchanger, the distal end of the heat medium passage being located at least 10mm farther from the axis of the spiral or helix than each preceding turn.

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10. The device according to any of the preceding claims 5-7, **characterized in that**, the heat medium outlet is located in overlap with the cylindrical axis of the container main body.

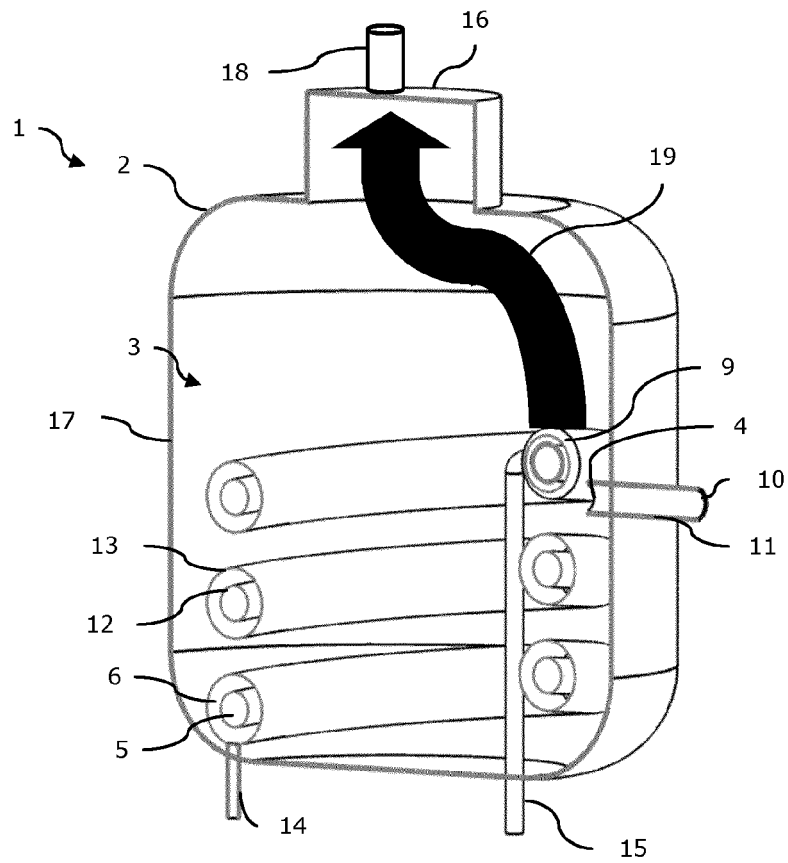


FIG. 1

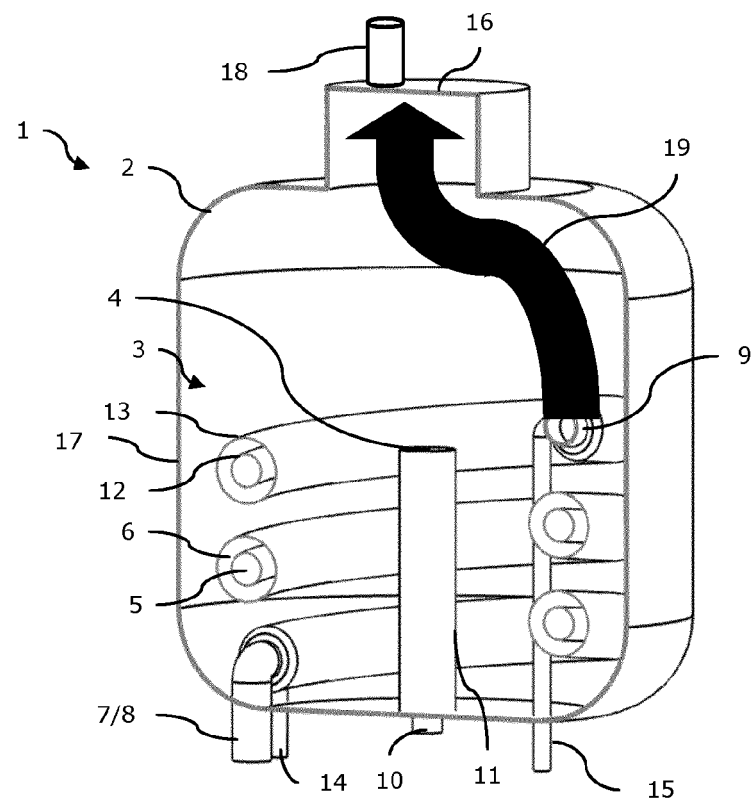


FIG. 2

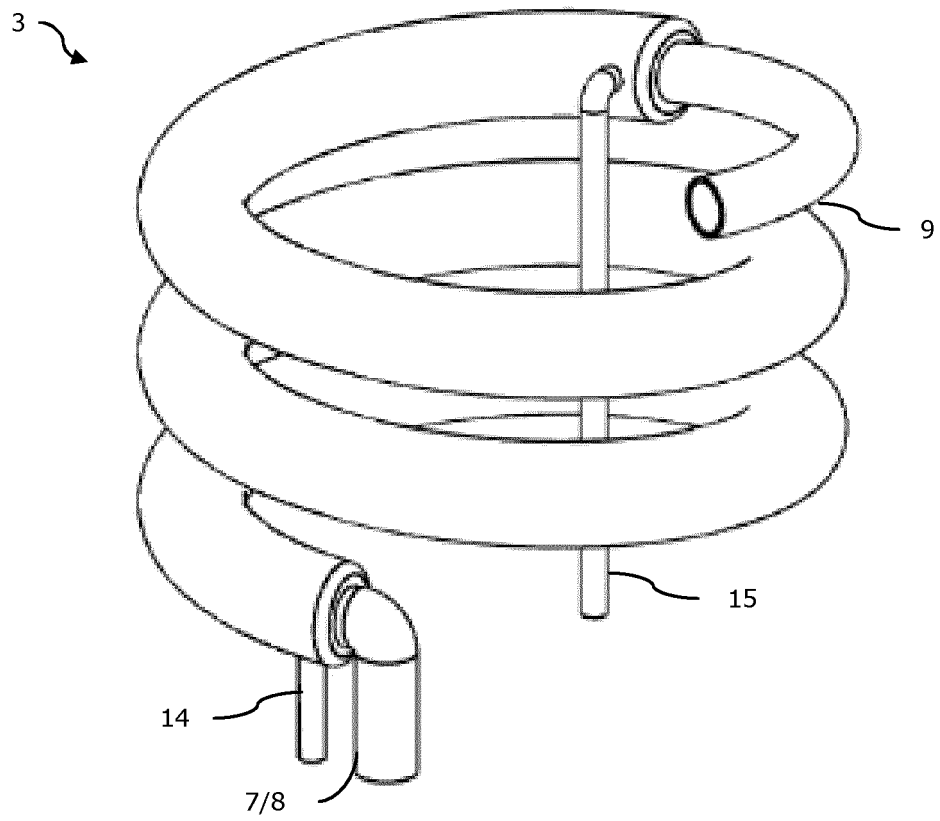


FIG. 3

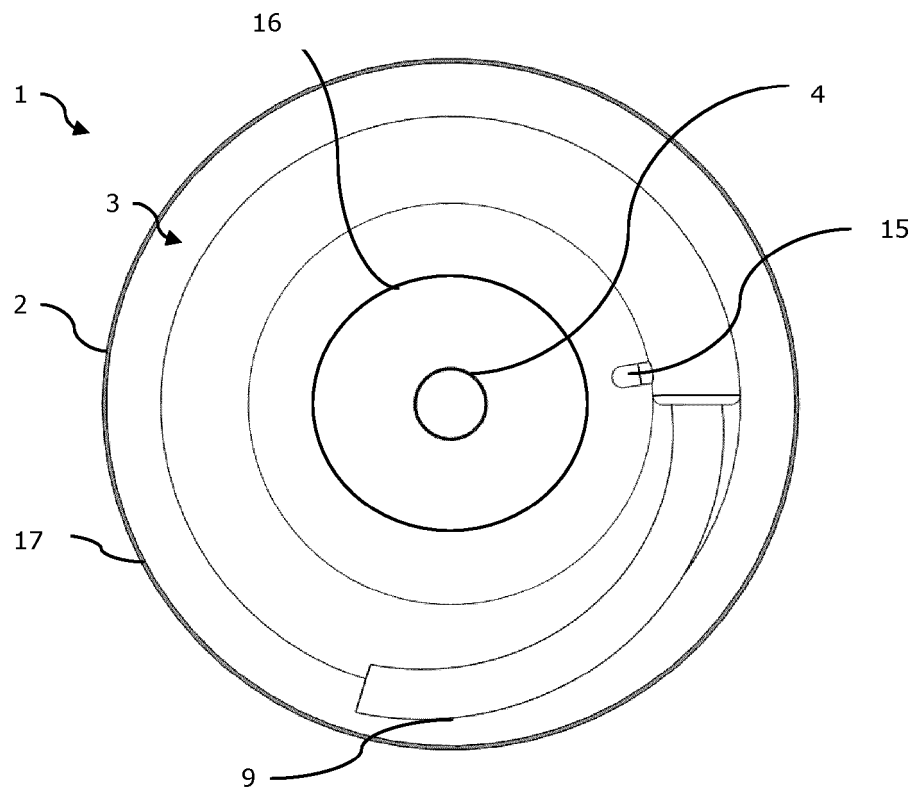


FIG. 4

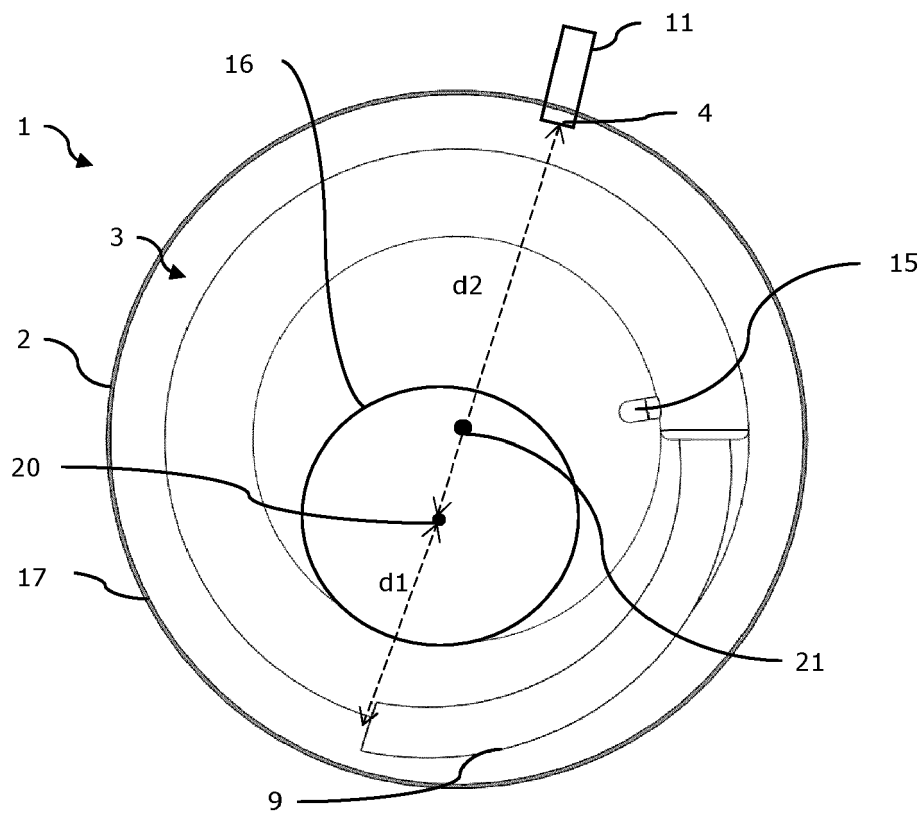


FIG. 5



EUROPEAN SEARCH REPORT

Application Number

EP 23 16 9623

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
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			F24D F24H F28D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 October 2023	Examiner Hoffmann, Stéphanie
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
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 9623

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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