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(54) **REFRIGERATING CIRCUIT AND METHOD OF SELECTIVELY COOLING OR DEFROSTING AN EVAPORATOR THEREOF**

KÜHLSCHALTUNG UND VERFAHREN ZUR SELEKTIVEN KÜHLUNG ODER ENTFROSTUNG
EINES VERDAMPFERS

CIRCUIT DE RÉFRIGÉRATION ET PROCÉDÉ SÉLECTIF DE REFROIDISSEMENT OU DE
DÉGIVRAGE D'UN ÉVAPORATEUR DU CIRCUIT

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Description

[0001] The invention relates to a refrigerating circuit and to a method of selectively cooling or defrosting an evaporator of a refrigerating circuit.

[0002] Refrigerating system evaporators, such as disclosed in JP61-272562, having a plurality of refrigerant pipes are well-known in the art. Refrigerant is flown through these pipes for effecting a heat exchange with an ambient air flow. Refrigerant flow direction and air flow direction often constitute a counter-flow relationship. It is also known to use the same pipes in a defrosting operation by flowing a hot gas therethrough. During a defrosting operation, however, the problem arises that one side of the evaporator (hot gas outlet) is not fully defrosted and the ice build up at this side remains unmelted. Moreover, at the other side of the evaporator (hot gas inlet) some of the water generated in the defrosting procedure normally evaporates, which leads to heavy ice build-up in parts of the refrigerating system that are still below 0°C. Refrigerating systems often comprise a Cu pipe serpentine, which is for example located in the floor of the refrigerating system, to which the evaporator is mounted, and helps in the defrosting operation by carrying hot fluid.

[0003] Accordingly, it would be beneficial to provide a refrigerating circuit having an evaporator, whose defrosting can be carried out in an energy-efficient manner.

[0004] Exemplary embodiments of the invention include a refrigerating circuit comprising a compressor, a condenser/gas cooler, an expansion device, an evaporator, and refrigerant conduits circulating a refrigerant therethrough. The evaporator comprises refrigerant piping comprising a plurality of substantially horizontal layers, each layer comprising a plurality of pipes, the pipes being substantially perpendicular to an air flow direction from an air inlet region to an air outlet region of the evaporator. A pipe selected from the group of the second pipe to the last but one pipe in the air flow direction in the bottom layer forms the entry pipe of the evaporator. The entry pipe is connectable with the expansion device to provide a refrigerating mode, and the entry pipe is connectable with a hot gas conduit to provide a defrosting mode for the evaporator.

[0005] Exemplary embodiments of the invention further include a method of selectively cooling or defrosting an evaporator of a refrigerating circuit, the method comprising the steps of compressing a refrigerant; flowing the refrigerant through a gas cooler/condenser and an expansion device, when cooling is selected, or flowing the refrigerant through a hot gas by-pass conduit, when defrosting is selected; flowing the refrigerant through refrigerant piping of the evaporator, the refrigerant piping comprising a plurality of substantially horizontal layers, each layer comprising a plurality of pipes; and flowing air through the evaporator with the air flow direction being substantially perpendicular to the orientation of the pipes. The refrigerant enters the refrigerant piping of the evaporator at a pipe of the group from the second pipe to the

last but one pipe in the bottom layer.

[0006] Embodiments of the invention are described in greater detail below with reference to the Figures wherein:

FIG. 1 shows a schematic of an exemplary evaporator and its integration in a refrigerating circuit in accordance with the present invention.

[0007] FIG. 1 shows a portion of a refrigerating circuit in accordance with an embodiment of the present invention in a schematic manner. As the compressor and the condenser/gas cooler are well-known elements in the art, they have been omitted from FIG. 1 for easy readability.

[0008] The evaporator 4 is shown in detail. It comprises two layers (8, 10) of refrigerant pipes (8a-8h, 10a-10h). As such evaporators are often disposed in the floor region of a refrigerating sales furniture, for example an island freezer, layer 8 is hereinafter also referred to as the bottom layer, whereas layer 10 is hereinafter also referred to as the top layer. Each layer comprises eight refrigerant pipes, which are shown as circles giving their representation a cross-sectional appearance, which indicates that the pipes run perpendicular to the drawing plane. The pipes are numbered with regard to the air flow direction 12, which is from left to right in the schematic of FIG. 1. 8a is the first pipe with regard to the air flow direction, 8b the second pipe, ..., and 8h is the eighth and last pipe with regard to the air flow direction. An analogous numbering is adhered to for the top layer 10.

[0009] The refrigerant pipes are interconnected by connection elements, which are schematically depicted by solid lines and dashed lines. The solid lines represent connection elements that are disposed towards the user from the drawing plane, whereas the dashed lines represent connection elements behind the drawing plane. In this manner, the pipes 8a to 8h and 10a to 10h combine with the connection elements to form a refrigerant serpentine whose long legs run back and forth through the drawing plane. This piping is used to flow a refrigerant through the evaporator, with the detailed description of the connection set-up and the resulting refrigerant flow given below.

[0010] The third pipe with regard to the air flow direction 12 in the bottom layer 8, i.e. pipe 8c, hereinafter also referred to as entry pipe, is in connection to an evaporator inlet section 14 of the refrigerant conduits. Said evaporator inlet section is selectively connected to a hot gas conduit 6 or the expansion device 2 of the refrigerating circuit. According means (not shown) for enabling a flow connection between the evaporator inlet section 14 and either the expansion device 2 or the hot gas conduit 6 and blocking the respective other of the expansion device 2 and the hot gas conduit 6 are well-known in the art and therefore not described in detail. The connection with the expansion device 2 is selected for a refrigerating mode, whereas the connection with the hot gas conduit 6 is selected for a defrosting mode.

[0011] In the embodiment shown in FIG. 1 the hot gas conduit 6 originates between the compressor and the condenser/gas cooler. Thus, it establishes a by-pass conduit, diverting the refrigerant after its compression and before its cooling in the condenser/gas cooler from the conventional refrigerating circuit. It is apparent that the junction between the compressor and the condenser/gas cooler may comprise appropriate means for guiding the refrigerant either into the hot gas conduit 6 or towards the condenser/gas cooler. The hot gas conduit 6 may also comprise an expansion device for controlling the temperature/pressure of the refrigerant upon entering the evaporator 4 in the defrosting mode.

[0012] As mentioned above, the refrigerant enters the evaporator 4 at the entry pipe 8c. From there it is flown through a first section 18 of the refrigerant piping of the evaporator 4. The first section comprises the pipes 8c, 8d, ..., 8g, and 8h, which are the entry pipe 8c and all pipes on the bottom layer that are downstream thereof. These pipes are interconnected by first connection elements 20. The refrigerant is flown substantially perpendicular to the air flow direction in the pipes and substantially in a co-flow relationship with the air flow direction 12 in the first connection elements 20 towards the end of the evaporator 4.

[0013] From pipe 8h the refrigerant is flown through the second section 22 of the refrigerant piping of evaporator 4. The second section 22 of refrigerant piping comprises the pipes on the top layer from the end of the evaporator 4 to the pipe that is on the same level as the entry pipe with regards to the air flow direction 12, in this embodiment the pipe 10c. The pipes of the second section 22 of the refrigerant piping are interconnected by second connection elements 24. The refrigerant flow in the pipes 10c to 10h of the second section 22 of refrigerant piping is substantially perpendicular to the air flow direction 12. The refrigerant flow in the second connection elements 24 exhibits a substantially counter-flow relationship with the air flow direction 12.

[0014] From pipe 10c the refrigerant is flown through a third section 26 of the refrigerant piping of evaporator 4, which is - in refrigerant flow direction - comprised of the pipes 8b, 10b, 10a, and 8a. Accordingly, pipe 8a is the exit pipe of the evaporator. It is connected to the evaporator outlet section 16 of the refrigerant conduits, which leads the refrigerant back to the compressor.

[0015] The above-described structure of the evaporator 4 according to an exemplary embodiment of the invention has a number of implications for the defrosting and the refrigerating modes. In the refrigerating mode it is the primary objective to generate a heat transfer between the refrigerant and the air flow that is as efficient as possible. The counter-flow relationship between the refrigerant and the air flow direction 12 in the second section 22 of the refrigerant piping provides for very good heat transfer conditions. Moreover, the third section 26 of the refrigerant piping provides for an extended region, where the refrigerant is at its warmest in the evaporator

and the air flow is also at its warmest right after entering the evaporator 4. This set-up provides for a maximum heating of the refrigerant and thus for a maximum heat transfer from the air flow before the refrigerant leaves the evaporator 4 through the exit pipe 8a. In the case that the refrigerant has been evaporated in the first or second section (18, 22) of the refrigerant piping, the third section 26 allows for a maximum amount of superheating of the gaseous refrigerant.

[0016] In the defrosting mode the above-described structure of the evaporator 4 is particularly efficient for a number of reasons. In the exemplary embodiment of FIG. 1, the hot refrigerant, after by-passing the condenser/gas cooler and the expansion device 2, enters the evaporator 4 at entry pipe 8c. At the point of entry the refrigerant is the warmest and has the biggest effect in melting the ice build-up in the evaporator 4. Thus, the region around the entry pipe 8c and the downstream portion thereof in the bottom layer receive the most heat, especially in the beginning stages of the defrosting operation. An advantageous effect thereof is that the support structure to which the evaporator 4 is attached, for example the floor portion of an island freezer, is warmed up starting in the middle region and expanding to the sides. A warming of the support structure at an early stage of the defrosting operation prevents a scenario wherein ice is melted somewhere in the evaporator 4 and the water is re-frozen at the support structure, when supposed to drain out of the evaporator 4. The set-up provides for the support structure, which may be slightly inclined, to be an ideal gutter for water generated by melting the ice in all parts of the evaporator 4 at later stages of the defrosting operation. Another advantage is that water vapour which may be generated around the entry pipe 8c, where continuous heating is effected by flowing hot fluid through the refrigerant piping, cannot easily leave the evaporator 4 and re-freeze in other parts of the refrigerating system, where the temperature is still below 0°C. In other words, instead of generating ice build-up outside of the evaporator 4, the water vapour helps in defrosting the evaporator 4 from the middle region towards the sides.

[0017] The foregoing discussion shows that the evaporator 4 of the exemplary embodiment of the invention in FIG. 1 has a structure that allows for extremely energy-efficient defrosting of the evaporator 4. This even allows basing the defrosting of the evaporator solely on the by-pass conduit, when CO₂ is used as a refrigerant. The refrigerant piping of the evaporator 4 of the exemplary embodiment is not designed in a way to sustain CO₂ in a liquid phase. That means that, when CO₂ is used as refrigerant, the condensation energy is not at the disposal of the defrosting process, which is compensated for by the energy-efficient layout of the evaporator 4.

[0018] As mentioned before, the hot gas conduit 6 may be a by-pass conduit to the refrigerating circuit. It may also be part of an independent defrosting circuit. It is apparent that in addition to the flow switching means between the expansion device 2 and the hot gas conduit 6,

second guiding means would be necessary to direct the fluid coming out of the evaporator 4 into the defrosting circuit or the refrigerant circuit. The defrosting circuit would in that case need additional means for generating fluid circulation, for example a compressor.

[0019] The hot gas conduit 6 may carry a fluid in a liquid or gaseous state to the evaporator, depending on the specific embodiment of the invention.

[0020] Instead of comprising two layers the evaporator 4 may comprise three or more layers as well. This would lead to some changes as to how the pipes are connected with connection elements. Assume an evaporator having the two layers 8 and 10, as depicted, as well as an additional third layer. Assume that the eight pipes of the third layer are denoted 30a, 30b, ..., 30g, and 30h, in analogy with the first layer 8 and the second layer 10. The first section 18 of the refrigerant piping would have the same structure as in the exemplary embodiment of FIG. 1. However, the second section 22 of the refrigerant piping would have a fairly different layout. It would comprise the pipes 10c to 10h of the intermediate layer and the pipes 30c to 30h of the third layer. A plurality of options can be thought of as to how to connect these pipes with each other. A first option would be connecting - in refrigerant flow direction - pipes 10a, 30h, 10b, 30g, 10f, etc., forming a kind of sawtooth wave shape of the connection elements.

[0021] Another option would be connecting - in refrigerant flow direction - pipes 10h, 30h, 30g, 10g, 10f, 30f, etc., forming a kind of square wave shape of the connection elements. Both options have in common that the refrigerant flows in a generally counter-flow relationship with respect to the air flow direction 12 in the second section 22 of the refrigerant piping. Additional options, for example options combining the two above-described ways of connecting the individual pipes, can be thought of. It is apparent that the connection options increase with the number of layers of refrigerant pipes. As far as the third section 26 of the refrigerant piping is concerned, a lot of options for connections starting at the last pipe of the second section 22, i.e. either 10c or 30c, to the exit pipe 8a exist. As is clear from simple geometric considerations, there is no possibility of connecting all pipes without any connection elements exhibiting co-flow relationship with the air flow direction 12. Therefore, a lot of secondary considerations are left to be considered by the designer when establishing the connection element layout.

[0022] Exemplary embodiments of the invention, as described above, allow for energy-efficient cooling of the air flow through an evaporator in a refrigerating mode as well as for energy-efficient defrosting of said evaporator in a defrosting mode. Introducing the hot gas into a pipe in the middle portion of the bottom layer of the evaporator in the defrosting mode provides for a number of advantages. The region around the point of entry of the hot gas will be heated most and will be defrosted quickest. Therefore, the support structure, to which the evaporator is mounted, will be defrosted in the beginning stages of a

defrosting operation and thus will provide for an ice-free surface, which is ideal for receiving and draining the water that is generated throughout the defrosting process. Moreover, the water vapour, which is generated in the most heated portion of the evaporator during the defrosting process, will not be able to leave the evaporator, as it will not stay a vapour on its way to the end portions of the evaporator. Thus, energy losses due to the heated vapour leaving the evaporator to be defrosted are minimized and ice built-up in other parts of the refrigerating system, caused by said water vapour, is prevented. These aspects allow for a highly efficient defrosting of the evaporator, eliminating the need for or at least reducing the extent of additional means for defrosting in the support structure or in the evaporator itself. This even holds true, when CO₂ is used as the hot gas in the defrosting operation, which is fundamentally less attractive for use in defrosting, as no condensation takes place at pressures common to these evaporators. The defrosting operation in a refrigerant circuit in accordance with an embodiment of the invention is so energy-efficient that shorter defrosting times can be achieved than with electric defrosting. This time duration advantage is paired with the overall simplification of not having an additional electric defrosting system integrated into a refrigerating system.

[0023] In a further embodiment of the invention, the hot gas conduit is a by-pass conduit originating between the compressor and the expansion device and ending between the expansion device and the evaporator. This structure allows for using the same fluid for the refrigerating operation as well as for the defrosting operation, which is very cost-efficient. It also eliminates the need for having a full second fluid circuit for the fluid of the defrosting operation and eliminates the need for ensuring a strict separation of the refrigerating fluid and the defrosting fluid. This layout also allows for a minimum amount of piping used and thus for a very compact design of the refrigerating circuit.

[0024] Furthermore, the refrigerant entry pipe may be a pipe in the first half of the evaporator in the air flow direction. In the invention according to claim 1 a first section of the refrigerant piping of the evaporator comprises the entry pipe and the pipes on the bottom layer that are downstream of the entry pipe with regard to the air flow direction. This allows for an early and thorough heating of the bottom region of the evaporator in the defrosting process, which is beneficial to the draining of the melted water during the later stages of the defrosting. This first section leaves the beginning of the evaporator in the air flow direction out, which leaves the option of flowing the refrigerant therethrough shortly before leaving the evaporator, which in turn is beneficial in the refrigerating mode. Therefore, this layout is a good basis for achieving an excellent trade-off between the refrigerating and the defrosting modes.

[0025] It is furthermore possible that first connection elements connect respective adjacent pipes of the first

section of the refrigerant piping of the evaporator, such that in operation the refrigerant flows in a co-flow relationship with the air flow direction in the first connection elements. This allows for an advantageous heating of the bottom layer, and therefore of the underlying support structure, from a middle region towards an end region of the evaporator.

[0026] In another embodiment of the invention, a second section of the refrigerant piping of the evaporator comprises the pipes on the level of and downstream from the entry pipe with regard to the air flow direction above the bottom layer. It is also possible that second connection elements connect the pipes of the second section of the refrigerant piping of the evaporator, such that in operation the refrigerant flows in an overall counter-flow relationship with the air flow direction in the second connection elements. This allows for using an advantageous counter-flow relationship between the refrigerant and the air flow in the refrigerating mode. This layout furthermore allows for implementing the beneficial counter-flow for one or a plurality of layers above the bottom layer, i. e. in the second section of the refrigerant piping.

[0027] Moreover, it is possible that the first pipe in the air flow direction in the bottom layer is an exit pipe. This exit pipe may be connected to an evaporator outlet section of the refrigerant conduits. Having the refrigerant leave the evaporator in the first pipe in the air flow direction in the bottom layer ensures that the refrigerant flows last through the inlet region of the evaporator with regard to the air flow. In the refrigerating mode, this leads to a region of heat exchange between the air flow and the refrigerant, when they are both in their warmest state throughout the evaporator. This allows for the maximum amount of superheating of the refrigerant, when in gaseous form already, which provides for maximum use of the energetic capacity of the refrigerant in the refrigerating process.

[0028] In a further embodiment, a third section of the refrigerant piping of the evaporator comprises the pipes upstream of the refrigerant entry pipe with regard to the air flow direction. This allows for an extended region of heat transfer between the air flow and the refrigerant, where they are both at their substantially warmest in the refrigerating mode. It allows for that region to include all layers, forming a heat exchange region with above described properties across the whole cross-section of the air flow.

[0029] The refrigerant piping of the evaporator may comprise two or three layers. An evaporator having four, five or more layers can also be thought of. Each layer of the refrigerant piping of the evaporator may comprise five to ten pipes, particularly six to eight pipes. These numbers of pipes have been found to be beneficial for an efficient heat exchange both in the refrigerating and the defrosting mode. Depending on the application, less than five pipes or more than ten pipes may also constitute a good layer size.

[0030] In a further embodiment, the refrigerant entry

pipe is the second or third pipe in the air flow direction in the bottom layer of the refrigerant piping of the evaporator. This allows for the hot gas entering the evaporator towards the middle in the refrigerating mode, advantageously heating the middle portion of the bottom region of the evaporator first in a defrosting mode. It also leaves room for having a heat exchange area of relatively warm refrigerant and relatively warm air flow in the beginning of the evaporator with regard to the air flow direction, when the system is operated in the refrigerating mode.

[0031] The refrigerant may be CO₂. It can also be R22 or R404A or any other refrigerant suitable to the refrigerating circuit.

[0032] In an exemplary embodiment, the air flow in the evaporator is in the refrigerating mode cooled down to a temperature below 0°C. In other words, the invention is suitable for freezers and below 0°C refrigerating systems, where defrosting is a big issue.

[0033] It is also possible that the refrigerating circuit comprises two expansion devices and two evaporators, a first expansion device and a first evaporator forming a below 0°C refrigerating portion of the refrigerating circuit, the second expansion device and the second evaporator forming an above 0°C refrigerating portion of the refrigerating circuit. Accordingly, the invention can be applied to a dual system including a freezer and a refrigerator. In this case, the defrosting may be carried out on the freezing portion or on the refrigerating portion or on both portions. It is apparent that according piping and according compressing means will be necessary.

[0034] With the method of selectively cooling or defrosting an evaporator of a refrigerating circuit according to exemplary embodiments of the invention, as described above, the same advantages can be attained as with the refrigerating circuit. This method can be developed further by method steps corresponding to the features as described with regard to the refrigerating circuit. In order to avoid redundancy such embodiments and developments of the method of selectively cooling or defrosting an evaporator of a refrigerating circuit are not repeated.

[0035] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

Reference Numerals

[0036]

2 Expansion device

- 4 Evaporator
- 6 Hot gas conduit
- 8 Bottom layer of refrigerant piping of evaporator
- 10 Top layer of refrigerant piping of evaporator
- 12 Air flow direction
- 14 Evaporator inlet section of refrigerant conduits
- 16 Evaporator outlet section of refrigerant conduits
- 18 First section of refrigerant piping of evaporator
- 20 First connection elements
- 22 Second section of refrigerant piping of evaporator
- 24 Second connection elements
- 26 Third section of refrigerant piping of evaporator

Claims

1. Refrigerating circuit comprising a compressor, a condenser/gas cooler, an expansion device (2), an evaporator (4), and refrigerant conduits circulating a refrigerant therethrough, wherein the evaporator (4) comprises refrigerant piping comprising a plurality of substantially horizontal layers (8, 10) each layer comprising a plurality of pipes (8a-8h, 10a-10h) the pipes being substantially perpendicular to an air flow direction (12) from an air inlet region to an air outlet region of the evaporator (4), wherein a pipe selected from the group of the second pipe (8b) to the last but one pipe (8g) in the bottom layer (8) forms the entry pipe (8c) of the evaporator (4), wherein the entry pipe (8c) is connectable with the expansion device (2) to provide a refrigerating mode, wherein the entry pipe (8c) is connectable with a hot gas conduit (6) to provide a defrosting mode for the evaporator (4), **characterized by** a first section (18) of the refrigerant piping of the evaporator (4) comprises the entry pipe (8c) and the pipes (8d-8h) on the bottom layer (8) that are downstream of the entry pipe (8c) with regard to the air flow direction (12).
2. Refrigerating circuit according to claim 1, wherein the hot gas conduit is a by-pass conduit originating between the compressor and the expansion device (2) and ending between the expansion device (2) and the evaporator (4).
3. Refrigerating circuit according to claim 1 or 2, wherein the refrigerant entry pipe (8c) is a pipe in the first half of the evaporator (4) in the air flow direction (12).
4. Refrigerating circuit according to claim 1, wherein first connection elements (20) connect respective adjacent pipes (8c,8d; 8d,8e; 8e,8f; 8f,8g; 8g,8h) of the first section (18) of the refrigerant piping of the evaporator (4), such that in operation the refrigerant flows in a co-flow relationship with the air flow direction (12) in the first connection elements (20).
5. Refrigerating circuit according to claim 1 or 4, wherein in a second section (22) of the refrigerant piping of the evaporator (4) comprises the pipes (10c-10h) on the level of and downstream from the entry pipe (8c) with regard to the air flow direction (12) above the bottom layer (8).
6. Refrigerating circuit according to claim 5, wherein second connection elements (24) connect the pipes (10c-10h) of the second section (22) of the refrigerant piping of the evaporator (4), such that in operation the refrigerant flows in an overall counter-flow relationship with the air flow direction (12) in the second connection elements (24).
7. Refrigerating circuit according to any of the previous claims, wherein the first pipe (8a) in the air flow direction (12) in the bottom layer (8) is an exit pipe (8a).
8. Refrigerating circuit according to any of the claims 5 to 7, wherein a third section (26) of the refrigerant piping of the evaporator (4) comprises the pipes (8a, 8b, 10a, 10b) upstream of the refrigerant entry pipe (8c) with regard to the air flow direction (12).
9. Refrigerating circuit according to any of the previous claims, wherein the refrigerant piping of the evaporator (4) comprises 2 or 3 layers.
10. Refrigerating circuit according to any of the previous claims, wherein each layer (8, 10) of the refrigerant piping of the evaporator (4) comprises 5 to 10 pipes, particularly 6 to 8 pipes.
11. Refrigerating circuit according to any of the previous claims, wherein the refrigerant entry pipe is the second or third pipe in the air flow direction (12) in the bottom layer (8) of the refrigerant piping of the evaporator (4).
12. Refrigerating circuit according to any of the previous claims, wherein the refrigerant is CO₂.
13. Refrigerating circuit according to any of the previous claims, wherein the air flow in the evaporator is in the refrigerating mode cooled down to a temperature below 0°C.
14. Refrigerating circuit according to any of previous claims, wherein the refrigerating circuit comprises two expansion devices and two evaporators, a first expansion device and a first evaporator forming a below 0°C refrigerating portion of the refrigerating circuit, the second expansion device and the second evaporator forming an above 0°C refrigerating portion of the refrigerating circuit.
15. Method of selectively cooling or defrosting an evap-

orator (4) of a refrigerating circuit, the method comprising the steps of:

- (a) compressing a refrigerant,
- (b)
 - (i) flowing the refrigerant through a gas cooler/condenser and an expansion device (2), when cooling is selected, or
 - (ii) flowing the refrigerant through a hot gas by-pass conduit (6), when defrosting is selected,
- (c) flowing the refrigerant through refrigerant piping of the evaporator (4), the refrigerant piping comprising a plurality of substantially horizontal layers (8, 10) each layer (8, 10) comprising a plurality of pipes (8a-8h, 10a-10h), and
- (d) flowing air through the evaporator (4) with the air flow direction (12) being substantially perpendicular to the orientation of the pipes (8a-8h, 10a-10h),

wherein the refrigerant enters the refrigerant piping of the evaporator (4) at a pipe of the group from the second pipe (8b) to the last but one pipe (8g) in the bottom layer (8), **characterized in that** the refrigerant flows through a first section (18) of the refrigerant piping of the evaporator (4) comprising the entry pipe (8c) and the pipes (8d-8h) on the bottom layer (8) that are downstream of the entry pipe (8c) with regard to the air flow direction (12).

Patentansprüche

1. Kühlkreislauf, umfassend einen Verdichter, einen Kondensator/Gaskühler, eine Expansionseinrichtung (2), einen Verdampfer (4) und Kältemittelleitungen, welche ein Kältemittel darin zirkulieren, wobei der Verdampfer (4) Kältemittelrohrleitungen umfasst, welche eine Mehrzahl von im Wesentlichen horizontalen Lagen (8, 10) umfassen, wobei jede Lage eine Mehrzahl von Rohren (8a-8h, 10a-10h) umfasst, wobei die Rohre im Wesentlichen senkrecht zu einer Luftstromrichtung (12) von einem Lufteinlassbereich zu einem Luftauslassbereich des Verdampfers (4) sind, wobei ein Rohr, welches aus der Gruppe vom zweiten Rohr (8b) bis zum vorletzten Rohr (8g) in der unteren Lage (8) ausgewählt wird, das Einlassrohr (8c) des Verdampfers (4) bildet, wobei das Einlassrohr (8c) mit der Expansionseinrichtung (2) verbindbar ist, um einen Kühlmodus bereitzustellen, wobei das Einlassrohr (8c) mit einer Heißgasleitung (6) verbindbar ist, um einen Entfrostermodus für den Verdampfer (4) bereitzustellen, **dadurch gekenn-**

zeichnet, dass ein erster Abschnitt (18) der Kältemittelrohrleitung des Verdampfers (4) das Einlassrohr (8c) und die Rohre (8d-8h) auf der unteren Lage (8) umfasst, welche stromabwärts des Einlassrohrs (8c) in Bezug auf die Luftstromrichtung (12) angeordnet sind.

2. Kühlkreislauf nach Anspruch 1, wobei die Heißgasleitung eine Umgehungsleitung ist, die zwischen dem Verdichter und der Expansionseinrichtung (2) beginnt und zwischen der Expansionseinrichtung (2) und dem Verdampfer (4) endet.
3. Kühlkreislauf nach Anspruch 1 oder 2, wobei das Kältemiteleinlassrohr (8c) ein Rohr in der ersten Hälfte des Verdampfers (4) in Luftstromrichtung (12) ist.
4. Kühlkreislauf nach Anspruch 1, wobei erste Verbindungselemente (20) entsprechend angrenzende Rohre (8c,8d; 8d,8e; 8e,8f; 8f,8g; 8g,8h) des ersten Abschnitts (18) der Kältemittelrohrleitung des Verdampfers (4) verbinden, so dass das Kältemittel im Betrieb in einer Gleichstrombeziehung mit der Luftstromrichtung (12) in den ersten Verbindungselementen (20) strömt.
5. Kühlkreislauf nach Anspruch 1 oder 4, wobei ein zweiter Abschnitt (22) der Kältemittelrohrleitung des Verdampfers (4) die Rohre (10c-10h) auf der Ebene und stromabwärts des Einlassrohrs (8c) in Bezug auf die Luftstromrichtung (12) über der unteren Lage (8) umfasst.
6. Kühlkreislauf nach Anspruch 5, wobei zweite Verbindungselemente (24) die Rohre (10c-10h) des zweiten Abschnitts (22) der Kältemittelrohrleitung des Verdampfers (4) verbinden, so dass das Kältemittel im Betrieb in einer Gesamtgegenstrombeziehung mit der Luftstromrichtung (12) in den zweiten Verbindungselementen (24) strömt.
7. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei das erste Rohr (8a) in Luftstromrichtung (12) in der unteren Lage (8) ein Auslassrohr (8a) ist.
8. Kühlkreislauf nach einem der Ansprüche 5 bis 7, wobei ein dritter Abschnitt (26) der Kältemittelrohrleitung des Verdampfers (4) die Rohre (8a, 8b, 10a, 10b) stromaufwärts des Kältemiteleinlassrohrs (8c) in Bezug auf die Luftstromrichtung (12) umfasst.
9. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei die Kältemittelrohrleitung des Verdampfers (4) 2 oder 3 Lagen umfasst.
10. Kühlkreislauf nach einem der vorhergehenden An-

sprüche, wobei jede Lage (8, 10) der Kältemittelrohrleitung des Verdampfers (4) 5 bis 10 Rohre, insbesondere 6 bis 8 Rohre, umfasst.

11. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei das Kältemiteleinlassrohr das zweite oder dritte Rohr in Luftstromrichtung (12) in der unteren Lage (8) der Kältemittelrohrleitung des Verdampfers (4) ist.
12. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei das Kältemittel CO₂ ist.
13. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei der Luftstrom im Verdampfer im Kühlmodus auf eine Temperatur unter 0 °C heruntergekühlt wird.
14. Kühlkreislauf nach einem der vorhergehenden Ansprüche, wobei der Kühlkreislauf zwei Expansionseinrichtungen und zwei Verdampfer umfasst, wobei eine erste Expansionseinrichtung und ein erster Verdampfer einen unter 0 °C kühlenden Bereich des Kühlkreislaufs bilden und die zweite Expansionseinrichtung und der zweite Verdampfer einen über 0 °C kühlenden Bereich des Kühlkreislaufs bilden.
15. Verfahren zur selektiven Kühlung oder Entfrostung eines Verdampfers (4) eines Kühlkreislaufs, wobei das Verfahren die folgenden Schritte umfasst:
 - (a) Verdichten eines Kältemittels,
 - (b)
 - (i) Strömen des Kältemittels durch einen Gaskühler/Kondensator und eine Expansionseinrichtung (2), wenn Kühlen ausgewählt ist, oder
 - (ii) Strömen des Kältemittels durch eine Heißgasumgehungsleitung (6), wenn Entfrostung ausgewählt ist,
 - (c) Strömen des Kältemittels durch die Kältemittelrohrleitung des Verdampfers (4), wobei die Kältemittelrohrleitung eine Vielzahl von im Wesentlichen horizontalen Lagen (8, 10) umfasst, wobei jede Lage (8, 10) eine Vielzahl von Rohren (8a-8h, 10a-10h) umfasst, und
 - (d) Strömen von Luft durch den Verdampfer (4), wobei die Luftstromrichtung (12) im Wesentlichen senkrecht zur Ausrichtung der Rohre (8a-8h, 10a-10h) ist,wobei das Kältemittel in die Kältemittelrohrleitung des Verdampfers (4) an einem Rohr aus der Gruppe von dem zweiten Rohr (8b) bis zum vorletzten Rohr (8g) in der unteren Lage (8) eintritt, **dadurch ge-**

kennzeichnet, dass

das Kältemittel durch einen ersten Abschnitt (18) der Kältemittelrohrleitung des Verdampfers (4) strömt, welche das Einlassrohr (8c) und die Rohre (8d-8h) auf der unteren Lage (8) umfasst, welche stromabwärts des Einlassrohrs (8c) in Bezug auf die Luftstromrichtung (12) angeordnet sind.

10 Revendications

1. Circuit de réfrigération comprenant un compresseur, un condenseur/refroidisseur de gaz, un dispositif de détente (2), un évaporateur (4), et des conduits de frigorigène dans lequel circule un frigorigène. dans lequel l'évaporateur (4) comprend une tuyauterie de frigorigène présentant plusieurs couches sensiblement horizontales (8, 10), comprenant chacune plusieurs tuyaux (8a-8h, 10a-10h), les tuyaux étant sensiblement perpendiculaires à un sens d'écoulement de l'air (12) d'une zone d'admission d'air à une zone de sortie d'air de l'évaporateur (4), dans lequel un tuyau choisi dans le groupe formé du second (8b) à l'avant-dernier tuyau (8g) installé dans la couche de fond (8) constitue le tuyau d'admission (8c) de l'évaporateur (4), dans lequel le tuyau d'admission (8c) peut être raccordé au dispositif de détente (2) pour assurer un mode de réfrigération, dans lequel le tuyau d'admission (8c) peut être raccordé à un conduit de gaz chaud (6) pour assurer un mode de dégivrage pour l'évaporateur (4), **caractérisé par** une première section (18) de la tuyauterie de frigorigène de l'évaporateur (4) comprenant le tuyau d'admission (8c) et les tuyaux (8d-8h) sur la couche de fond (8) qui sont en aval du tuyau d'admission (8c) par rapport au sens d'écoulement de l'air (12).
2. Circuit de réfrigération selon la revendication 1, dans lequel le conduit de gaz chaud est un conduit de dérivation ayant son origine entre le compresseur et le dispositif de détente (2) et se terminant entre le dispositif de détente (2) et l'évaporateur (4).
3. Circuit de réfrigération selon la revendication 1 ou 2, dans lequel le tuyau d'admission du frigorigène (8c) est un tuyau dans la première moitié de l'évaporateur (4) dans le sens d'écoulement de l'air (12).
4. Circuit de réfrigération selon la revendication 1, dans lequel des premiers éléments de raccordement (20) sont raccordés à des tuyaux adjacents respectifs (8c, 8d ; 8d, 8e ; 8e, 8f ; 8f, 8g ; 8g, 8h) de la première section (18), de la tuyauterie de frigorigène de l'évaporateur (4), de sorte qu'en fonctionnement le frigorigène s'écoule dans une relation de co-écoulement avec le sens d'écoulement de l'air (12) dans les pre-

miers éléments de raccordement (20).

5. Circuit de réfrigération selon la revendication 1 ou 4, dans lequel une deuxième section (22) de la tuyauterie de frigorigène de l'évaporateur (4) comprend les tuyaux (10c-10h) au niveau et en aval du tuyau d'admission (8c) par rapport au sens d'écoulement de l'air (12) au-dessus de la couche de fond (8). 5
6. Circuit de réfrigération selon la revendication 5, dans lequel les seconds éléments de raccordement (24) sont raccordés aux tuyaux (10c-10h) de la deuxième section (22) de la tuyauterie de frigorigène de l'évaporateur (4), de sorte qu'en fonctionnement le frigorigène s'écoule dans une relation globalement à contre-courant avec le sens d'écoulement de l'air (12) dans les seconds éléments de raccordement (24). 10
7. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel le premier tuyau (8a) dans le sens d'écoulement de l'air (12) dans la couche de fond (8) est un tuyau de sortie (8a). 20
8. Circuit de réfrigération selon l'une quelconque des revendications 5 à 7, dans lequel une troisième section (26) de la tuyauterie de frigorigène de l'évaporateur (4) comprend les tuyaux (8a, 8b, 10a, 10b) en amont du tuyau d'admission de frigorigène (8c) par rapport au sens d'écoulement de l'air (12). 25
9. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel la tuyauterie de frigorigène de l'évaporateur (4) comprend 2 ou 3 couches. 30
10. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel chaque couche (8, 10) de la tuyauterie de frigorigène de l'évaporateur (4) comprend 5 à 10 tuyaux, en particulier 6 à 8 tuyaux. 35
11. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel le tuyau d'admission de frigorigène est le deuxième ou le troisième tuyau dans le sens d'écoulement de l'air (12) dans la couche de fond (8) de la tuyauterie de frigorigène de l'évaporateur (4). 40
12. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel le frigorigène est du CO₂. 45
13. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel l'écoulement de l'air dans l'évaporateur est dans le mode de réfrigération refroidi à une température inférieure à 0 °C. 50

14. Circuit de réfrigération selon l'une quelconque des revendications précédentes, dans lequel le circuit de réfrigération comprend deux dispositifs de détente et deux évaporateurs, un premier dispositif de détente et un premier évaporateur constituant une partie de réfrigération du circuit de réfrigération inférieure à 0 °C, le second dispositif de détente et le second évaporateur constituant une partie de réfrigération du circuit de réfrigération supérieure à 0 °C.

15. Procédé permettant de refroidir ou de dégivrer sélectivement un évaporateur (4) d'un circuit de réfrigération, le procédé comprenant les étapes consistant à :

- (a) compresser le frigorigène,
- (b)

(i) faire passer le frigorigène à travers un condensateur/refroidisseur de gaz et un dispositif de détente (2), quand la réfrigération est choisie, ou

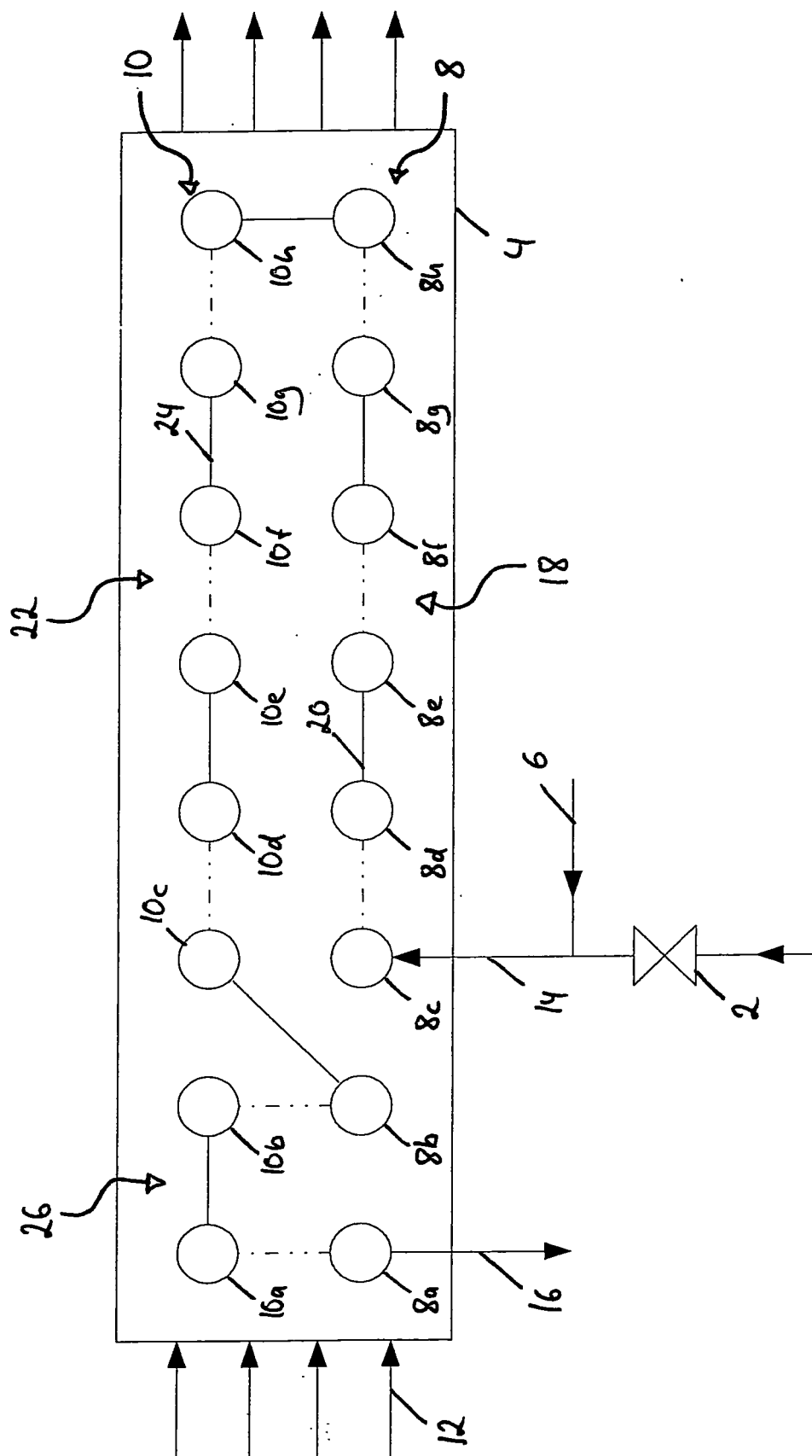
(ii) faire passer le frigorigène à travers un conduit de dérivation de gaz chaud (6), quand le dégivrage est choisi,

- (c) faire passer le frigorigène à travers la tuyauterie de frigorigène de l'évaporateur (4), la tuyauterie de frigorigène étant constituée de plusieurs couches sensiblement horizontales (8, 10) chaque couche (8, 10) comprenant plusieurs tuyaux (8a-8h, 10a-10h), et
- (d) faire passer l'air à travers l'évaporateur (4) le sens d'écoulement de l'air (12) étant sensiblement perpendiculaire à l'orientation des tuyaux (8a-8h, 10a-10h),

dans lequel le frigorigène pénètre dans la tuyauterie de frigorigène de l'évaporateur (4) au niveau d'un tuyau du groupe formé du second (8b) à l'avant-dernier tuyau (8g) dans la couche de fond (8), **caractérisé en ce que**

le frigorigène s'écoule à travers une première section (18) de la tuyauterie de frigorigène de l'évaporateur (4) comprenant le tuyau d'admission (8c) et les tuyaux (8d-8h) sur la couche de fond (8) qui sont en aval du tuyau d'admission (8c) par rapport au sens d'écoulement de l'air (12).

Fig. 1



REFERENCES CITED IN THE DESCRIPTION

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