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(54) **REFRIGERATION SYSTEM**

(57) A refrigerant system (1) is described comprising a refrigerant circuit having a first heat exchanger (2), a compressor (3), a second heat exchanger (4) and a separator (5) connected to a refrigerant outlet of the first heat exchanger.

It should be possible to remove liquid from a refrigerant flow even with a limited size of the separator.

To this end, the separator (5) comprises at least two flow paths arranged in parallel between an inlet (12) and an outlet (13).

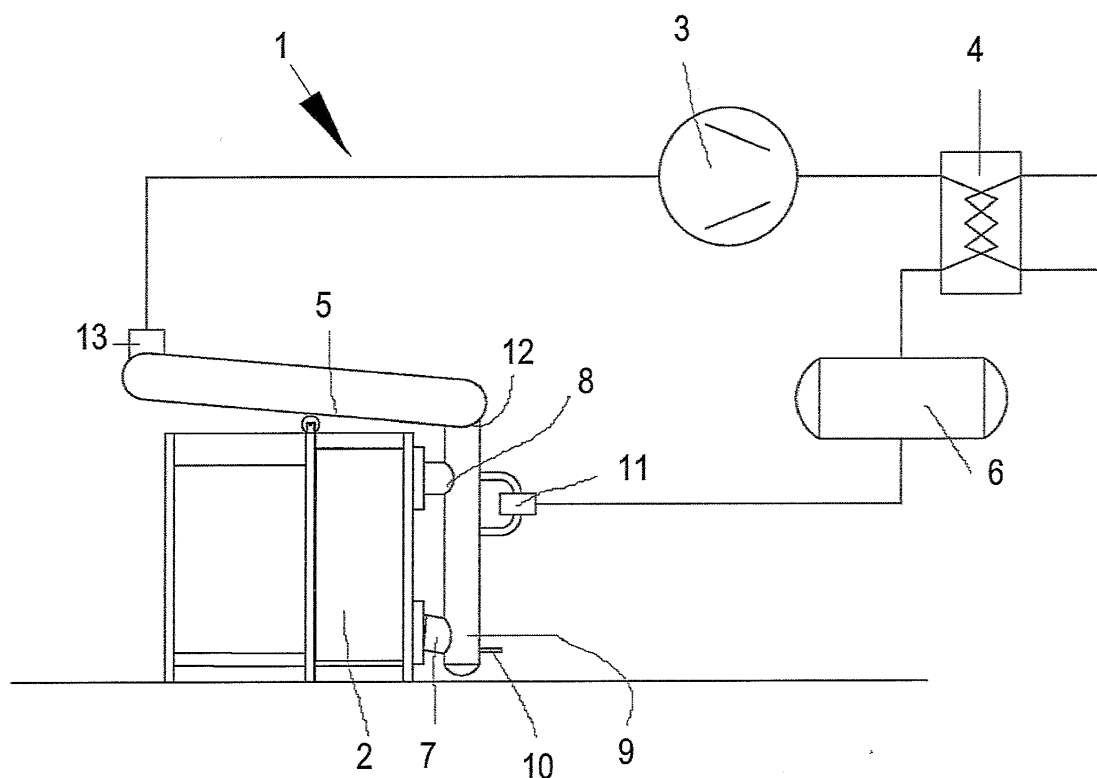


Fig. 1

Description

[0001] The present invention relates to a refrigeration system comprising a refrigerant circuit having a first heat exchanger, a compressor, a second heat exchanger, and a separator connected to an outlet of the first heat exchanger.

[0002] In such a refrigeration circuit a refrigerant is circulated. Gaseous refrigerant is compressed by the compressor. This leads to an increased temperature. When the compressed refrigerant gas is guided through a heat exchanger, the so-called condenser, it is cooled and changes from the gaseous state to a liquid state. The liquid refrigerant is then supplied to the other heat exchanger, the so-called evaporator. In the evaporator the refrigerant is evaporated while drawing heat from the ambient air or any other fluid, so that the ambient air is cooled. The refrigerant leaving the evaporator returns to the suction side of the compressor.

[0003] The refrigerant leaving the evaporator or first heat exchanger is in many cases not fully gaseous. It contains as well refrigerant in liquid form. The liquid phase of the refrigerant may be up to 30 % of the whole refrigerant leaving the evaporator. This liquid refrigerant must be removed from the refrigerant flow in order to avoid a situation in which liquid enters the compressor. Liquid entering the compressor can damage or destroy the compressor. To this end, the separator is used.

[0004] In some applications the space available for the separator is limited. Thus, the size of the separator is limited as well. This makes it difficult to reliably remove all liquid from the refrigerant flow.

[0005] The object underlying the invention is to remove liquid from the refrigerant flow even with limited size of the separator.

[0006] This object is solved with a refrigeration system as described at the outset in that the separator comprises at least two flow paths arranged in parallel between an inlet and an outlet.

[0007] Such a design has more than one flow path in the separation zone. The use of two or more flow paths arranged in parallel has the effect that the velocity of the refrigerant flow is decreased so that the liquid has more time to "fall" out of the refrigerant flow. Thus, the length of the flow path can be reduced correspondingly. Furthermore, when the flow paths have a circular section, the diameter of this section can be reduced and correspondingly the height of the separator can be kept small while maintaining the same area of the flow paths.

[0008] In an embodiment of the invention the flow paths are inclined in the same direction from the inlet to the outlet. In other words, the outlet is arranged in a position higher than the position of the inlet in the direction of gravity. Thus, liquid refrigerant removed from the refrigerant flow can flow back in direction towards the inlet under the action of gravity. Thus, the liquid refrigerant can be removed from the separator.

[0009] In an embodiment of the invention the flow paths

have the same angle of inclination. Such an angle can be rather small, for example 5° or 10°. Liquid removed from the refrigerant flow has the same conditions in all flow paths to flow back to the input.

[0010] In an embodiment of the invention the flow paths have the same lengths. This is a simple design to make the flow resistance in all flow paths equal or almost equal.

[0011] In an embodiment of the invention the separator is symmetrical with respect to a line connecting the inlet and the outlet. In such a construction the flow through the flow paths can be made the same through all flow paths.

[0012] In an embodiment of the invention each flow path comprises at least one curvature. Such a curvature provides a beneficial flow path for the separation. The creation of turbulence is avoided or at least reduced helping the separation of the gaseous and the liquid refrigerant.

[0013] In an embodiment of the invention the number of flow paths is two. Although this is a rather small number, the area available for the flow is sufficient to pass the refrigerant flow with a velocity which is low enough to give the refrigerant liquid enough time to fall out of the flow.

[0014] In an embodiment of the invention the flow paths are arranged in tubes, wherein the tubes surround a tube free space. The tubes form a kind of "donut", which is a simple constructional solution.

[0015] In an embodiment of the invention the tubes are arranged in form of a rectangle, wherein the inlet and the outlet are arranged at opposite sides of the rectangle. The rectangle will have rounded or squared corners. Such a rectangle form of the separator can easily be made by using generally available semi-finished products.

[0016] In an embodiment of the invention the first heat exchanger comprises a refrigerant inlet connected to a connecting pipe and a refrigerant outlet connected to the connecting pipe, wherein the inlet of the separator is connected to the connecting pipe. Refrigerant in liquid form can be supplied to the connecting pipe up to a certain level. This has the effect that the same level of liquid refrigerant is available within the first heat exchanger. This refrigerant is at least partly evaporated in the first heat exchanger and escapes at the refrigerant outlet. From there, the refrigerant flow consisting of a gaseous phase and of a liquid phase enters the separator. Liquid refrigerant removed from the refrigerant flow in the separator can flow back to the connecting pipe.

[0017] In an embodiment of the invention the connecting pipe is arranged in parallel to the direction of gravity. Thus, the connecting pipe is arranged vertically. Liquid refrigerant removed from the refrigerant flow can directly flow down to the refrigerant inlet of the first heat exchanger.

[0018] In an embodiment of the invention coalescing means are arranged in a region at the inlet. Thus, the refrigerant flow is guided through the coalescing means. The coalescing means have the effect that liquid droplets

contained in the refrigerant flow combine into larger drops or droplets so that it is easier to remove these droplets.

[0019] In an embodiment of the invention the coalescing means comprise a mesh, preferably made of metal. Other materials are possible. This is a simple design of coalescing means.

[0020] In addition or alternatively, impingement means are arranged in a region at the inlet. Impingement means can be formed by a surface which is arranged perpendicular or almost perpendicular to a flow direction of the refrigerant flow. Thus, drops of liquid refrigerant hit the surface and can be removed from the surface by gravity.

[0021] The invention is now described in more detail with reference to the drawing, wherein:

Fig. 1 shows a schematic illustration of a refrigeration system,

Fig. 2 shows a front view of a heat exchanger with separator and

Fig. 3 shows a top view of the separator.

[0022] Fig. 1 schematically shows a refrigeration system 1 comprising a refrigerant circuit having a first heat exchanger 2, a compressor 3, a second heat exchanger 4 and a separator 5.

[0023] Furthermore, in the embodiment shown, the refrigerant circuit comprises an accumulator 6.

[0024] The first heat exchanger 2 is a plate heat exchanger. However, other types of heat exchangers can be used. The first heat exchanger comprises a refrigerant inlet 7 and a refrigerant outlet 8. A connecting pipe 9 is connected to the refrigerant inlet 7 and to the refrigerant outlet 8. The connecting pipe 9 comprises an oil drain 10. Furthermore, the connecting pipe 9 comprises an expansion valve 11 through which refrigerant in liquid form from the accumulator 6 can be supplied into the connecting pipe 9. The expansion valve can be of a float type or another type, controlled by a liquid level measurement.

[0025] The connecting pipe 9 is oriented in vertical direction (corresponding to the direction of gravity). The liquid level in the connecting pipe 9 is controlled to provide a driving force to move refrigerant through the heat exchanger. The liquid refrigerant in the first heat exchanger 2 evaporates. The evaporation needs substance to be cooled, which could be heat which is withdrawn from another fluid circulating through a secondary side of the first heat exchanger 2, a product contained in the first heat exchanger 2 or from ambient air around the first heat exchanger 2. The column of liquid refrigerant within the connecting pipe 9 drives the refrigerant out of the refrigerant outlet 8 to an upper part of the column 9. However, this refrigerant flow is not in all cases totally gaseous. In most cases it comprises a gaseous phase and a liquid phase. However, the liquid phase must not arrive at the compressor 3, since the compressor 3 can be damaged or destroyed, when liquid enters the compressor 3.

[0026] The compressor 3 compresses the gaseous refrigerant. This compression leads to an elevated temperature and pressure of the gaseous refrigerant. The gaseous refrigerant with elevated temperature is guided through the second heat exchanger 4, wherein the heat of the gaseous refrigerant is transferred to a secondary fluid, such as the ambient air, water or glykol. The temperature of the refrigerant is lowered and the refrigerant is liquified and guided to the accumulator 6.

[0027] In order to remove the liquid phase from the refrigerant flow before the refrigerant flow enters the compressor 3, the separator 5 is used.

[0028] The separator 5 comprises an inlet 12 connected to the connecting tube 9 and an outlet 13 connected to the compressor 3.

[0029] As can be seen in Fig. 3, the separator 5 is in form of a donut, i.e. it forms a rectangle having rounded corners. More precisely, the separator provides two flow paths 14, 15. The flow path 14 is arranged within a tube 16 and the flow path 15 is arranged within a tube 17. Both tubes 16, 17 are connected in the region of the inlet 12 and in the region of the outlet 13. Both tubes 16, 17 have the same length and are inclined upwardly from the inlet 12 towards the outlet 13. The angle of inclination for both tubes 16, 17 is the same. This angle is in a region from 1° to 20°.

[0030] The separator 5 is symmetrical with respect to a line 18 connecting the inlet 12 and the outlet 13. This means that both flow paths 14, 15 have the same flow resistance.

[0031] As mentioned above, the separator 5 is in form of a rectangle. The inlet 12 and the outlet 13 are arranged at opposite sides of the rectangle. The rectangle has rounded corners, so that each flow path comprises two curvatures 19, 20 (for flow path 14) and 21, 22 (for flow path 15). A space 23 within the rectangle is kept free from tubes.

[0032] The inlet 12 is arranged in vertical direction at the upper end of the connecting tube 9. Since the inlet 12 is arranged in the axis of symmetry of the separator 5, the separator 5 is symmetric with respect to a plane intersecting the connecting tube 9.

[0033] Coalescing means 24 and/or impingement means 25 are arranged in a region at the inlet. Other locations are possible.

[0034] When the refrigeration system 1 is operated, refrigerant comes out of the refrigerant outlet 8 of the first heat exchanger 2 or evaporator. The flow of refrigerant having a liquid phase and a gaseous phase is guided through the separator 5. In the separator 5 the refrigerant flow flows along the two flow paths 14, 15. Due to the fact that two flow paths 14, 15 are arranged in parallel, the velocity of the refrigerant flow is reduced so that liquid refrigerant can separate from the gaseous refrigerant. This is supported by the coalescing means 24 and/or the impingement means 25.

[0035] Liquid refrigerant removed from the refrigerant flow comes to the bottom of the tubes 16, 17. Since the

tubes 16, 17 are inclined, the liquid refrigerant flows back to the input 12 and from there to the connecting tube 9, so that it can directly enter the first heat exchanger 2.

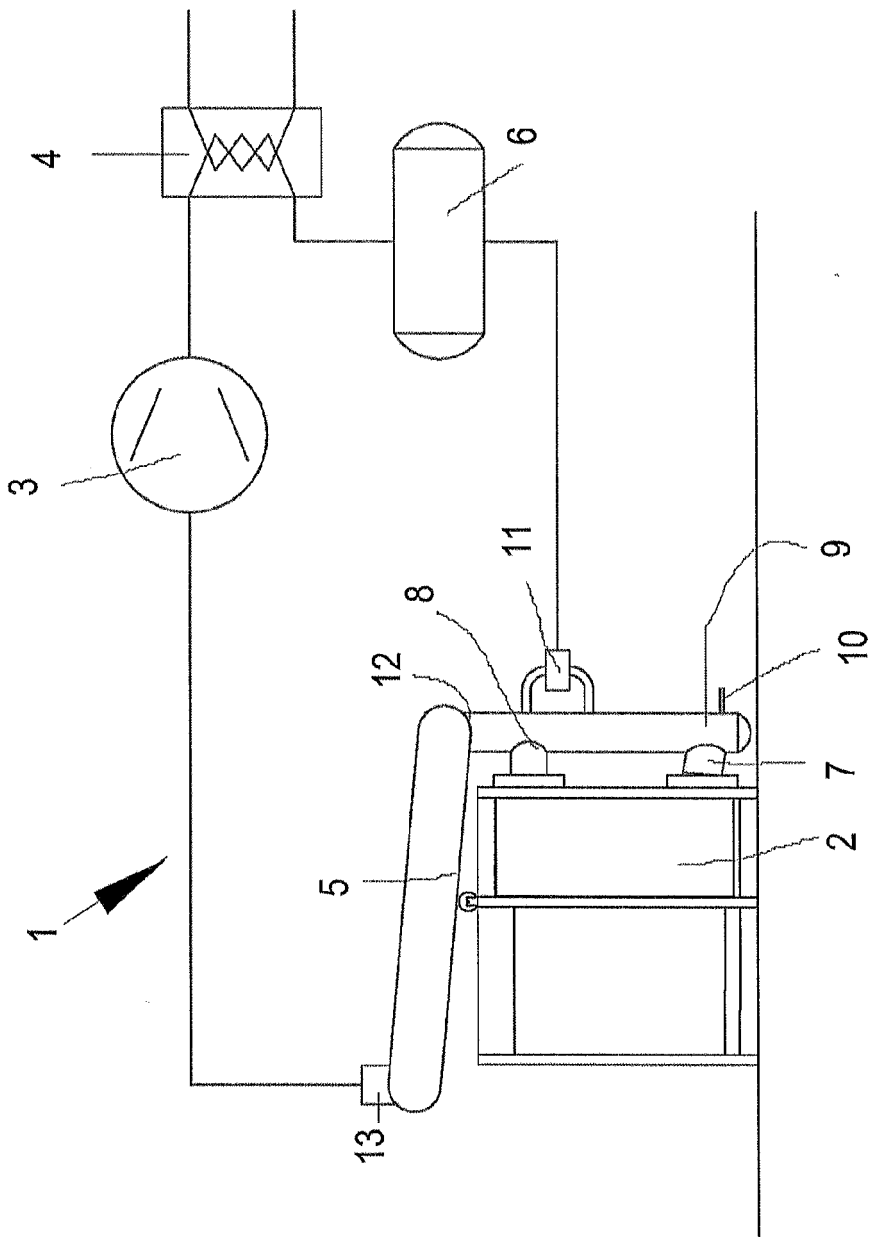
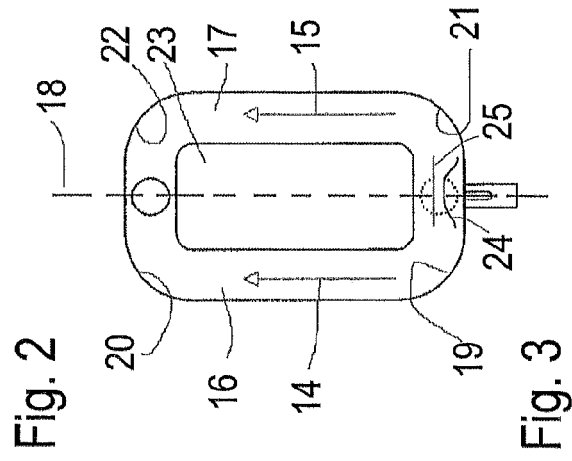
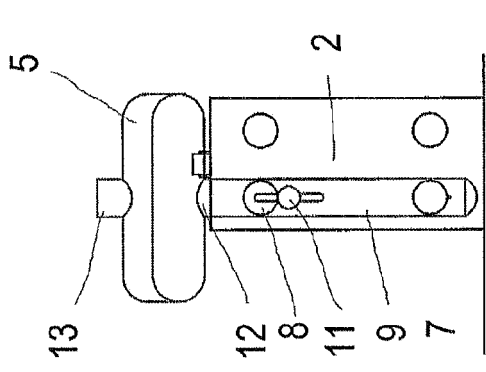
[0036] If this is not desired, it is of course possible to use additional piping to connect a liquid drain of the separator 5 with a position in the refrigerant system downstream the compressor 3.

Claims

1. Refrigeration system (1) comprising a refrigerant circuit having a first heat exchanger (2), a compressor (3), a second heat exchanger (4), and a separator (5) connected to a refrigerant outlet (8) of the first heat exchanger (2), **characterized in that** the separator (5) comprises at least two flow paths (14, 15) arranged in parallel between an inlet (12) and an outlet (13). 5
2. Refrigeration system according to claim 1, **characterized in that** the flow paths (14, 15) are inclined in the same direction from the inlet (12) to the outlet (13). 10
3. Refrigeration system according to claim 2, **characterized in that** the flow paths (14, 15) have the same angle of inclination. 15
4. Refrigeration system according to any of claims 1 to 3, **characterized in that** the flow paths (14, 15) have the same length. 20
5. Refrigeration system according to any of claims 1 to 4, **characterized in that** the separator (5) is symmetrical with respect to a line (18) connecting the inlet (12) and the outlet (13). 25
6. Refrigeration system according to any of claims 1 to 5, **characterized in that** each flow path (14, 15) comprises at least one curvature (19-22). 30
7. Refrigeration system according to any of claims 1 to 6, **characterized in that** the number of flow paths (14, 15) is two. 35
8. Refrigeration system according to claim 7, **characterized in that** the flow paths (14, 15) are arranged in tubes (16, 17), wherein the tubes (16, 17) surround a tube free space (23). 40
9. Refrigeration system according to claim 8, **characterized in that** the tubes (16, 17) are arranged in form of a rectangle, wherein the inlet (12) and the outlet (13) are arranged at opposite sides of the rectangle. 45
10. Refrigeration system according to any of claims 1 to 50

9, **characterized in that** the first heat exchanger (2) comprises a refrigerant inlet (7) connected to a connecting pipe (9) and the refrigerant outlet (8) is connected to the connecting pipe (9), wherein the inlet (12) of the separator (5) is connected to the connecting pipe (9).

11. Refrigeration system according to claim 10, **characterized in that** the connecting pipe (9) is arranged in parallel to the direction of gravity. 55
12. Refrigeration system according to any of claims 1 to 11, **characterized in that** coalescing means (24) are arranged in a region at the inlet (12).
13. Refrigeration system according to claim 12, **characterized in that** the coalescing means (24) comprise a mesh made of metal.
14. Refrigeration system according to any of claims 1 to 13, **characterized in that** impingement means (25) are arranged in a region at the inlet. 60





EUROPEAN SEARCH REPORT

 Application Number
 EP 19 19 2999

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 February 2020	Examiner Ritter, Christoph
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	

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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