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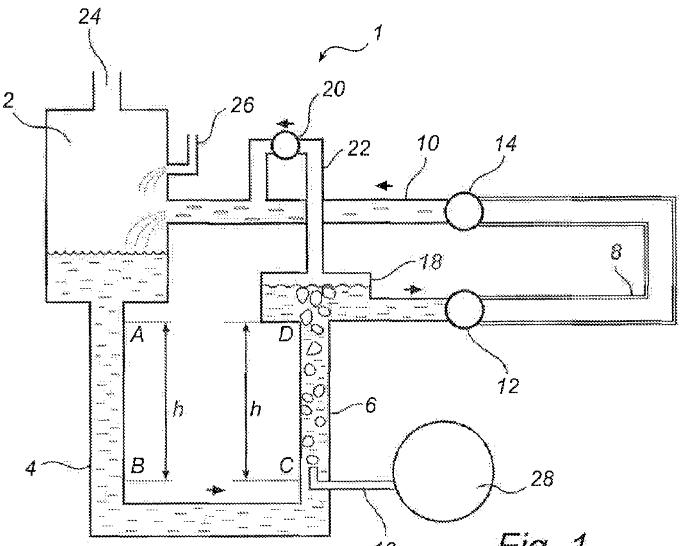

Fig. 1

(57) Abstract: The disclosure relates to a refrigerant device and a method for providing additional head to support a refrigeration liquid feed system. The refrigerating device comprises a refrigerant liquid container (2), a sinking conduit(4) and a rising conduit (6), the sinking conduit (4) extending downwardly to a connection with the rising conduit(6), the rising conduit (6) extending upwardly from the connection with the sinking conduit (4). The refrigerating device further comprises an evaporator(8) having an inlet (12) connected downstream to the rising conduit (6) and an outlet (14) connected to the refrigerant liquid container (2) via a return conduit (10), and a gas injector (16) connected to the rising conduit (6), adapted to supply gas in order to allow gas to rise together with liquid refrigerant in the rising conduit (6) thereby reducing the total density of the mixture of liquid refrigerant and gas relative the density of liquid refrigerant.

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DEVICE AND METHOD FOR PROVIDING ADDITIONAL HEAD TO SUPPORT A REFRIGERATION LIQUID FEED SYSTEM

Field of invention

The present invention relates to a refrigerant device and a method for providing additional head to support a refrigeration liquid feed system.

Technical Background

The pressure drop across the refrigerant side of evaporators in refrigeration systems vary due to physical design, operating conditions, refrigerant feed rate and refrigerant type.

When feeding refrigerant liquid from a low volume system or from gravity feed vessels the available liquid head provide liquid pressure to drive the refrigerant through the refrigerant loops of the evaporator.

The head provided is sometimes not high enough to drive sufficient amounts of refrigerant through the evaporator loops for different reasons such as the evaporator loop length is too long, heat load is too high, evaporation temperature is too low or the pipe diameter of the loops is too small. The available head may be limited for different reasons such as limited height above the evaporator or that flow restriction in the refrigerant pipes which connects to the evaporator may be too high. Too low refrigerant flow to an evaporator will significantly reduce its efficiency.

In JP03211381 a thermo siphon is described. In the thermo siphon the refrigerant is self-circulating by using density differences in a rising pipe and a falling pipe. The refrigerant liquid is heated by a heater which is energized to operate a vapor pump, the vaporized working fluid is sucked from the outlet side of an evaporator through a bypass, supplied to a nozzle of an air-lift pump and discharged from the tip of the nozzle into the rising pipe. The discharged vapor working fluid is turned into bubbles and flows up along the rising pipe. As a result, the working fluid containing the bubbles flows into the evaporator due to the density difference between the liquid working fluid on one hand and the bubble containing working fluid on the other hand and a rising stream caused by rising of the bubbles, vaporizes by absorbing heat from the surroundings at the evaporator, flows down along a falling pipe to a condenser where it gives off heat to the surroundings and liquefies.

In JP59094444 a natural circulation type boiling cooler is described. The cooler comprises an enclosed circulating circuit comprising a rising tube and a sinking tube. The refrigerant liquid is heated above boiling temperature by a heater in order to produce bubbles. Due to the production of the bubbles a density difference occurs between the two phase refrigerant gas liquid mixture in the rising tube and the one phase refrigerant liquid in the sinking tube. Due to the density difference the refrigerant liquid is circulated in the enclosed circulating circuit. The flow of the two phase refrigerant gas liquid mixture is guided to and cooled by a heat sink section in order to cool down the two phase refrigerant gas liquid mixture into one phase refrigerant liquid.

Summary of the invention

An object of the present invention is to provide additional head to support any refrigeration liquid feed system.

The above object is achieved by the refrigerating device and method according to the independent claims.

A refrigerating device is provided. The refrigerating device comprises a refrigerant liquid container, a sinking conduit and a rising conduit, the sinking conduit extending downwardly to a connection with the rising conduit, the rising conduit extending upwardly from the connection with the sinking conduit. The refrigerating device further comprises an evaporator having an inlet connected downstream to the rising conduit and an outlet connected to the refrigerant liquid container via a return conduit. In addition, the refrigerating device comprises a gas injector connected to the rising conduit. The gas injector being adapted to supply gas in order to allow gas to rise together with liquid refrigerant in the rising conduit thereby reducing the total density of the mixture of liquid refrigerant and gas relative the density of liquid refrigerant.

By means of the refrigerating device it is possible to provide additional head to support any refrigeration liquid feed system. During operation a flow of refrigerant liquid is conducted from the refrigerant liquid container via the sinking conduit, the rising conduit, the evaporator and the return conduit back to the refrigerant liquid container. Due to the density of the refrigerant liquid and the gravity a liquid pressure is created in the refrigerant liquid container and the sinking conduit in proportion to the depth below the refrigerant liquid level. The pressure in one point is proportional to the height of refrigerant liquid above it and the density of the refrigerant liquid. The gas injector is adapted to supply gas to the rising conduit. The gas is supplied in order to allow gas to rise together with the refrigerant in the rising conduit and thereby reducing the total density of the mixture of refrigerant and gas relative the density of refrigerant. Thus, the pressure at any given point in the rising conduit, at least above the point where the gas is injected via the gas injector, is higher than in the corresponding point at the same height of the sinking conduit. Alternatively, the liquid height in the rising conduit is higher than in the sinking conduit to provide the same pressure. Thus, the head in the refrigeration liquid feed system is increased.

The refrigerating device may also comprise a gas liquid separator arranged downstream the rising conduit and upstream the evaporator. The gas liquid separator arranged downstream the rising conduit and upstream the evaporator separates the gas and the liquid. The liquid flow is directed to the inlet of the evaporator whereas the gas is directed to a gas purge conduit. Thus, the gas liquid separator ensures that only liquid or at least only a limited amount of vapor is directed to the evaporator. By only directing liquid to the evaporator the efficiency of the evaporator is increased compared with supplying the evaporator with a mixture of liquid and gas.

The refrigerating device may also comprise a pressure regulating device connected to the gas liquid separator. The pressure regulating device allows flow of gas from the gas liquid separator. Further the pressure regulating device regulates the pressure in the gas liquid separator.

The gas from the gas liquid separator may be recirculated to the refrigerant liquid container either directly or via the return conduit. By recirculating the gas the gas may be reused.

The gas from the gas liquid separator may be recirculated to the gas injector. By recirculating the gas the gas may be reused.

A gas vent may be connected to the gas liquid separator. The gas may be recirculated via a gas vent. The gas vented via the gas vent may also be released to the surroundings.

Further the refrigerant liquid container may comprise a gas vent. The gas may then be recirculated via the gas vent. The gas vented via the gas vent may also be released to the surroundings.

The gas supplied by the gas injector may be pressurized. The supplied gas may be pressurized by an internal or external compressor. The compressed gas may have a higher pressure than the pressure in the rising conduit. By supplying gas having a higher pressure than the pressure in the rising conduit the risk for liquid passing into the gas injector is reduced.

The gas may be refrigerant vapor. By using refrigerant vapor no alien substance is added to the refrigerant.

The gas may be air. By using air a simple device is achieved.

A method for circulating a refrigerant liquid in a refrigerating device is also provided. The method comprises conducting a flow of refrigerant liquid from a refrigerant liquid container via a sinking conduit, a rising conduit, an evaporator and a return conduit back to the refrigerant liquid container, and supplying gas via a gas injector connected to the rising conduit in order to allow gas to rise together with refrigerant liquid in the rising conduit thereby reducing the total density of the mixture of refrigerant liquid and gas relative the density of refrigerant liquid.

The method may further comprise separating the supplied gas from the refrigerant liquid at a gas liquid separator located downstream to the evaporator.

The method may further comprise regulating the pressure in the gas liquid separator by means of a pressure regulating device.

The method may further comprise recirculating the gas from the pressure regulating device to the return conduit or to the refrigerant liquid container.

The method may further comprise pressurizing the gas before supplying the gas via the gas injector.

The supplied gas may be refrigerant vapor.

The method may further comprise venting refrigerant vapor from the liquid refrigerant container and supplying the vented refrigerant vapor to the gas injector.

A further scope of applicability of the present invention will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Brief description of the drawings

The invention will by way of example be described in more detail with reference to the appended schematic drawing, which shows presently preferred embodiments of the invention.

Figure 1 illustrates a refrigerating device according to an embodiment of the invention.

Figure 2 illustrates a refrigerating device according to an embodiment of the invention.

Figure 3 illustrates a refrigerating device according to an embodiment of the invention.

Figure 4 illustrates a refrigerating device according to an embodiment of the invention.

Detailed description of preferred embodiments

The present invention relates to a refrigerant device and a method for providing additional head to support a refrigeration liquid feed system. The refrigeration liquid feed system may be a low volume system or a gravity feed system. It should also be mentioned that the invention also can provide additional head to support a pump feed system, as well as be used on its own to pump refrigerant liquid or any liquid.

Figure 1, to which reference is made, illustrates a refrigerating device 1 according to one embodiment of the invention. The refrigerating device 1 comprises a refrigerant liquid container 2, a sinking conduit 4, a rising conduit 6, an evaporator 8 and a return conduit 10. The sinking conduit 4 is extending downwardly from the refrigerant liquid container 2 to a connection with the rising conduit 6. The sinking conduit 4 may be positioned vertically or sloped or a combination of these positions. The sinking conduit 4 may even have horizontal sections. Further, the sinking conduit 4 is connected to the refrigerant liquid container 2 below the surface of the refrigerant liquid in the refrigerant liquid container 2. The rising conduit 6 is extending upwardly from the connection with the sinking conduit 4. The rising conduit 6 may be positioned vertically or sloped or a combination of these positions. The rising conduit 6 may even have horizontal sections. The evaporator 8 has an inlet 12 connected downstream to the rising conduit 6 and an outlet 14 connected to the refrigerant liquid container 2 via the return conduit 10. The return conduit 10 may be positioned vertically, horizontally, sloped or a combination of these positions. Refrigerant liquid is contained in the refrigerant liquid container 2. The level of refrigerant liquid is either above, lateral to or below the evaporator 8.

During operation a flow of refrigerant liquid is conducted from the refrigerant liquid container 2 via the sinking conduit 4, the rising conduit 6, the evaporator 8 and the return conduit 10 back to the refrigerant liquid container 2.

The refrigerant liquid may be any suitable refrigerant liquid known by the skilled man. An example of a refrigerant liquid is ammonia.

The refrigerating device 1 further comprises a gas injector 16 connected to the rising conduit 6. The gas injector 16 is adapted to supply gas to the rising conduit 6. The gas is supplied in order to allow gas to rise together with the refrigerant in the rising conduit 6 and thereby reducing the total density ρ_2 of the mixture of refrigerant and gas relative the density ρ_1 of refrigerant. The supplied gas may be pressurized. The gas may further be pressurized, e.g. by using a gas compressor 28 and/or a pressure vessel. The gas compressor 28 may be placed external or internal. The pressure vessel may be placed external or internal. According to one embodiment, the supplied gas may be air. According to another embodiment, the supplied gas may be refrigerant vapor. By using refrigerant vapor no alien substance is added to the refrigerant.

Further, the refrigerating device 1 comprises a gas liquid separator 18. The gas liquid separator 18 is arranged downstream the rising conduit 6 and upstream the evaporator 8. The gas liquid separator 18 directs the liquid flow to the inlet 12 of the evaporator 8 and directs the gas via a gas purge conduit 22. The gas may be directed back to the refrigerant liquid container 2. Thus, the gas purge conduit 22 may be connected directly to the refrigerant liquid container 2 or, as in figure 1, indirectly to the refrigerant liquid container 2 via the return conduit 10. Alternatively, may the gas separated in the gas liquid separator 18 be directed to a first gas vent (not shown). An outlet of the first gas vent may further be connected to a suction side of a compressor. The compressor may be the compressor 28 mentioned above. The gas directed from the gas liquid separator may be dry gas or mixed gas and refrigerant liquid.

According to one embodiment, a part of the gas separated at the gas liquid separator 18 may be recirculated to the gas injector 16. The rest of the gas separated at the gas liquid separator 18 may then either be recirculated to the refrigerant liquid container 2 directly or indirectly via the return conduit 10 or be released to the surroundings.

The refrigerating device 1 also comprises a pressure regulating device 20. The pressure regulating device 20 is connected to the gas liquid separator 18. The pressure regulating device 20 is integrated in the gas purge conduit 22. The pressure regulating device 20 is used to allow flow of gas from the gas liquid separator 18 and to regulate the pressure in the gas liquid separator 18. If the first gas vent is used it may be connected downstream the pressure regulating device 20.

As mentioned above the gas directed from the gas liquid separator 18 is directed back to the refrigerant liquid container 2. Thus the gas from the gas liquid separator 18 may be recirculated directly to the refrigerant liquid container 2 or, as in figure 1, indirectly to the refrigerant liquid container 2 via the return conduit 10.

The refrigerant liquid container 2 may contain means for separating refrigerant liquid from refrigerant vapor. A second gas vent 24 may be connected to the refrigerant liquid container 2. The outlet of the gas vent 24 may further be connected to a suction side of a refrigeration compressor (not shown). Thus, the refrigerant vapor may be compressed back to liquid phase and be recirculated to the refrigerant liquid container 2. Alternatively, the refrigerant vapor may be fed to the gas injector 16 and be used as the gas supplied by the gas injector 16. The refrigerant vapor may even be fed to the compressor 28 for further use in the gas injector 16.

Further, the refrigerating device 1 may comprise a refrigerant in feed conduit 26 connected directly to the refrigerant liquid container 2 or to the return conduit 10. The in feed conduit 26 is used to replace refrigerant that has evaporated and has left the refrigerating device 1. The evaporated refrigerant may leave the refrigerating device 1 via either of the first and second gas vents mentioned above.

Let us assume that the gas used in the refrigerating device 1 is refrigerant vapor. Then the function of the refrigerating device 1 illustrated in figure 1 may be explained as followed:

Refrigerant liquid is contained in the refrigerant liquid container 2. Due to the density ρ_1 of the refrigerant liquid and the gravity the pressure increases in the refrigerant liquid container 2 and the sinking conduit 4 in proportion to the depth below the refrigerant liquid level. The pressure in one point is proportional to the height of refrigerant liquid above it and the density of the refrigerant liquid. Thus, the increase in pressure from point A to point B is

$$\rho_1 \times g \times h,$$

where ρ_1 is the density of the liquid, g is the gravity acceleration constant and h is the height between point A and point B.

The static pressure in point C is equal to the pressure in point B since these points are on the same level. Refrigerant vapor is injected via the gas injector 16 at point C and the refrigerant vapor bubbles, with significantly lower density, will rise upwards together with the refrigerant liquid in the rising conduit 6.

The resulting density ρ_2 of the mixture of refrigerant liquid and gas will be lower than the density ρ_1 for pure refrigerant liquid and therefore the pressure p at point D, in same physical height as point A, will be:

$$p(\mathrm{D}) = p(\mathrm{A}) + h \times g \times \rho_1 - h \times g \times \rho_2,$$

where p(A) is the pressure in point A and p(D) is the pressure in point D.

Since ρ_1 is a larger number than ρ_2 it is clear that the pressure p(D) in point D is higher than the pressure p(A) in point A. Thus, the pressure gained is dependent on the height h and the difference in density formed by the flow of gas that is injected in point C via the gas injector 16.

The gas liquid separator 18, at the end of the rising conduit 6, directs the liquid flow to the inlet 12 of the evaporator 8 and directs the refrigerant vapor via the gas purge conduit 22 back to the refrigerant liquid container 2.

The pressure regulating device 20 connected to the gas liquid separator 18 via the gas purge conduit 22 regulates the pressure in the gas liquid separator 18. The vapor directed from the gas liquid separator 18 is then directed back to the refrigerant liquid container 2 via the return conduit 10. Thus the vapor from the pressure regulating device 20 is recirculated back to the refrigerant liquid container 2.

In the evaporator the refrigerant is taking up heat from the surroundings and out from the outlet 14 of the evaporator 8 there is normally a mixed flow of refrigerant vapor and refrigerant liquid which via the return conduit 10 is returned to the liquid container 2.

From the liquid container 2 which may comprise means for separating vapor from liquid the vapor may be vented via the gas vent 24. The outlet of the gas vent 24 may further be connected to the suction side of the refrigeration compressor (not shown). Thus, the refrigerant vapor may be compressed back to liquid phase and be recirculated to the refrigerant liquid container 2. Alternatively, may the refrigerant vapor be fed to the gas injector 16 and be used as the gas supplied by the gas injector 16. The refrigerant vapor may even be fed to the compressor 28 for further use in the gas injector 16.

It should also be noted that refrigerant liquid also can be fed via the gas injector 16, then in the form of a 2-phase flow of mixed liquid and vapor. The refrigerant liquid may be pressurized and may be at least partly vaporized by expansion. The pressure of the liquid is decreased and a part of the liquid is vaporized due to the expansion. According to an embodiment the refrigerant liquid may be subjected to expansion through a valve and thereafter being supplied to the rising conduit 6 via the gas injector 16. By supplying refrigerant liquid via the gas injector 16 in the form of a 2-phase flow of mixed liquid and vapor the pressure in point D will be increased not only due to density difference but also due to that an injection effect is achieved by injecting the refrigerant liquid.

Above the basic principles of the inventive refrigerating device 1 was shown with reference to figure 1. Figures 2, 3 and 4 illustrate alternative embodiments of refrigerating devices 1 according to the invention. The basic principles for the refrigerating devices according to the embodiments illustrated in figures 2, 3 and 4 are the same as for the embodiment illustrated in figure 1.

Figure 2, to which reference now is made, illustrates an alternative embodiment of the inventive refrigerating device 1 in which the refrigerant liquid container 2 is used as a sinking conduit 4 and the rising conduit 6 is located inside the refrigerant liquid container 2 used as the sinking conduit 4. The sinking conduit 4 is thus formed by the wall of the refrigerant liquid container 2 and the wall of the rising conduit 6. The wall of the refrigerant liquid container 2 may be annular. Also the wall of the rising conduit 6 may be annular. The rising conduit 6 may be centrally positioned in the refrigerant liquid container 2. Alternatively, the rising conduit 6 may be positioned shifted towards one side of the liquid container 2. The sinking conduit 4 is extending downwardly to a connection with the rising conduit 6. The rising conduit 6 is extending upwardly from the connection with the sinking conduit 4. As mentioned before, the rising conduit 6 may be positioned vertically or sloped or a combination of these positions. The rising conduit 6 may even have horizontal sections. The evaporator 8 has an inlet 12 connected downstream to the rising conduit 6 and an outlet 14 connected to the refrigerant liquid container 2 via the return conduit 10. The return conduit 10 may be positioned vertically, horizontally, sloped or a combination of these positions. Refrigerant liquid is contained in the refrigerant liquid container 2. The level of refrigerant liquid is either above, lateral to or below the evaporator 8. The refrigerating device 1 further comprises a gas injector 16 connected to the rising conduit 6. The gas injector 16 is adapted to supply gas to the rising conduit 6. The gas is supplied in order to allow gas to rise together with the refrigerant in the rising conduit 6 and thereby reducing the total density of the mixture of refrigerant and gas relative the density of refrigerant and thereby according to what is described above increasing the pressure in the rising conduit 6. Also this embodiment of the refrigerating device 1 may comprise a gas liquid separator 18. The gas liquid separator 18 is arranged downstream the rising conduit 6 and upstream the evaporator 8. The gas liquid separator 18 directs the liquid flow to the inlet 12 of the evaporator 8 and directs the gas via a gas purge conduit 22. The gas may be directed back to the refrigerant liquid container 2. Please see above for a more detailed description of the gas liquid separator 18. Further, also this embodiment of the refrigerating device 1 may comprise a pressure regulating device 20. The pressure regulating device 20 is connected to the gas liquid separator 18. The pressure regulating device 20 is integrated in the gas purge conduit 22. The pressure regulating device 20 is used to allow flow of gas from the gas liquid separator 18 and to regulate the pressure in the gas liquid separator 18.

An advantage with the design of the inventive refrigerating device 1 according to figure 2 is that the refrigerating device 1 may be compact.

Figure 3, to which reference now is made, illustrates yet an alternative embodiment of the inventive refrigerating device 1. As for the embodiment shown in figure 2, the refrigerant liquid container 2 is used as a sinking conduit 4 and the rising conduit 6 is located inside the refrigerant liquid container 2 used as the sinking conduit 4. The sinking conduit 4 is thus formed by the wall of the refrigerant liquid container 2 and the wall of the rising conduit 6. The wall of the refrigerant liquid container 2 may be annular.

Also the wall of the rising conduit 6 may be annular. The rising conduit 6 may be centrally positioned in the refrigerant liquid container 2. Alternatively, the rising conduit 6 may be positioned shifted towards one side of the liquid container 2. The sinking conduit 4 is extending downwardly to a connection with the rising conduit 6. The rising conduit 6 is extending upwardly from the connection with the sinking conduit 4. As mentioned before, the rising conduit 6 may be positioned vertically or sloped or a combination of these positions. The rising conduit 6 may even have horizontal sections. The evaporator 8 has an inlet 12 connected downstream to the rising conduit 6 and an outlet 14 connected to the refrigerant liquid container 2 via the return conduit 10. The return conduit 10 may be positioned vertically, horizontally, sloped or a combination of these positions. Refrigerant liquid is contained in the refrigerant liquid container 2. The level of refrigerant liquid is either above, lateral to or below the evaporator 8. The refrigerating device 1 further comprises a gas injector 16 connected to the rising conduit 6. The gas injector 16 is adapted to supply gas to the rising conduit 6. The gas is supplied in order to allow gas to rise together with the refrigerant in the rising conduit 6 and thereby reducing the total density of the mixture of refrigerant and gas relative the density of refrigerant and thereby according to what is described above increasing the pressure in the rising conduit 6. This embodiment also comprises a conduit having one end connected to the rising conduit 6 and the other end being located inside the refrigerant liquid container 2. The end being located inside the refrigerant liquid container 2 is open. Additionally, the open end being located inside the refrigerant liquid container 2 is above the level of refrigerant liquid in the refrigerant liquid container 2. Thus, the gas supplied via the gas injector 16 may escape from the refrigerant liquid and are being supplied to the refrigerant liquid container 2. Thus, the conduit having one end connected to the rising conduit 6 and the other end being located inside the refrigerant liquid container 2 is forming a gas liquid separator 18.

An advantage with the design according to figure 3 of the inventive refrigerating device 1 is that it may be compact.

Figure 4, to which reference now is made, illustrates yet an alternative embodiment of the inventive refrigerating device 1. This embodiment of the refrigerating device 1 further comprises a second sinking conduit 5. As for the embodiments shown in figure 2 and 3, the refrigerant liquid container 2 is used as a sinking conduit 4 and the rising conduit 6 is located inside the refrigerant liquid container 2 used as the sinking conduit 4. The sinking conduit 4 is formed by the wall of the refrigerant liquid container 2, the wall of the rising conduit 6 and the wall of the second sinking conduit 5. The wall of the refrigerant liquid container 2 may be annular. Also the wall of the rising conduit 6 may be annular. In addition, also the wall of the second sinking conduit 5 may be annular. The sinking conduit 4 is extending downwardly to a connection with the rising conduit 6. The rising conduit 6 is extending upwardly from the connection with the sinking conduit 4. As mentioned above, the rising conduit 6 may be positioned vertically or sloped or a combination of these positions. The rising conduit 6 may even have horizontal sections. The rising conduit 6 is connected to an inlet of the second sinking conduit 5.

The upper end of the second sinking conduit 5 is open and is thus forming a gas liquid separator 18.

According to the embodiment shown in figure 4 the rising conduit 6 is used to pump refrigerant liquid to the second sinking conduit 5. Thus, the second sinking conduit 5 is located downstream the rising conduit 6. The inlet of the second sinking conduit 5 is located above the level of the refrigerant liquid in the refrigerant liquid container 2, i.e. the sinking conduit 4. The second sinking conduit 5 is extending downwardly to a connection with the inlet 12 of the evaporator 8. The second sinking conduit 5 may be positioned vertically or sloped or a combination of these positions. The second sinking conduit 5 may even have horizontal sections.

The same basic idea as described above is used to pump refrigerant liquid up to an inlet of the second sinking conduit 5. Thus, the gas injector 16 is connected to the rising conduit 6 in order to supply gas and in order to allow gas to rise together with the refrigerant in the rising conduit 6 and thereby reducing the total density of the mixture of refrigerant and gas relative the density of refrigerant and thereby according to what is described above being able to increase the level of the refrigerant liquid in the rising conduit 6. Under normal operation the level of refrigerant liquid in the rising conduit 6 may be increased to double the height as compared with the level of refrigerant liquid in the rising conduit 6 when no gas is supplied thereto.

The evaporator 8 has an inlet 12 connected downstream to the second sinking conduit 5 and an outlet 14 connected to the refrigerant liquid container 2 via the return conduit 10. The return conduit 10 may be positioned vertically, horizontally, sloped or a combination of these positions.

An advantage with the design according to figure 4 of the inventive refrigerating device 1 is that it may be compact. Another advantage with the design according to figure 4 of the inventive refrigerating device 1 is that it does not build downwards in height.

It will be appreciated that the present invention is not limited to the embodiments shown. Several modifications and variations are thus conceivable within the scope of the invention. For example may the embodiment described in connection with figure 4 be combined with the embodiment described in figure 1. Such a combination will result in an embodiment with increased pressure to circulate the refigerant liquid.

CLAIMS

1. A refrigerating device comprising:

a refrigerant liquid container (2),

a sinking conduit (4) and a rising conduit (6), the sinking conduit (4) extending downwardly to a connection with the rising conduit (6), the rising conduit (6) extending upwardly from the connection with the sinking conduit (4),

an evaporator (8) having an inlet (12) connected downstream to the rising conduit (6) and an outlet (14) connected to the refrigerant liquid container (2) via a return conduit (10), and

a gas injector (16) connected to the rising conduit (6), adapted to supply gas in order to allow gas to rise together with liquid refrigerant in the rising conduit (6) thereby reducing the total density of the mixture of liquid refrigerant and gas relative the density of liquid refrigerant.

2. The refrigerating device according to claim 1, further comprising a gas liquid separator (18) arranged downstream the rising conduit (6) and upstream the evaporator (8).

3. The refrigerating device according to claim 2, further comprising a pressure regulating device (20) connected to the gas liquid separator (18) to allow flow of gas from the gas liquid separator (18) and to regulate the pressure in the gas liquid separator (18).

4. The refrigerating device according to any one of claims 2-3, adapted to recirculate the gas from the gas liquid separator (18) to the return conduit (10) or to the refrigerant liquid container (2).

5. The refrigerating device according to any one of claims 2-4, adapted to recirculate the gas from the gas liquid separator (18) to the gas injector (16).

6. The refrigerating device according to any one of claims 1-5, wherein the refrigerant liquid container (2) comprises a gas vent (24).

7. The refrigerating device according to any one of claims 1-6, wherein the gas injector (16), is adapted to supply pressurized gas.

8. The refrigerating device according to claim 7, further comprising a connection to a source of externally pressurized gas.

9. The refrigerating device according to any one of claims 1-8, wherein the gas is refrigerant vapor.

10. The refrigerating device according to any one of claims 1-9, wherein the gas is air.

11. A method for circulating a refrigerant liquid in a refrigerating device, said method comprising:

conducting a flow of refrigerant liquid from a refrigerant liquid container (2) via a sinking conduit (4), a rising conduit (6), an evaporator (8) and a return conduit (10) back to the refrigerant liquid container (2), and

supplying gas via a gas injector (16) connected to the rising conduit (6) in order to allow gas to rise together with refrigerant liquid in the rising conduit (6) thereby reducing the total density of the mixture of refrigerant liquid and gas relative the density of refrigerant liquid.

12. The method according to claim 11, further comprising separating the supplied gas from the refrigerant liquid at a gas liquid separator (18) located upstream to the evaporator (8).

13. The method according to claim 12, further comprising regulating the pressure in the gas liquid separator (18) by means of a pressure regulating device (20).

14. The method according to claim 13, further comprising recirculating the gas from the gas liquid separator (18) to the return conduit (10) or to the refrigerant liquid container (2).

15. The method according to any one of claims 11-14, further comprising pressurizing the gas before supplying the gas via the gas injector (16).

16. The method according to any one of claims 11-15, wherein the gas is refrigerant vapor.

17. The method according to any one of claims 11-16, further comprising venting refrigerant vapor from the liquid refrigerant container (2) and supplying the vented refrigerant vapor to the gas injector (16).

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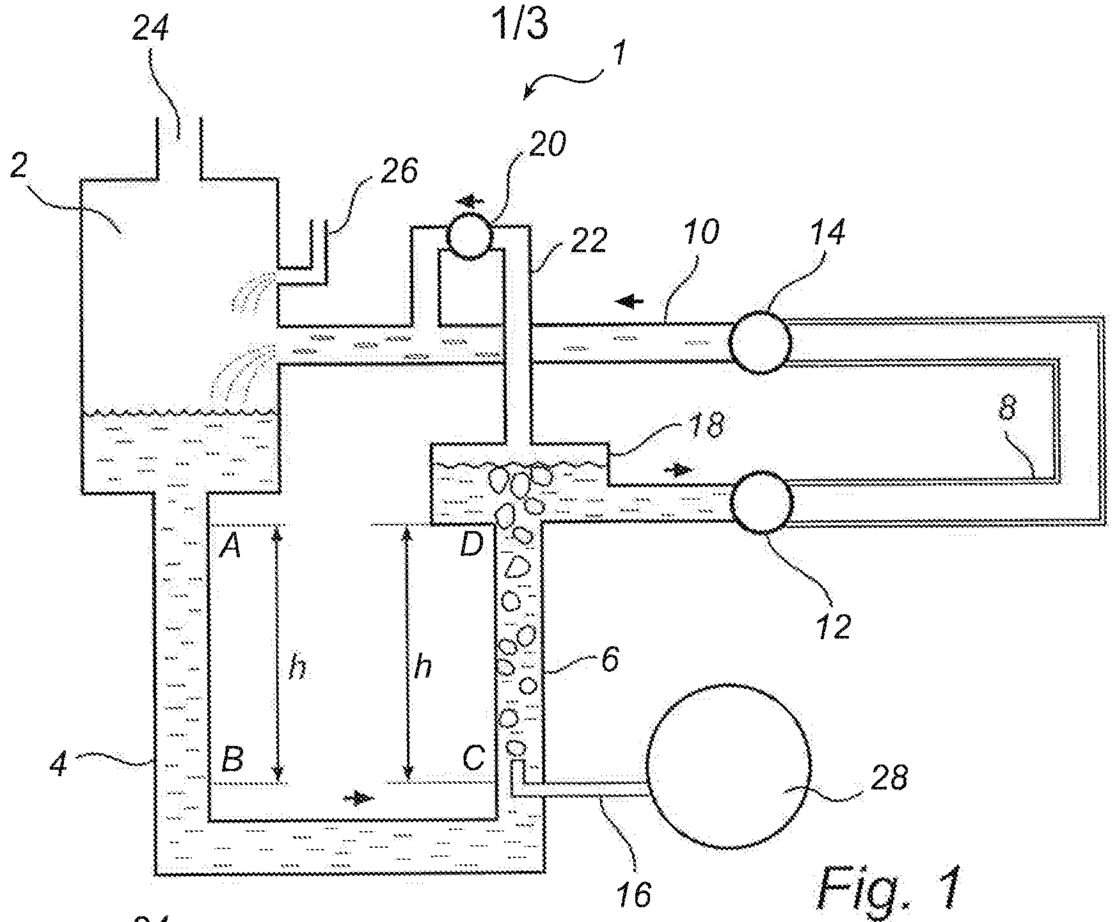
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Fig. 1

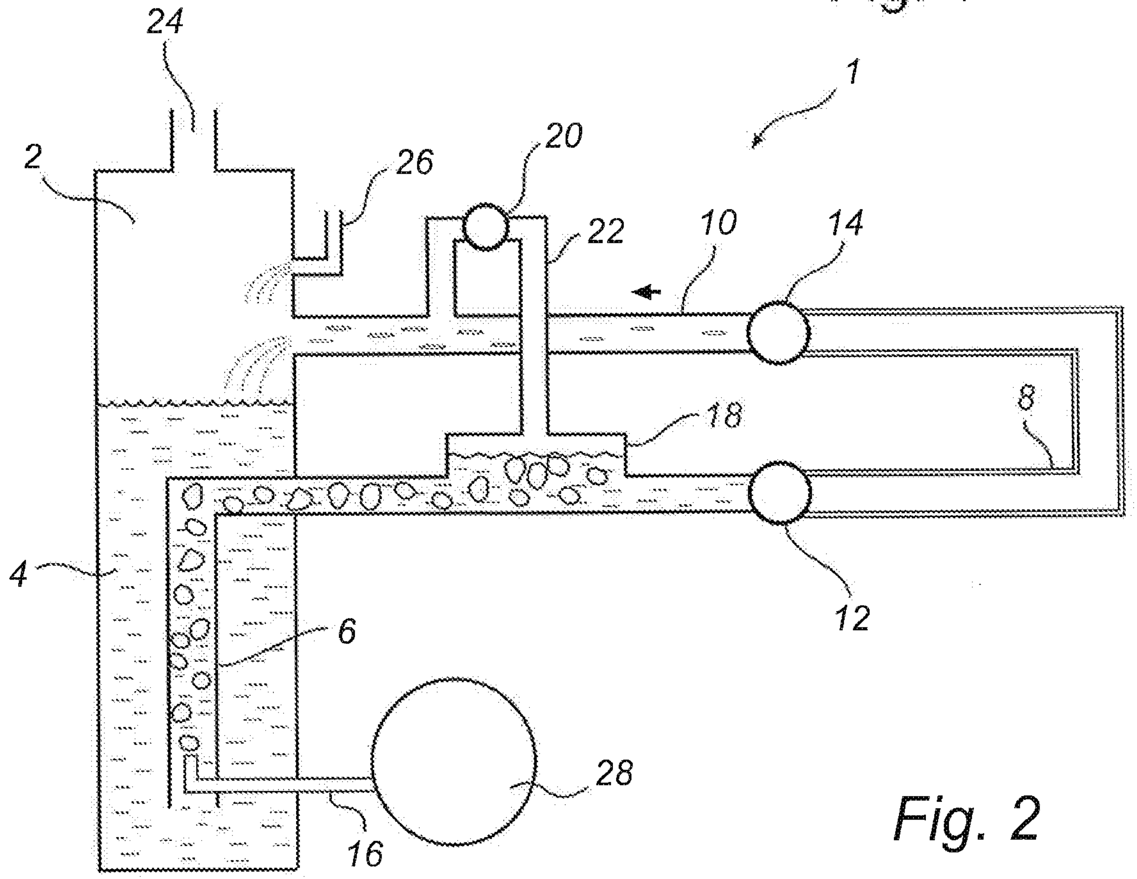
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Fig. 2

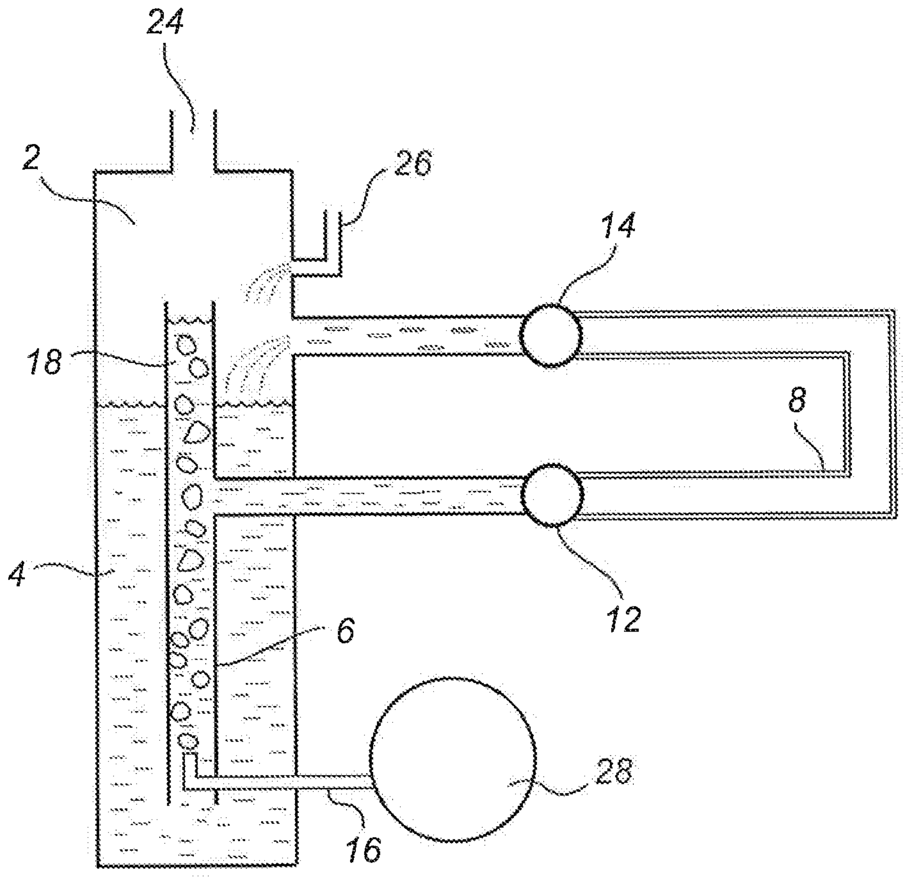

Fig. 3

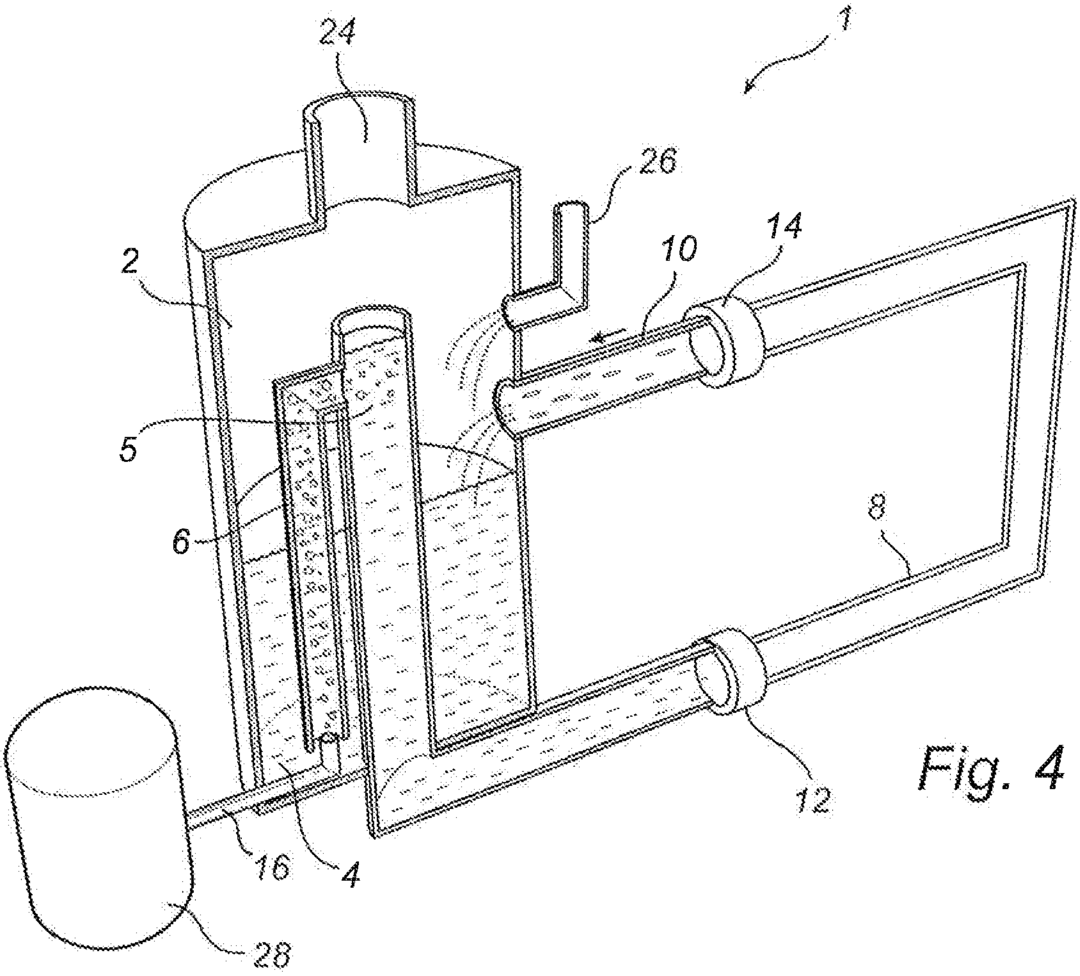

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2010/050724

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC:F04F, F25B

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3211381 A (TOSHIBA CORP), 17 September 1991 (1991-09-17); Abstract of EPODOC --	1-17
A	JP 3211381 A (TOSHIBA CORP), 17 September 1991 (1991-09-17); figures 1 and 6 --	1-17
A	US 4666377 A (BROWN MELVIN H), 19 May 1987 (1987-05-19); column 1, line 13 - column 3, line 30; column 4, line 23 - column 4, line 25; column 10, line 49 - column 10, line 52; figure 1; TABLE II --	1-17
A	GB 1552309 A (COMMISSARIAT ENERGIE ATOMIQUE), 12 September 1979 (1979-09-12); whole document --	1-17
A	DE 2536604 A1 (LICENTIA GMBH), 24 February 1977 (1977-02-24); whole document -- ----------	1-17

☐ Further documents are listed in the continuation of Box C. ☒ 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
05-10-2010	05-10-2010

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Continuation of: second sheet

International Patent Classification (IPC)

F25B 41/00 (2006.01)
F04F 1/18 (2006.01)

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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

JP	3211381 A	17/09/1991	NONE			
US	4666377 A	19/05/1987	NONE			
GB	1552309 A	12/09/1979	ES	466871	A1	16/10/1978
			FR	2380448	B1	25/04/1980
			IL	53997	A	31/07/1980
DE	2536604 A1	24/02/1977	NONE			