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(54) No-frost refrigerator and method for controlling it

(57) A no-frost refrigerator comprises a sequential refrigeration circuit having a compressor, a condenser and at least two evaporators downstream a valve configured to direct refrigerant flow to any said evaporators. The refrigerator also comprises a second valve configured to divert refrigerant flow downstream the compressor towards at least one auxiliary condenser in series with the condenser and in heat exchange with at least one of the evaporators for its defrosting.

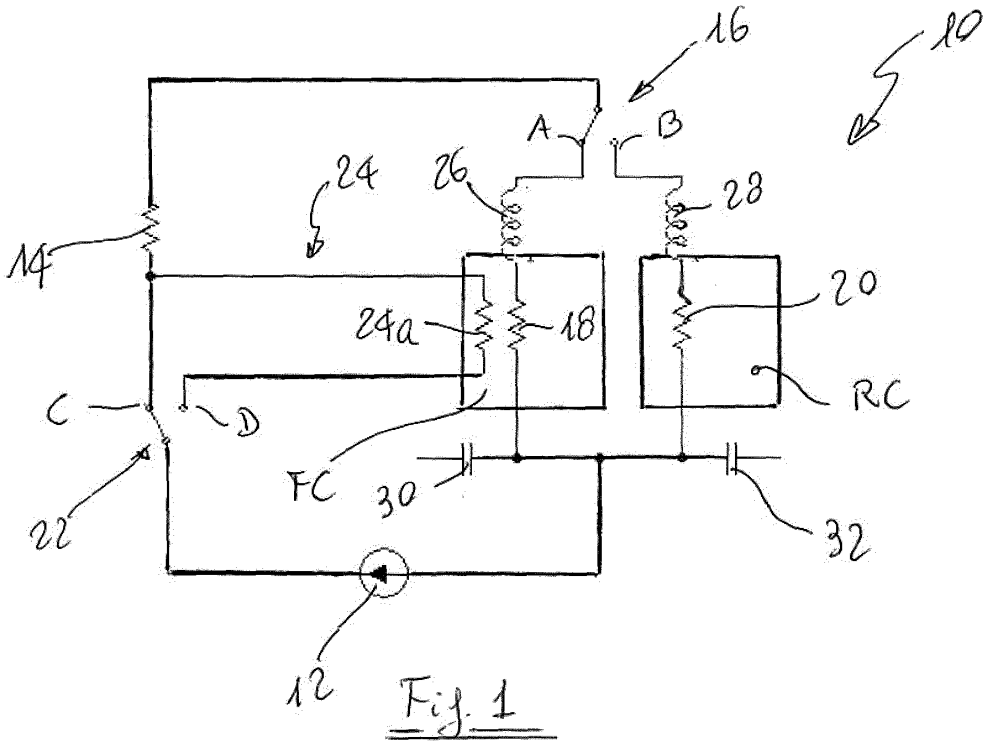

Fig. 1

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Description

[0001] The present invention relates to a no-frost refrigerator comprising a sequential refrigeration circuit having a condenser and at least two evaporators downstream a valve configured to direct refrigerant flow to any of the evaporators.

[0002] With the term "no-frost refrigerator" we mean any refrigeration appliance where a flow of air is directed towards an evaporator for creating a flow of cooled air which is used to cool at least one refrigeration cavity or compartment (different from the so called "static" evaporator where there is no forced flow of air).

[0003] On no-frost appliances, the electrical resistor used to defrost the evaporator has got a major impact on declared energy consumption, being the device with the higher absorption power in the entire appliance. Actually, calrod, distributed or radiant heaters are usually provided to warm-up the evaporator, to clean it from ice when in blocked condition (with reduced efficiency as a consequence). That kind of electrical heater is usually provided with a bimetal sensor, to indicate the end of defrost period. The power consumption of such a heater is usually much higher than the one of the compressor itself, creating an absorption peak during defrost (that is one of the reason for the higher declared energy consumption of no-frost appliance with respect to static ones).

[0004] Even if the general solution of using hot gas for defrosting purposes is known in the art (as shown for instance in US2007/0119196 and US6931880), there was no adoption of this solution in a more complex refrigeration circuit as the hybrid sequential circuit.

[0005] It is an object of the present invention to find a solution for a sequential refrigeration circuit able to solve the same task with a lower energy consumption, in order to achieve a superior energy class, and to provide a no-frost refrigerator with a thermodynamic cycle having a high efficiency.

[0006] Such object is reached thanks to the features listed in the appended claims.

[0007] The technical solution according to the invention is suitable only for the so-called sequential thermodynamic vapor compression circuits. In such a circuit, at least two evaporators are present, with the task of cooling down two different cavities: fresh-food compartment and freezer compartment. In a sequential circuit, a three-way electrovalve is used to divert the refrigerant flow to alternatively either one or the other evaporator or to both of them, which are linked in parallel configuration downstream the condenser. The solution according to the invention makes use of an additional condenser coil, presents upstream and in series with the condenser and wrapped around the evaporator to be defrosted (in a hybrid appliance, the evaporator of the freezer). The coil is fed with refrigerant liquid at high temperature only when required, thanks to an second three-way electrovalve (eventually driven even a bimetal sensor), which normally manages the bypass of the additional coil itself. The main features of such kind of defrost are as follows:

- if the no-frost evaporator is the freezer one, the compressor must be switched on during defrost operation and the fresh food compartment evaporator has to be fed in the meanwhile;
- if both the evaporators are no-frost ones, the second electrovalve needs three independent ways out: one to the heat loop of the first evaporator, one to the heat loop of the second evaporator, and one to bypass the defrost circuits;
- being the heat loop upstream the condenser, the condensation temperature will be significantly lower, dramatically increasing the efficiency of the vapor compression cycle during defrost.

[0008] Further features and advantages of a refrigerator according to the invention will become clear from the following description, with reference to the attached drawings in which:

- figure 1 is a schematic view of a refrigerating circuit of a hybrid refrigerator according to the invention;
- figure 2 is a view similar to figure 1 and refers to a refrigerator having two no-frost evaporators; and
- figure 3 is a pressure vs. enthalpy diagram which shows how, in a no-frost refrigerator according to the invention, thermal energy given to the defrosted evaporator is transferred to the second evaporator thanks to the increase of cooling capacity generated by the decrease of condensation temperature.

[0009] With reference to figure 1, a refrigeration circuit 10 comprises a compressor 12, a condenser 14, a first three-way valve 16 for directing the refrigerant flow towards a first evaporator 18 of a freezer compartment FC or towards a second evaporator 20 of a refrigeration compartment RC or to both evaporators. According to the invention, the circuit 10 comprises, upstream the condenser 14, a second three-way valve 22 for diverting the refrigerant flow towards an auxiliary condenser loop 24 in series with the condenser 14 and carrying a portion 24a in heat exchange relationship with the evaporator 18 of the freezer compartment FC. The circuit 10 comprises also capillary tubes 26 and 28 upstream the first evaporator 18 and the second evaporator 20 respectively, as well as accumulators 30 and 32 downstream the evaporators, such accumulators assuring a correct balance of the refrigerant load when working conditions change.

[0010] In the configuration shown in figure 1, where the first valve 16 is in the A position and the second valve 22 is in the C or in the D position, there is no defrosting since the auxiliary condenser loop is idle. The first valve 16 is driven by the electronic control unit (not shown) according to the actual temperatures in the freezer FC and in the refrigeration chamber RC and it can also direct the refrigerant flow to both evaporators 18 and 20 simultaneously. When the first evaporator 18 has to be de-

frosted, then the second valve 22 is moved to the "D" position in order to direct hot fluid in the auxiliary condenser loop 24 towards the heat exchanger 24a. At the same time the first valve 16 is driven by the control unit in the "B" position so that the refrigeration compartment is still cooled. During defrost cycle the first valve 16 cannot be maintained in a configuration where both evaporators are fed with refrigerant fluid. At the same time, when the auxiliary condenser loop 24 is activated, the compressor 12 is maintained in its "on" configuration. The fact that in the example shown in the figures the auxiliary condenser loop is placed upstream the condenser 14 is not to be intended as a limitation of the present invention. An auxiliary condenser loop positioned downstream the condenser could have different advantages but still having a beneficial effect on the thermodynamic cycle. An upstream position gives as a main advantage a decrease of the average condensation temperature, with an increase of the compression efficiency, while a downstream position gives a sub-cooling of refrigerant fluid upstream the capillary tube 28 of the fresh food compartment RC with an increase of cooling capacity and a decrease of refrigerant flow noises. The portion 24a of the auxiliary condenser loop 24 and the first evaporator 18 are preferably made as a single component, preferably made of metal, where the first evaporator 18 and said heat exchange portion 24a of the auxiliary condenser loop 24 are integrated. Roll-bond technology can be used for producing such integrated heat exchanges which is positioned inside the freezer compartment FC.

[0011] The embodiment shown in figure 2 refers to a fully no-frost refrigerator where either the evaporator 18 of the freezer compartment FC and the evaporator 20 of the refrigeration compartment RC are no-frost evaporators. The major different between the solution of figure 1 and figure 2 is the use of a four-way valve 33 which can direct the refrigerant flow, for instance upstream the condenser 14, toward a first auxiliary condenser loop 24 substantially identical to the auxiliary condenser loop of the first embodiment, or to a second auxiliary condenser loop 34 which directs hot gas towards a portion 34a in heat-exchange relationship with the second evaporator 20 of the refrigeration compartment RC. In this embodiment the first valve 16, when a defrost cycle is started, diverts the refrigerant flow towards the evaporator which is not subjected to defrost.

Claims

1. No-frost refrigerator comprising a sequential refrigeration circuit (10) having a compressor (12), a condenser (14) and at least two evaporators (18, 20) downstream a valve (16) configured to direct refrigerant flow to any of the evaporators (18, 20), **characterized in that** it comprises a second valve (22, 32) configured to divert refrigerant flow downstream the compressor (12) towards at least one auxiliary condenser (24, 24a) in series with the condenser (14) and in heat exchange relationship with at least one of the evaporators (18, 20) for defrosting thereof.

2. No-frost refrigerator according to claim 1, wherein the second valve (22, 32) is placed upstream the condenser (14).

3. No-frost refrigerator according to claim 1, wherein the second valve (22, 32) is placed downstream the condenser (14).

4. No-frost refrigerator according to any of claims 1 to 3, wherein only the evaporator (18) in heat exchange relationship with said auxiliary condenser (24, 24a) is a no-frost evaporator.

5. No- frost refrigerator according to any of claims 1 to 3, wherein both evaporators (18, 20) are no-frost evaporators, the second valve (32) being a four-way valve for diverting the refrigerant flow towards a first or a second auxiliary condenser (24, 34) in heat exchange relationship with a first (18) or a second evaporator (20).

6. Method for controlling a no-frost refrigerator comprising a sequential refrigeration circuit (10) having a compressor (12), a condenser (14) and at least two evaporators (18, 20) in parallel downstream a valve (16) configured to direct refrigerant flow to any of the evaporators (18, 20), **characterized in that** it comprises the steps of:

   - diverting the flow of refrigerant downstream the compressor (12) towards an auxiliary condenser (24, 24a, 34, 34a) in heat exchange relationship with one the evaporators (18, 20) in order to defrost it; and
   - simultaneously directing the refrigerant flow downstream the condenser (14) towards the other evaporator (18, 20).

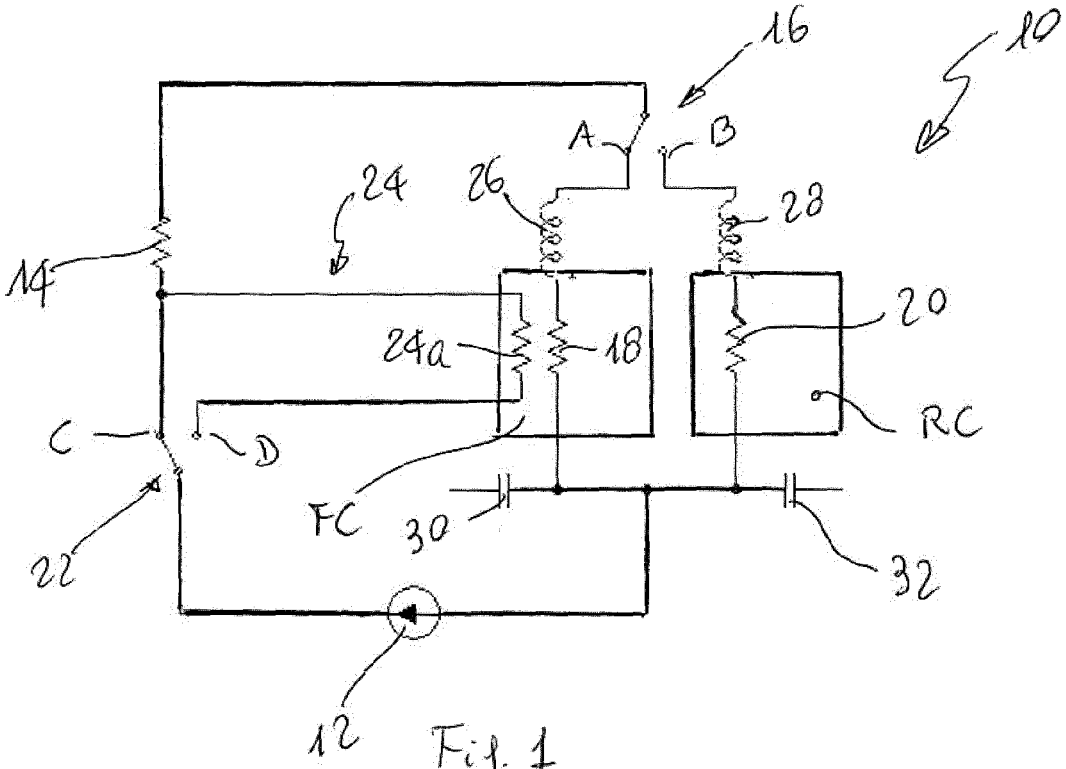
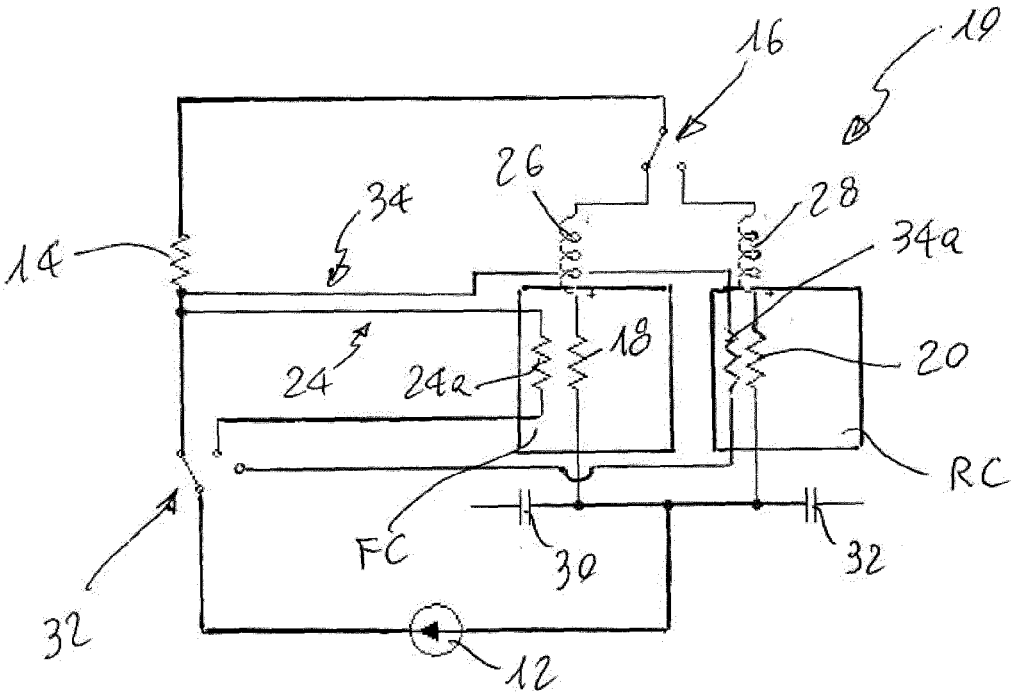

16
10
A
B
24
26
28
14
24a
18
20
C
D
RC
FC
30
22
32
12

Fig. 1


16
19
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14
34a
24
24a
18
20
RC
FC
30
32
32
12

Fig. 2

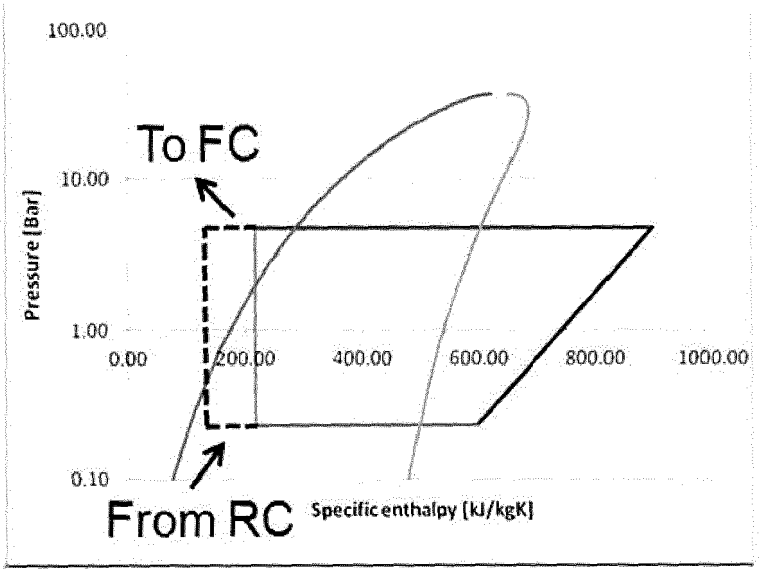
100.00
To FC
10.00
Pressure [Bar]
1.00
0.00
200.00
400.00
600.00
800.00
1000.00
0.10
From RC
Specific enthalpy [kJ/kgK]

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 4128

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	DE 20 2008 005337 U1 (LIEBHERR HAUSGERAETE LIENZ [AT]) 20 August 2009 (2009-08-20) * the whole document *	1,2,4-6	INV. F25B6/04 F25B40/02 F25B41/00
X	JP H01 184378 A (SAKAI REITOU KOGYO KK) 24 July 1989 (1989-07-24) * abstract; figure 9 *	1,3-6	F25B47/02 F25D17/00 F25D29/00
A	EP 2 636 976 A1 (WHIRLPOOL CO [US]) 11 September 2013 (2013-09-11) * the whole document *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
F25B F25D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 February 2015	Lucic, Anita

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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16-02-2015

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

REFERENCES CITED IN THE DESCRIPTION

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