(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) **EP 3 875 873 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.09.2021 Bulletin 2021/36

(51) Int Cl.:
F25B 47/02 $^{(2006.01)}$ ***F25B 41/00*** $^{(2021.01)}$

(21) Application number: **20161245.4**

(22) Date of filing: **05.03.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Carrier Corporation**
Palm Beach Gardens, FL 33418 (US)

(72) Inventors:
- **FREIBAUER, Mathias**
  65719 Hofheim am Taunus (DE)
- **NEEB, Christoph Karl**
  55128 Mainz (DE)

(74) Representative: **Dehns**
St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(54) REFRIGERATION SYSTEM WITH HOT GAS DEFROST

(57) A refrigeration system comprises a main refrigeration circuit comprising a compression device 12, a heat rejecting heat exchanger 14, an expansion device 18 and a heat absorbing heat exchanger 16. In addition, the refrigeration system includes a hot gas bypass line 20, wherein the hot gas bypass line is fluidly connected to the main refrigeration circuit at a point between the compression device 12 and the heat rejecting heat exchanger 14; and a valve 24 for controlling the flow of refrigerant fluid through the hot gas bypass line 20; wherein the heat absorbing heat exchanger 16 comprises a coil, the coil comprising an inlet and an outlet; wherein the hot gas bypass line 20 includes a first hot gas injection line 21 and a second hot gas injection line 22, the first hot gas injection line 21 being fluidly connected to the main refrigerant circuit between the inlet of the coil of the heat absorbing heat exchanger 16 and the expansion device 18, and the second hot gas injection line 22 being fluidly connected to the coil of the heat absorbing heat exchanger 16 at an intermediate point between the inlet and the outlet of the coil. The refrigeration system is arranged such that during a defrost mode of operation, the valve 24 is controlled to allow refrigerant fluid from the compression device 12 to flow through the hot gas bypass line 20 and the first and second hot gas injection lines 21, 22 in order to provide hot gas from the compression device 12 to enter into the coil of the heat absorbing heat exchanger 16 at two distinct points; the inlet of the coil and at the intermediate point. A method of controlling the defrost mode of operation of the refrigeration system is also provided.

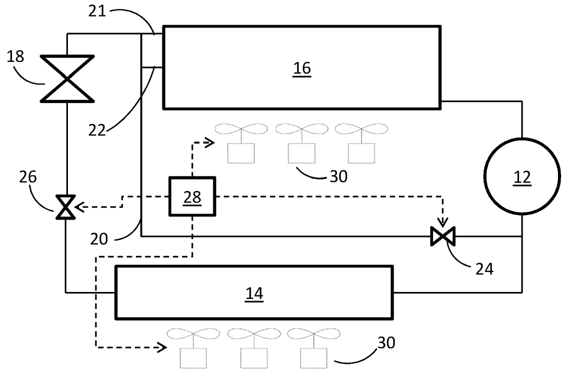

FIG. 1

EP 3 875 873 A1

Description

[0001] The present invention relates to refrigeration systems and more particularly to a refrigeration system having a defrost operation utilising hot gas refrigerant.

[0002] Refrigeration systems operating at temperatures below freezing will eventually experience an accumulation of frost on the cooling elements of evaporators from exposure to water vapour. The formation of ice on the cooling elements poses several issues. It can inhibit the efficient transfer of heat, and obstruct the flow of air through the evaporator, especially if large amounts of ice are allowed to build-up on the cooling elements. Hence, ice formation and build-up can lead to lower efficiency, increased energy consumption and increased running costs.

[0003] Therefore, in order to counteract these issues, it is known to provide refrigeration systems with a defrost mode of operation to remove frost from the surface of cooling elements. Existing hot gas defrost systems use the system's internal energy to defrost the cooling elements, utilising the naturally occurring high temperature compressor discharge gas to add the necessary heat required to accomplish the defrost cycle. A standard method of doing this is to introduce a distinct bypass pipe running from the outlet of the compressor to the inlet of the evaporator.

[0004] As the refrigerant flows forward through the evaporator its heat energy is transferred to the frost accumulation on the evaporator cooling elements.

[0005] One of the drawbacks with single evaporator systems utilizing hot gas defrost is the elimination of any meaningful load on the compressor during the defrost cycle. With the evaporator receiving hot gas at its inlet and acting like a condenser in the process of melting the accumulated frost, the refrigeration cycle cannot continue for long without a refrigeration load. So, the defrost duration needs to be extremely short on single evaporator systems.

[0006] It will therefore be appreciated that a reduction in defrost duration is desirable. It always remains the case that increases in efficiency and reductions in energy consumption are desirable.

[0007] According to a first aspect, there is provided a refrigeration system comprising: a main refrigeration circuit comprising: a compression device, a heat rejecting heat exchanger, an expansion device and a heat absorbing heat exchanger; a hot gas bypass line, wherein the hot gas bypass line is fluidly connected to the main refrigeration circuit at a point between the compression device and the heat rejecting heat exchanger; and a valve for controlling the flow of refrigerant fluid through the hot gas bypass line; wherein the heat absorbing heat exchanger comprises a coil, the coil comprising an inlet and an outlet; wherein the hot gas bypass line includes a first hot gas injection line and a second hot gas injection line, the first hot gas injection line being fluidly connected to the main refrigerant circuit between the inlet of the coil of the heat absorbing heat exchanger and the expansion device, and the second hot gas injection line being fluidly connected to the coil of the heat absorbing heat exchanger at an intermediate point between the inlet and the outlet of the coil; and wherein the refrigeration system is arranged such that during a defrost mode of operation, the valve is controlled to allow refrigerant fluid from the compression device to flow through the hot gas bypass line and the first and second hot gas injection lines in order to provide hot gas from the compression device to enter into the coil of the heat absorbing heat exchanger at two distinct points; the inlet of the coil and at the intermediate point.

[0008] The use of a hot gas bypass line to inject hot gaseous refrigerant directly into the coil of the heat absorbing heat exchanger has the advantage, in comparison to electric defrost methods, of warming the coil from the inside, ensuring the majority of the thermal energy is directed to warming the accumulated frost. The use of a second injection line, to inject hot gaseous refrigerant at the intermediate point, which is a second distinct location in the coil of the heat absorbing heat exchanger, allows part of the hot gas refrigerant to directly reach a later portion of the coil of the heat absorbing heat exchanger, which is usually subject to higher frost accumulation. Hot gas can hence be used to defrost these later portions of the coil without losing thermal energy due to flow through an earlier portion of the coil and the environment surrounding the coil. The use of a hot gas bypass line with a first hot gas injection line and a second hot gas injection line therefore ensures that the whole coil of the heat absorbing heat exchanger is subject to a more even heat distribution during a defrost mode of operation. This more efficient use of the thermal energy of the hot gaseous refrigerant provides a refrigeration system with a lower overall energy consumption during defrost and a shorter defrost duration.

[0009] The refrigeration system may be arranged such that when there is excessive frost accumulation then a valve can be controlled such that a defrost mode of operation is initiated and refrigerant fluid is directed into the hot gas bypass line from the main refrigeration circuit. The valve may be operated manually, or the refrigeration system may include a controller for automatic control of the valve, in order to achieve this.

[0010] This controller may also control other elements within the refrigeration circuit, such as the compression device and/or the expansion device. The controller may receive temperature measurements from sensors, such as a sensor for ambient air temperature (outside air temperature), a sensor for temperature of the temperature controlled environment, and/or sensors within the main refrigeration circuit or the bypass line such as for measuring temperatures and/or pressures. The sensors may be comprised as a part of the refrigeration system.

[0011] The controller may control the valve in response to measurements received from sensors, or a defrost mode of operation may be initiated automatically, for example if a certain time has lapsed since a previous defrost operation was undertaken. Precise control of the defrost operations of the refrigeration system can minimise the amount of wasted energy and reduce overall energy consumption. The controller may also be configured to allow for a manual initiation of the defrost mode, such as in response to input from a maintenance technician or other user.

[0012] The main refrigeration circuit may not generally include any further components, i.e. be a typical single-stage vapor-compression refrigeration system.

[0013] The main refrigeration circuit may not include any other components between the compression device and the heat absorbing heat exchanger.

[0014] The main refrigeration circuit may not include any other components between the heat absorbing heat exchanger and the expansion device.

[0015] The main refrigeration circuit may not include any other components between the expansion device and the heat rejecting heat exchanger.

[0016] The main refrigeration circuit may not include any other components between the heat rejecting heat exchanger and the compression device.

[0017] The hot gas bypass line may be arranged such that it provides a direct connection between the outlet of the compression device and the coil of the heat absorbing heat exchanger. The refrigeration fluid may not undergo any thermodynamic change when flowing from the outlet of the compression device to the coil of the heat absorbing heat exchanger through the hot gas bypass line. The refrigeration fluid may not undergo any heat exchange, i.e. lose and/or gain heat to and/or from another portion of the refrigeration system, when flowing from the outlet of the compression device to the coil of the heat absorbing heat exchanger through the hot gas bypass line.

[0018] The hot gas bypass line may comprise no further components.

[0019] By providing a direct connection between the outlet of the compression device and the coil of the heat absorbing heat exchanger, the maximum amount of heat energy within the refrigeration fluid can be used to defrost the coil. By not undergoing any thermodynamic changes or heat exchange the refrigeration fluid arrives at the coil at about the same temperature as it leaves the outlet of the compression device, and therefore at the maximum possible temperature. This ensures full and complete defrost using all the heat energy available within the hot gas refrigerant.

[0020] The refrigeration system may include other valves in order to further control or maintain the flow of refrigerant, such as further solenoid valves or check valves. The main refrigeration circuit may include further valves to ensure proper functioning of the components within the main refrigeration circuit, such as a pressure regulator valve at the outlet of the heat absorbing heat exchanger to modulate the pressure of the refrigerant before it reaches the intake of the compression device. Proper and reliable operation of the refrigeration system therefore may be achieved.

[0021] The refrigeration system may include fans configured to draw air over the heat absorbing heat exchanger and/or the heat rejecting heat exchanger. The heat absorbing heat exchanger fans may further be operated to direct cooling air into the temperature controlled environment during normal operation of the refrigeration system, thereby achieving improved circulation of the air in the temperature controlled environment.

[0022] The fans may be turned off, by the controller or otherwise, upon starting the defrost mode of operation. The fans may be turned off for the entire defrost process. Alternatively, the heat absorbing heat exchanger fans may be turned back on during the defrost mode of operation after a certain period of time. In this way, the air surrounding the cooling elements of the heat absorbing heat exchanger fans is allowed to warm more uniformly and to a higher temperature before being actively passed to the temperature controlled environment, where ice removal may also be desired.

[0023] The second hot gas injection line may comprise one or more hot gas injection lines, each one of the one or more hot gas injection lines being fluidly connected to the coil of the heat absorbing heat exchanger at a branch point between the inlet and the outlet of the coil. The branch points may be evenly distributed along the length of the coil, or alternatively may be attached at points that are randomly, or otherwise, distributed along the length of the coil of the heat absorbing heat exchanger. By distributing the branch points along the length of the coil according to the demands of the defrost operation of the refrigeration system, those parts of the coil which experience a heavier accumulation of frost can be more specifically targeted with hot gaseous refrigerant. Thus, by not wasting this thermal energy to other, earlier parts of the coil or to the temperature controlled environment, more complete and efficient defrost of the coil of the heat absorbing heat exchanger may be achieved.

[0024] The location of the intermediate point of injection may be chosen according to the considerations of the refrigeration system, wherein the considerations may include the concentration of frost accumulation and/or the positioning of the heat absorbing heat exchanger relative to the fans and/or the path the melted frost takes as it flows away from the coil of the heat absorbing heat exchanger.

[0025] The heat absorbing heat exchanger may be a multi-circuit heat absorbing heat exchanger comprising a plurality of coil circuits. In this embodiment, the expansion device is connected to an inlet of a refrigerant distributor, but in other embodiments the main refrigeration circuit may branch to a plurality of expansion devices, each one of the plurality of expansion devices connected to the inlet of a corresponding one of the plurality of coil circuits. Preferably, the refrigerant distributor is mounted directly to the expansion device outlet, but optionally is connected by a straight line. The refrigerant distributor has a plurality of outlets, wherein each outlet is connected to the inlet of a corresponding one of the plurality of coil circuits via distribution tubing.

[0026] The first hot gas injection line of the bypass line may extend to an intermediate inlet of the refrigerant distributor, or to a branch point in the main refrigeration circuit between the distributor and the expansion device.

[0027] As discussed above, the second hot gas injection line may comprise one or more hot gas injection lines. Each of these one or more injection lines may extend to a respective refrigerant distributor. Each refrigerant distributor has a plurality of outlets, wherein each outlet is connected to a branch point in a corresponding one of the plurality of coil circuits via distribution tubing.

[0028] Thus, each one of the one or more hot gas injection lines is fluidly connected to a branch point on each one of the plurality of coil circuits. These branch points may be distributed evenly along the length of each coil circuit, or may be randomly, or otherwise, distributed along the length of each coil circuit. Each of the plurality of coil circuits may have the same distribution of branch points, or may have a different distribution of branch points, depending on the requirements of the defrosting operation.

[0029] The use of refrigerant distributors ensures that refrigerant, which may be two-phase refrigerant having a mix of liquid and gas phases, is distributed to each of the plurality of coil circuits evenly during both normal operation and defrost operation. This is beneficial to the effectiveness and reliability of the refrigeration system during normal operation, and ensures complete defrost of each coil circuit during defrost operation.

[0030] The compression device may be any suitable device for raising the pressure of the refrigerant fluid, and hence may be a compressor of any suitable type, such as a compressor known for refrigeration circuits. For some types of refrigeration systems the compression device may be a pump. The compression device may be arranged to operate with single phase refrigerant, i.e. fully gaseous refrigerant, or with a two phase refrigerant having a mix of liquid and gas phases. The compression device can have an inlet connected to a fluid pathway from the heat absorbing heat exchanger and an outlet connected to a fluid pathway to the heat rejecting heat exchanger. In some examples the fluid pathways provide a direct connection with no other refrigeration system components that would modify the state of the refrigerant fluid.

[0031] The expansion device may be any suitable device for reducing the pressure of the refrigerant fluid, such as an expansion valve, or a separator with an expansion function. The expansion device may be arranged to provide a controllable degree of expansion, such as via use of a valve with a controllable degree of opening. The expansion valve may be an electronic expansion valve. The expansion valve may be an externally equalized expansion valve.

[0032] The heat absorbing heat exchanger may be an evaporator. The heat rejection heat exchanger may be a condenser.

[0033] According to another aspect, there is provided a method of controlling a defrost mode of operation of a refrigeration system, wherein the refrigeration system comprises: a main refrigeration circuit comprising: a compression device, a heat rejecting heat exchanger, an expansion device and a heat absorbing heat exchanger; a hot gas bypass line, wherein the hot gas bypass line is fluidly connected to the main refrigeration circuit at a point between the compression device and the heat rejecting heat exchanger; and a valve for controlling the flow of refrigerant fluid through the hot gas bypass line; wherein the heat absorbing heat exchanger comprises a coil, the coil comprising an inlet and an outlet; wherein the hot gas bypass line includes a first hot gas injection line and a second hot gas injection line, the first hot gas injection line being fluidly connected to the main refrigerant circuit between the inlet of the coil of the heat absorbing heat exchanger and the expansion device, and the second hot gas injection line being fluidly connected to the coil of the heat absorbing heat exchanger at an intermediate point between the inlet and the outlet of the coil; the method comprising: controlling the valve to initiate a defrost mode of operation and allow refrigerant fluid from the compression device to flow through the hot gas bypass line and the first and second hot gas injection lines in order to provide hot gas from the compression device to enter into the coil of the heat absorbing heat exchanger at two distinct points; the inlet of the coil and at the intermediate point.

[0034] The controlling of the valve may be manual, or the refrigeration system may include a controller for automatic controlling of the valve, in order to achieve this.

[0035] The method of controlling a defrost mode of operation may also comprise controlling elements within the main refrigeration circuit, such as the compression device and/or the expansion device.

[0036] The method of controlling a defrost mode of operation may also comprise the controller receiving temperature measurements from sensors, such as a sensor for ambient air temperature (outside air temperature), a sensor for temperature of the temperature controlled environment, and/or sensors within the main refrigeration circuit or the bypass line such as for measuring temperatures and/or pressures.

[0037] The controlling of the valve by the controller may be in response to measurements received from sensors.

[0038] The controlling of the valve by the controller may be initiated automatically, for example if a certain time has lapsed since a previous defrost operation was undertaken.

[0039] The controlling of the valve by the controller may be manually initiated such as in response to input from a maintenance technician or other user.

[0040] The method of controlling a defrost mode of operation may also comprise controlling other valves in the main refrigeration circuit and/or the hot gas bypass line.

[0041] The method of controlling a defrost mode of operation may also comprise controlling fans configured to draw air over the heat absorbing heat exchanger and/or the heat rejecting heat exchanger. The heat absorbing heat exchanger fans may further be controlled to direct cooling air into the temperature controlled environment during normal operation of the refrigeration system, thereby achieving improved circulation of the air in the temperature controlled environment.

[0042] The controlling of the fans may comprise turning the heat absorbing heat exchanger and/or the heat rejecting heat exchanger fans off upon starting the defrost mode of operation. The heat absorbing heat exchanger fans may be turned off for the entire defrost process. Alternatively, the heat absorbing heat exchanger fans may be turned back on during the defrost mode of operation after a certain period of time. In this way, the air surrounding the cooling elements of the heat absorbing heat exchanger fans is allowed to warm more uniformly and to a higher temperature before being actively passed to the temperature controlled environment, where ice removal may also be desired.

[0043] Certain preferred embodiments of the present invention will now be described, by way of example only, with reference to the following drawings, in which:

Figure 1 is a schematic diagram for a refrigeration system using a main refrigeration circuit and a hot gas bypass line connected to the main refrigeration circuit;

Figure 2 shows a schematic diagram of a multi-circuit evaporator;

Figure 3 shows temperatures at evaporator coil bends during a hot gas defrost operation of an evaporator where hot gas is injected at the inlet only; and

Figure 4 shows temperatures at evaporator coil bends during a hot gas defrost operation of an evaporator where hot gas is injected at the inlet as well as at an intermediate point (evaporator coil bend 6).

[0044] As seen in Figure 1, a refrigeration system includes a compression device 12, a heat rejecting heat exchanger 14, an expansion device 18 and a heat absorbing heat exchanger 16 that together form a main refrigeration circuit. The main refrigeration circuit contains a refrigerant fluid and circulation of the refrigerant fluid via the compression device 12 enables the refrigeration system to utilise a refrigeration cycle (or heat pump cycle) to satisfy a cooling (or heating) load. In this example the compression device 12 is a compressor 12 for compression of gaseous refrigerant fluid, the heat rejecting heat exchanger 14 is a condenser for at least partially condensing the refrigerant fluid, the expansion device 18 is an expansion valve for expanding the refrigerant fluid, and the heat absorbing heat exchanger 16 is an evaporator for at least partially evaporating the refrigerant fluid. The refrigeration system may advantageously be arranged so that the fluid is fully condensed at the condenser 14, and fully evaporated at the evaporator 16. In many cases it is beneficial to avoid the presence of liquid at the inlet to the compressor 12.

[0045] The refrigeration system is configured to provide control and maintenance of temperature conditions of an environment, such as the inside of a freezer cabinet. The main refrigeration circuit may be situated outside of the temperature controlled environment. Air passages may be provided to allow air to circulate between the main refrigeration circuit and the temperature controlled environment, and the refrigeration system may include fans 30 configured to direct air across the condenser 14 and the evaporator 16 and into or away from the temperature controlled environment.

[0046] The refrigeration system includes a hot gas bypass line 20 for use in a defrost mode of operation. The inlet of the hot gas bypass line is attached to the main refrigerant circuit via the discharge line between the outlet of the compressor 12 and the inlet of the condenser 14. The hot gas bypass line 20 includes a valve 24, which is a solenoid valve with an open state and a closed state, and may include a check valve or a pressure regulator/flow control (not shown). The hot gas bypass line 20 includes a first hot gas injection line 21 and a second hot gas injection line 22. The first hot gas injection line 21 may be attached to the main refrigeration circuit between the outlet of the expansion valve 18 and the inlet of the evaporator 16. The second hot gas injection line 22 may be attached to the evaporator coil between the inlet and the outlet of the evaporator 16, preferably halfway between the inlet and the outlet of the evaporator 16.

[0047] The second hot gas injection line 22 may comprise one or more injection lines which may be attached to the evaporator coil between the inlet and the outlet of the evaporator 16. The one or more hot gas injection lines may be attached to the evaporator coil at points evenly distributed along the length of the evaporator coil, but may also be attached at points that are randomly or otherwise distributed along the length of the evaporator coil.

[0048] The refrigeration system includes a controller 28 for automatic control of the valve 24 and the fans 30.

[0049] The main refrigeration circuit may also include a solenoid valve 26, with an open and closed state, between the expansion valve 18 and the condenser 14. The valve 26 is controlled by the controller 28 in order to control the flow of refrigerant fluid through the main refrigerant circuit.

[0050] In Figure 2 a multi-circuit evaporator 16 is shown. The evaporator 16 in Figure 2 comprises a plurality of evaporator coils 36.

[0051] In order to facilitate the use of multi-circuit evaporator 16, the main refrigeration circuit may include a refrigerant distributor 31 installed between the outlet of the expansion valve 18 adapted to distribute the refrigerant to the inlet of each of the plurality of coils 36 of the evaporator 16. The first injection line 21 may be directly connected to the distributor 31, as in Figure 2, or the first injection line may 21 be directly connected to the line between the outlet of the expansion valve 18 and the inlet of the distributor 31.

[0052] The second injection line 22 may be directly connected to a refrigerant distributor 32 which is adapted to distribute the heated refrigerant to an injection point of each of the plurality of coils 36, wherein the injection point is between the inlet and the outlet of each of the plurality of coils 36. The injection point may be halfway between the inlet and the outlet of each of the plurality of coils 36, or it may be closer to either the inlet or the outlet.

[0053] The operation of the system is now described with reference to Figures 1 and 2.

[0054] A defrost mode of operation may be initiated automatically, for example if a certain time has lapsed since a previous defrost cycle was undertaken, or manually. During normal operation of the refrigeration system, the main refrigeration circuit is operated in a cooling mode to cool the air within the temperature-controlled environment (freezer cabinet). Valve 26 is open and valve 24 is closed, and fans 30 are turned on. Refrigerant circulates through the main refrigerant circuit in a normal refrigerant cycle, and the fans 30 draw air across the evaporator 16 and pass the cooled air into/through the temperature-controlled environment.

[0055] Upon switching from normal operation to a defrost operation, the controller 28 will open valve 24 and close valve 26, and fans 30 are turned off. Hot refrigeration fluid is diverted from the discharge line through the hot gas bypass line 20 and into first injection line 21 and second injection line 22. First injection line 21 delivers hot refrigeration fluid into distributor 31 which evenly distributes the refrigeration fluid between the inlets of each of the plurality of coils 36. Second injection line 22 delivers hot refrigeration fluid into distributor 32 which evenly distributes the refrigeration fluid between the injection points of each of the plurality of coils 36.

[0056] By injecting hot refrigerant into the evaporator coils in two or more separate locations, the thermal energy of the refrigerant is more evenly distributed in the evaporator. The thermal energy is therefore more effectively used, and the defrost duration is shortened. The refrigeration system can therefore quickly resume normal operation. The overall energy consumption of the refrigeration system is also lowered.

[0057] The refrigeration system may not include any elements other than those shown in Figure 1, i.e. the main refrigeration circuit may be a typical single-stage vapor-compression refrigeration system. Alternatively, the refrigeration system may include other elements not shown in Figure 1, such as a pressure regulator valve at the outlet of the evaporator 16 to modulate the pressure of the refrigerant before it reaches the intake of the compressor 12. The refrigeration system may also include other more complex additions to the main refrigeration circuit or hot gas bypass line 20 such as to adapt the refrigeration system for particular requirements.

Claims

1. A refrigeration system comprising:

a main refrigeration circuit comprising: a compression device, a heat rejecting heat exchanger, an expansion device and a heat absorbing heat exchanger;

a hot gas bypass line, wherein the hot gas bypass line is fluidly connected to the main refrigeration circuit at a point between the compression device and the heat rejecting heat exchanger; and

a valve for controlling the flow of refrigerant fluid through the hot gas bypass line;

wherein the heat absorbing heat exchanger comprises a coil, the coil comprising an inlet and an outlet;

wherein the hot gas bypass line includes a first hot gas injection line and a second hot gas injection line, the first hot gas injection line being fluidly connected to the main refrigerant circuit between the inlet of the coil of the heat absorbing heat exchanger and the expansion device, and the second hot gas injection line being fluidly connected to the coil of the heat absorbing heat exchanger at an intermediate point between the inlet and the outlet of the coil; and

wherein the refrigeration system is arranged such that during a defrost mode of operation, the valve is controlled to allow refrigerant fluid from the compression device to flow through the hot gas bypass line and the first and second hot gas injection lines in order to provide hot gas from the compression device to enter into the coil of the heat absorbing heat exchanger at two distinct points; the inlet of the coil and at the intermediate point.

2. A refrigeration system as claimed in claim 1, wherein the refrigeration system further comprises a controller, the controller being configured to control the valve.

3. A refrigeration system as claimed in claim 1 or claim 2, wherein the hot gas bypass line is arranged to provide a direct connection between the outlet of the compression device and the coil of the heat absorbing heat exchanger.

4. A refrigeration system as claimed in claim 3, wherein the hot gas bypass line is arranged such that the hot gas from the compression device does not undergo any thermodynamic change when flowing from the outlet of the compression device to the coil of the heat absorbing heat exchanger.

5. A refrigeration system as claimed in claim 3 or claim

4, wherein the hot gas bypass line is arranged such that the hot gas from the compression device does not undergo heat exchange when flowing from the outlet of the compression device to the coil of the heat absorbing heat exchanger.

6. A refrigeration system as claimed in any preceding claim, wherein the main refrigeration circuit does not include any other components between the compression device and the heat absorbing heat exchanger.

7. A refrigeration system as claimed in any preceding claim, wherein the intermediate point is between the middle of the coil and the outlet of the coil.

8. A refrigeration system as claimed in any of claims 1 to 6, wherein the second hot gas injection line comprises one or more hot gas injection lines, each one of the one or more hot gas injection lines being fluidly connected to the coil of the heat absorbing heat exchanger at a respective intermediate point between the inlet and the outlet of the coil.

9. A refrigeration system as claimed in claim 8, wherein the respective intermediate points are distributed evenly along the length of each of the plurality of coil circuits.

10. A refrigeration system as claimed in any preceding claim, wherein the heat absorbing heat exchanger is a multi-circuit heat absorbing heat exchanger comprising a plurality of coils.

11. A refrigeration system as claimed in claim 10 when dependent on claim 8 or claim 9, wherein each of the one or more hot gas injection lines extends to the inlet of a refrigerant distributor, each refrigerant distributor having a plurality of outlets, each outlet connected to a corresponding one of the plurality of coils at the respective intermediate point between the inlet and the outlet of the coil.

12. A refrigeration system as claimed in claim 10 or claim 11, wherein the outlet of the expansion device is connected to an inlet of a refrigerant distributor, the refrigerant distributor having a plurality of outlets, each outlet connected to the inlet of a corresponding one of the plurality of coils.

13. A refrigeration system as claimed in any of claims 10 to 12, wherein the first hot gas injection line of the bypass line extends to an intermediate inlet of the refrigerant distributor.

14. A method of controlling a defrost mode of operation of a refrigeration system, wherein the refrigeration system comprises:

a main refrigeration circuit comprising: a compression device, a heat rejecting heat exchanger, an expansion device and a heat absorbing heat exchanger;

a hot gas bypass line, wherein the hot gas bypass line is fluidly connected to the main refrigeration circuit at a point between the compression device and the heat rejecting heat exchanger; and

a valve for controlling the flow of refrigerant fluid through the hot gas bypass line;

wherein the heat absorbing heat exchanger comprises a coil, the coil comprising an inlet and an outlet;

wherein the hot gas bypass line includes a first hot gas injection line and a second hot gas injection line, the first hot gas injection line being fluidly connected to the main refrigerant circuit between the inlet of the coil of the heat absorbing heat exchanger and the expansion device, and the second hot gas injection line being fluidly connected to the coil of the heat absorbing heat exchanger at an intermediate point between the inlet and the outlet of the coil; the method comprising:

controlling the valve to initiate a defrost mode of operation and allow refrigerant fluid from the compression device to flow through the hot gas bypass line and the first and second hot gas injection lines in order to provide hot gas from the compression device to enter into the coil of the heat absorbing heat exchanger at two distinct points; the inlet of the coil and at the intermediate point.

15. A method of controlling a defrost mode of operation as claimed in claim 14, wherein the valve is controlled by a controller.

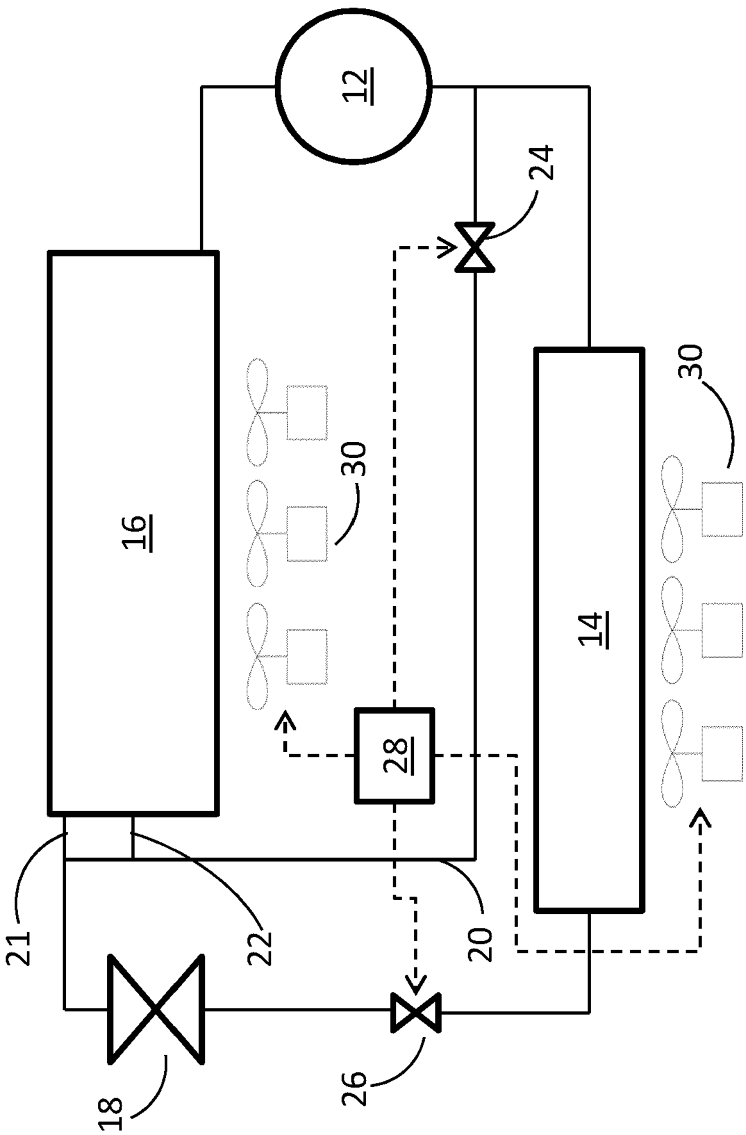

FIG. 1

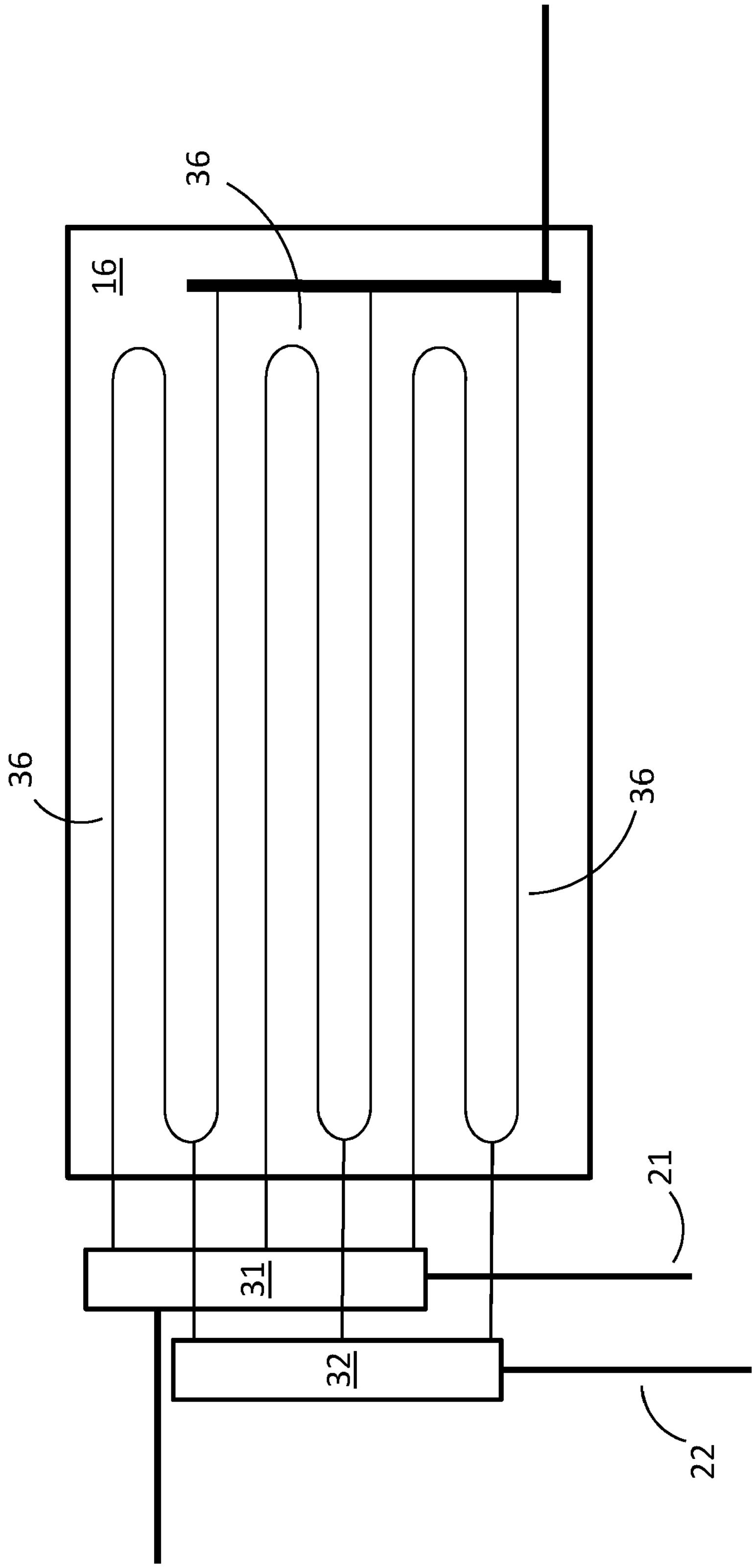

FIG. 2

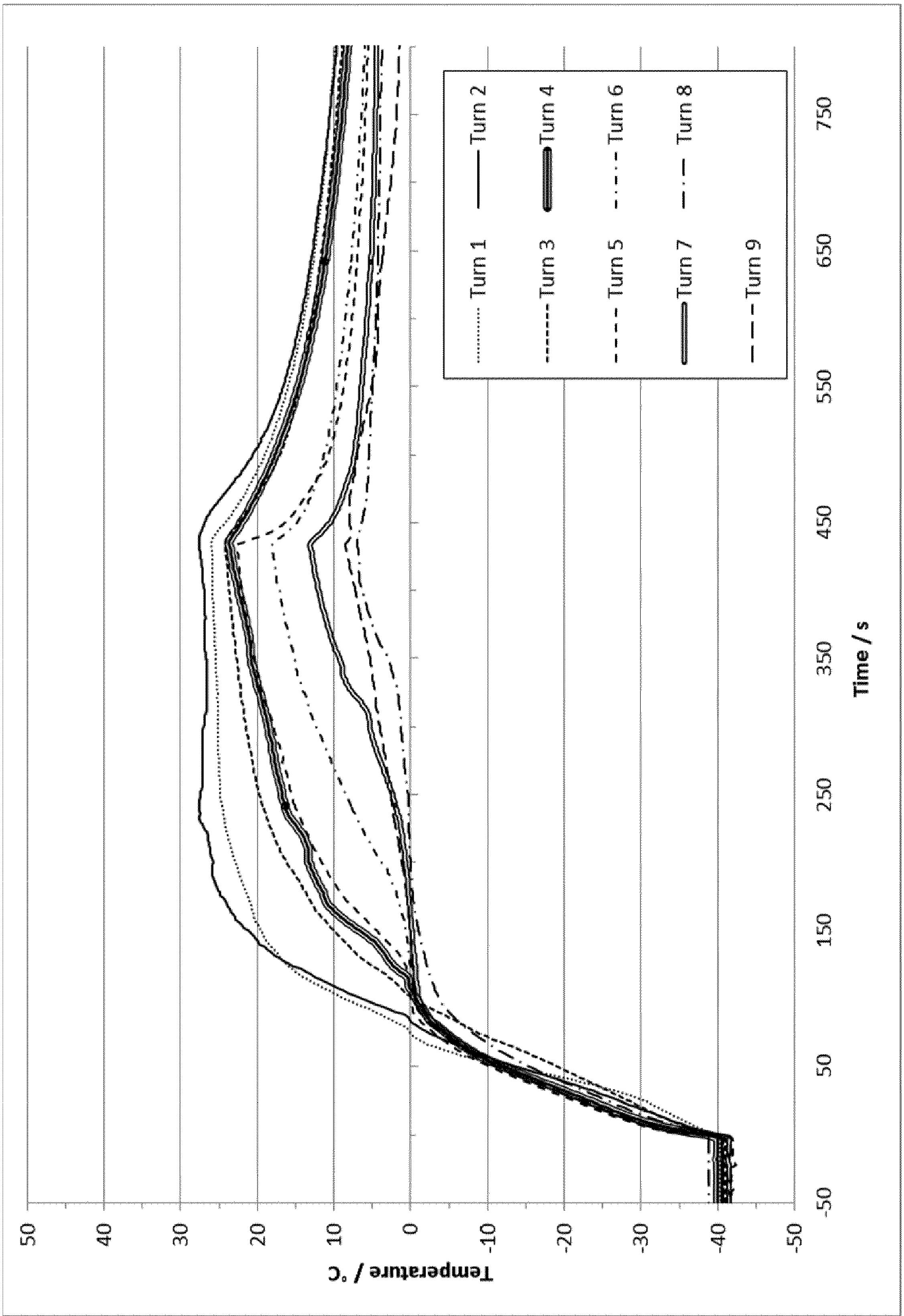
Temperature / °C
Time / s
50
40
30
20
10
0
-10
-20
-30
-40
-50
-50
50
150
250
350
450
550
650
750
Turn 1
Turn 2
Turn 3
Turn 4
Turn 5
Turn 6
Turn 7
Turn 8
Turn 9

FIG. 3

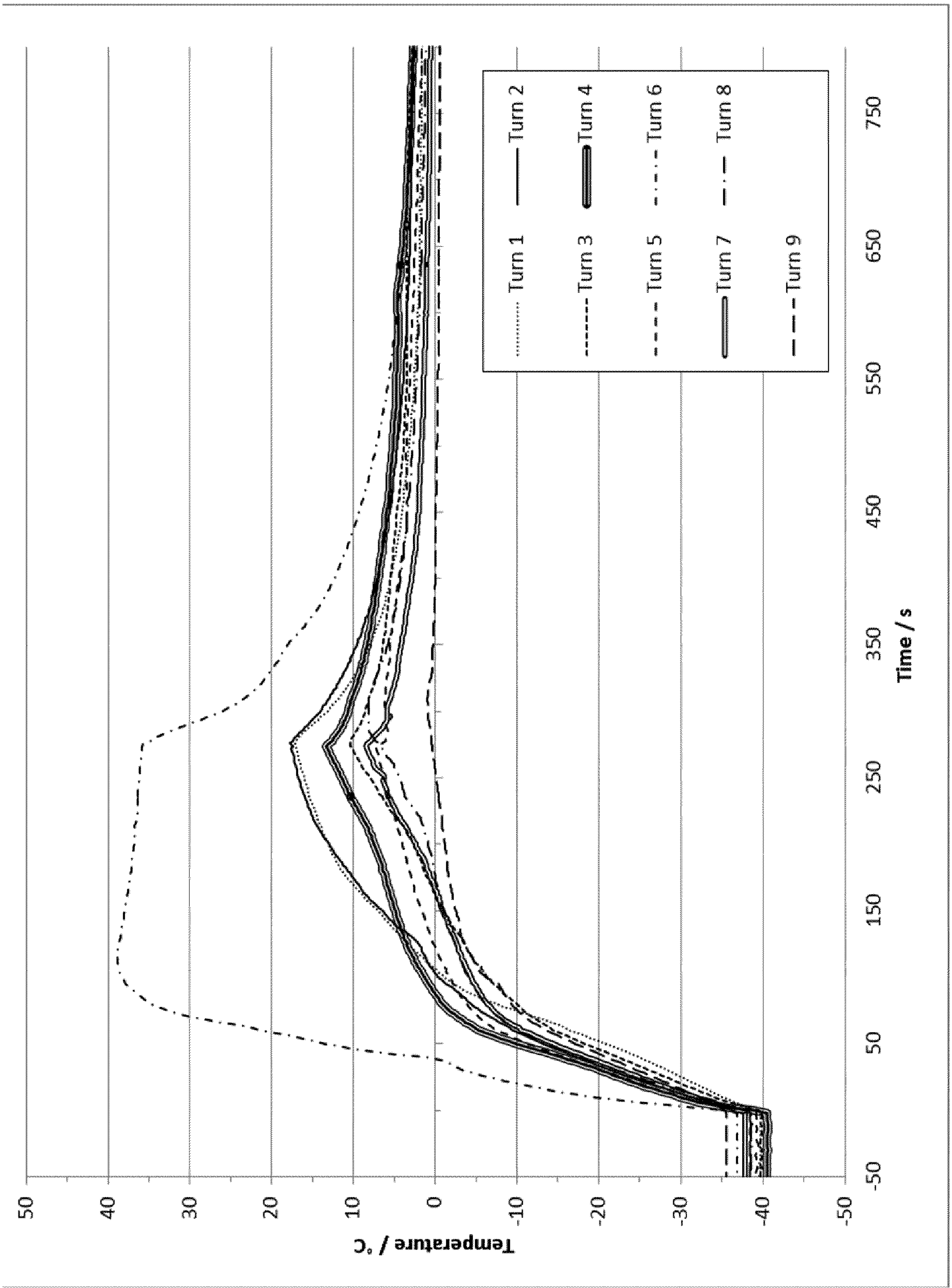
Temperature / °C
Time / s
50
40
30
20
10
0
-10
-20
-30
-40
-50
-50
50
150
250
350
450
550
650
750
Turn 1
Turn 2
Turn 3
Turn 4
Turn 5
Turn 6
Turn 7
Turn 8
Turn 9

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 16 1245

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	JP S52 118260 U (HITACHI LTD.) 7 September 1977 (1977-09-07) * paragraph [0002]; figure 1 * -----	1-9,14, 15 10-13	INV. F25B47/02 F25B41/00
X Y	KR 102 049 426 B1 (DAESUNG MAREF CO LTD [KR]) 28 November 2019 (2019-11-28) * paragraphs [0032] - [0050]; figure 1 * -----	1-9,14, 15 10-13	
Y	US 4 625 524 A (KIMURA TAKASHI [JP] ET AL) 2 December 1986 (1986-12-02) * column 2, lines 41-63; figure 1 * -----	10-13	
Y	CN 107 084 561 A (TCL AIR CONDITIONER CO LTD) 22 August 2017 (2017-08-22) * paragraphs [0042] - [0048], [0055] - [0059]; figures 1,2,5 * -----	10-13	
A	JP S55 79756 U (MITSUBISH ELECTRIC CORP.) 2 June 1980 (1980-06-02) * paragraph [0002]; figures 1,2 * -----	1-3,6-15	

TECHNICAL FIELDS SEARCHED (IPC)
F25B

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 August 2020	Weisser, Meinrad

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 ON EUROPEAN PATENT APPLICATION NO. EP 20 16 1245

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-08-2020

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP S52118260	U	07-09-1977	NONE		
KR 102049426	B1	28-11-2019	NONE		
US 4625524	A	02-12-1986	EP 0184200	A2	11-06-1986
			JP H0686969	B2	02-11-1994
			JP S61240063	A	25-10-1986
			US 4625524	A	02-12-1986
CN 107084561	A	22-08-2017	NONE		
JP S5579756	U	02-06-1980	NONE		

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82