



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.03.2022 Bulletin 2022/13

(51) International Patent Classification (IPC):
F25D 21/08 ^(2006.01) **F25D 21/12** ^(2006.01)
F25D 21/14 ^(2006.01)

(21) Application number: **21198534.6**

(52) Cooperative Patent Classification (CPC):
F25D 21/08; F25D 21/14; F25D 2321/1412;
F25D 2321/1413; F25D 2700/02; F25D 2700/14

(22) Date of filing: **23.09.2021**

(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

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(30) Priority: **28.09.2020 US 202063084219 P**
17.09.2021 US 202117478347

(54) **REFRIGERATED DEVICE WITH ENHANCED DEFROST AND CONDENSATE PAN HEATER CONTROL**

(57) A refrigerated device includes a compartment including an access door, and a door sensor for identifying an open condition of the access door. A refrigeration circuit for cooling the compartment includes an evaporator coil with an associated evaporator fan and a condenser with an associated condenser fan. At least one heat source is selectively activatable to provide heat. A controller is configured to selectively activate the heat source based upon an approximated amount of water that enters the compartment during door open conditions.

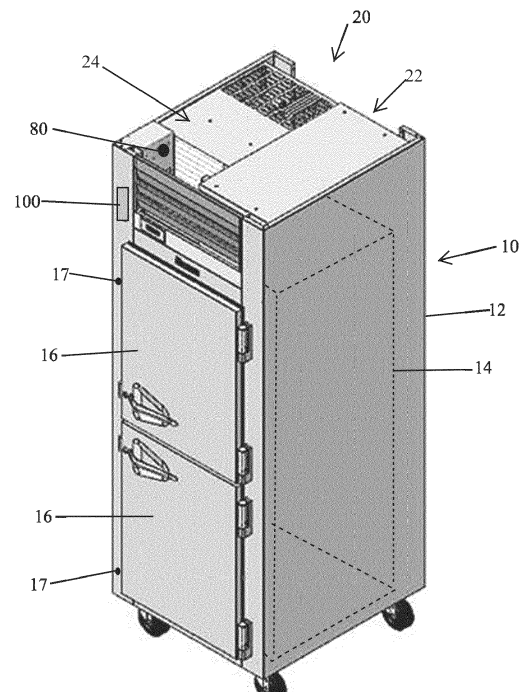


Fig. 1

Description

TECHNICAL FIELD

5 **[0001]** This application relates generally to refrigerated devices, such as refrigerator units and freezer units and, more specifically, to a control system for controlling defrost operations and/or a condensate pan heating element in such devices.

BACKGROUND

10 **[0002]** Refrigerators are used in numerous settings, such as in a commercial setting or in a domestic setting. Typically, refrigerators are used to store and maintain food products by providing a cooled environment into which the products can be stored. Refrigeration systems typically include a refrigerated cabinet into which the food products are placed and a refrigeration assembly for cooling the air and products in the refrigerated cabinet. The refrigeration assembly often
15 includes an evaporator assembly and a condenser assembly, each forming a portion of a refrigerant loop or circuit. A refrigerant is used to carry heat from air within the refrigerated cabinet to the ambient environment surrounding the refrigerated cabinet. The refrigerant absorbs heat in the evaporator assembly and then rejects the absorbed heat in the condenser assembly.

20 **[0003]** Condensate on the evaporator coils may freeze, and such frost may accumulate on evaporator coils of the evaporator assembly, which decreases the efficiency of the refrigeration assembly. Defrosting cycles are typically utilized to remove the frost from the evaporator coils. Once frost has been removed from the evaporator coils, the defrost water or condensate may be transferred to a condensate pan where it may accumulate and be evaporated to ambient environment.

25 **[0004]** Certain operating environments, specifically those with higher dew points and larger numbers of door openings to the cabinet, lead to more condensate and more frost build-up on the evaporator coils. It is known from U.S. Patent No. 10,323,875 that door openings affect the amount of frost build-up, and therefore a door open sensor can aid in the determination of when to initiate a defrost cycle. However, improvements continue to be sought.

SUMMARY

30 **[0005]** In one aspect, a refrigerated device includes a compartment including an access door, and a door sensor for identifying an open condition of the access door. A refrigeration circuit is provided for cooling the compartment, the refrigeration circuit including an evaporator coil with an associated evaporator fan and a condenser with an associated condenser fan. A controller is configured to: (i) based upon an output of the door sensor, maintain a count of a number
35 of door openings since a last defrost operation and (ii) approximate an amount of water that enters the compartment based at least in part on the count of the number of door openings.

40 **[0006]** In another aspect, a refrigerated device includes a cooled compartment including an access door, and a door sensor for identifying an open condition of the access door. A refrigeration circuit is provided for cooling the compartment, the refrigeration circuit including an evaporator coil with an associated evaporator fan and a condenser with an associated condenser fan. At least one heat source is selectively activatable to provide heat. A controller is configured to approximate
an amount of water that enters the compartment based at least in part on each of a count of door openings, a duration of each door opening, wherein the controller is further configured to selectively activate the heat source based at least in part upon the approximated amount of water.

45 **[0007]** In another aspect, a refrigerated device includes a compartment including an access door, and a door sensor for identifying an open condition of the access door. A refrigeration circuit for cooling the compartment includes an evaporator coil with an associated evaporator fan and a condenser with an associated condenser fan. At least one heat source is selectively activatable to provide heat. A controller is configured to selectively activate the heat source, wherein the controller is configured to, based upon the output of the door sensor, count a number of door openings since a last defrost operation and to approximate an amount of water that enters the compartment based the count of door openings
50 and to activate the heat source based at least in part upon the approximated amount of water.

55 **[0008]** In another aspect, a method of controlling a defrost operation of a refrigerated device including a cooled compartment that is closeable by at least one door, involves the steps of: approximating an amount of water that enters cooled compartment as a result of door open conditions; and initiating a defrost operation based at least in part upon the approximated amount of water. In implementations, the step of approximating involves taking into account both a number of door openings and duration of such door openings. In implementations, the step of approximating involves taking into account a dew point of an ambient environment in which the refrigerated device is located.

[0009] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

- 5 Fig. 1 shows a refrigerated device;
 Figs. 2 and 3 show an evaporator unit and condenser unit atop the refrigerated device; and
 Figs. 4 and 5 show the condenser unit of the device;

DETAILED DESCRIPTION

- 10 **[0011]** U.S. Patent No. 10,323,875 is incorporated herein by reference and forms a part of this disclosure.
- [0012]** Figs. 1-5 show a refrigerated device 10 (refrigerator and/or freezer) with a cabinet 12 defining one or more internal compartments 14 that are cooled and accessible via one or more doors 16. Door open sensors 17 are also shown.
- 15 **[0013]** The refrigeration system 20 of the device is located at the top of the cabinet 12 and includes an evaporator unit or assembly 22 and a condenser unit or assembly 24. The evaporator unit 22 includes an evaporator coil 22a and an air circulation fan 22b (shown schematically in Fig. 2), and a path for condensate to run to the condensate pan of the condenser unit 24. A heater 23, shown schematically, for defrosting of the evaporator coil is also shown. The condenser unit 24 includes the condenser coil 30, fan 32 and condensate pan 34, as well as the compressor 36. As best seen in Fig. 5, the floor 40 of the condenser unit includes three openings 42, 44 and 46 to the condensate pan 34.
- 20 **[0014]** A hot gas loop 60 is provided in the condensate pan for condensate heating, and a supplemental electric heating element 62 is also provided in the condensate pan in order to further enhance the heating of the condensate and increase the evaporation rate.
- [0015]** The device includes a controller 100 configured for controlling the various operations of the device, including cooling operations and defrost operations (involving activation of the heat sources 23 and 62). As used herein, the term
- 25 controller is intended to broadly encompass any circuit (e.g., solid state, application specific integrated circuit (ASIC), an electronic circuit, a combinational logic circuit, a field programmable gate array (FPGA)), processor(s) (e.g., shared, dedicated, or group - including hardware or software that executes code), software, firmware and/or other components, or a combination of some or all of the above, that carries out the control functions of the device or the control functions of any component thereof.
- 30 **[0016]** Here, the controller 100 is configured to selectively activate the heat sources 23 and 62. In particular, the controller 100 is configured to, based upon the output of the door sensors 17, a) maintain a count a number of door openings since a last defrost operation and b) approximate an amount of water that enters the compartment 14 based the count of door openings and c) selectively activate the heat sources 23 and 62 based at least in part upon the approximated amount of water. The approximated amount of water is determined in grains of water. A grain of water is
- 35 approximately one drop, and there are 7,000 grains of water to one pound of water.
- [0017]** In order to facilitate the approximation of the amount of water, the device includes at least one sensor 80 for detecting a temperature and a relative humidity of ambient air that surrounds the compartment 14. The controller 100 is configured to calculate a dew point temperature based on the temperature and the relative humidity of the ambient air. The controller 100 is configured to approximate the amount of water that enters the compartment 14 for each door open condition based at least in part upon the dew point temperature during each door open condition. Generally, the
- 40 higher the dew point, the more moisture in the air entering the compartment, and the longer the door is open, the more air, and thus more water, that will enter. In addition, the controller 100 may further be configured to approximate the amount of water that enters the compartment 14 for each door open condition based at least in part upon a duration of each door open condition. Generally, the higher the dew point, the more moisture in the air entering the compartment, and the longer the door is open, the more air, and thus more water, that will enter (e.g., longer door open condition
- 45 means more ambient air entry and, thus, higher amount of water entry). Thus, the controller can be configured to approximate ambient air entry volume, and identify moisture content (e.g., grains) in that volume based upon the dew point. A psychrometric chart in the memory of the controller 100 may be used in the approximation, as such a chart includes information on the amount of water in air at various conditions.
- 50 **[0018]** Generally, when the approximated grains of water entering the compartment are higher, defrost operations, using at least one of the heaters 23 and 62, will be initiated with more frequency, at least in some modes of the device 10. Thus, the controller is configured such that a next defrost operation, following the last defrost operation, is carried out by activating the heat source sooner if the approximated amount of water is high verses if the approximated amount of water is low. By way of example, in one implementation, the controller 100 is configured such that a next defrost
- 55 operation occurs upon the sooner of (i) a time since the last defrost operation reaching a set time threshold or (ii) the approximated grains of water reaching a set grains threshold. In another example, the controller is configured with various grains of water ranges that are used to set the threshold time for triggering the next defrost operation (e.g., for approximated grains less than X1, the set time threshold is ST1, for approximated grains between X1 and X2, the set

time threshold is ST2, for approximated grains between X2 and X3, the set time threshold is ST3, for approximated grains between X3 and X4, the set time threshold is ST4, and so on, where $X1 < X2 < X3 < X4$ and $ST1 > ST2 > ST3 > ST4$). However, other implementations are possible. In another example, in one implementation, the controller 100 is configured such that a next defrost operation occurs upon the sooner of (i) a trigger based upon one or more factors that do not include approximating the amount of water that enters the cabinet or (ii) the approximated grains of water reaching a set grains threshold.

[0019] Also, if the approximated grains of water that entered since the last defrost is a higher number, as compared to a lower number, the supplemental heater 62 will be run/energized for a longer duration because it will take longer to evaporate a higher amount of water entering the condensate pan. The duration can be matched to the approximated amount of water (e.g., for approximated grains less than X1, the duration is D1, for approximated grains between X1 and X2, the duration is D2, for approximated grains between X2 and X3, the duration is D3, for approximated grains between X3 and X4, the duration is D4, and so on, where $X1 < X2 < X3 < X4$ and $D1 > D2 > D3 > D4$).

[0020] Thus, in certain implementations, a series of grains of water set points can be used by the controller 100 to initiate the heater control functions.

[0021] In one example, the approximated grains of water entering the cabinet for various door opening durations (DODUR#) at various dew point temperatures (DPTMP#) can be stored in memory of the controller. Table 1 below is exemplary, as many additional data points could be included.

Table 1.

Approximated Grains of Water Entry as a Function of Door					
Open Duration and Dew Point Temperature					
	DPTMP1	DPTMP2	DPTMP3	DPTMP4	DPTMP5
DODUR1	300	500	700	9000	1100
DODUR2	600	1000	1400	1800	2200
DODUR3	900	1500	2100	2700	3300
DODUR4	1200	2000	2800	3600	4400
DODUR5	1500	2500	3500	4500	5500

[0022] The data for such a table for any give refrigerated device can be obtained by testing of the device. More specifically, a refrigerated device can be tested by repeatedly opening and closing the door under various conditions, and monitoring how much water is condensed out of the cabinet air after door closure.

[0023] In one implementation, a refrigerated device includes: a cooled compartment including an access door; a door sensor for identifying an open condition of the access door; a refrigeration circuit for cooling the compartment, the refrigeration circuit including an evaporator coil with an associated evaporator fan and a condenser with an associated condenser fan; at least one heat source selectively activatable to provide heat; a controller configured to approximate an amount of water that enters the compartment based at least in part on detected door openings and duration of the detected door openings, wherein the controller is further configured to selectively activate the heat source based at least in part upon the approximated amount of water.

[0024] In versions of such refrigerated device, the heat source is associated with the evaporator coil for use in defrost operations of the evaporator coil.

[0025] In versions of such refrigerated device, the controller is configured such that a next defrost operation, following the last defrost operation, is carried out by activating the heat source sooner if the approximated amount of water is high verses if the approximated amount of water is low.

[0026] In versions of such refrigerated device, the heat source is associated with a condensate pan that collects condensate from the evaporator coil.

[0027] In versions of such refrigerated device, the controller is configured such that the heat source is activated for a longer period of time if the approximated amount of water is high verses if the approximated amount of water is low.

[0028] It is to be clearly understood that the above description is intended by way of illustration and example only, is not intended to be taken by way of limitation, and that other changes and modifications are possible.

Claims

1. A refrigerated device, comprising:

a compartment including an access door;
 a door sensor for identifying an open condition of the access door;
 a refrigeration circuit for cooling the compartment, the refrigeration circuit including an evaporator coil with an
 associated evaporator fan and a condenser with an associated condenser fan;
 at least one heat source selectively activatable to provide heat;
 a controller configured to approximate an amount of water that enters the compartment, wherein the controller
 is further configured to selectively activate the heat source based at least in part upon the approximated amount
 of water.

2. The refrigerated device of claim 1, wherein the controller configured to: (i) based upon an output of the door sensor, maintain a count of a number of door openings since a last defrost operation and (ii) approximate an amount of water that enters the compartment based at least in part on the count of the number of door openings.

3. The refrigerated device of claim 2, wherein the approximated amount of water is determined in grains of water.

4. The refrigerated device of claim 2, further comprising:

at least one sensor for detecting a temperature and a relative humidity of ambient air that surrounds the compartment;
 wherein the controller is configured to determine a dew point temperature based on the temperature and the relative humidity of the ambient;
 wherein the controller is configured to approximate the amount of water that enters the compartment for each door open condition based at least in part upon the dew point temperature during each door open condition.

5. The refrigerated device of claim 4, wherein the controller is further configured to approximate the amount of water that enters the cabinet for each door open condition based at least in part upon a duration of each door open condition.

6. The refrigerated device of claim 1, wherein the heat source is associated with the evaporator coil for use in defrost operations of the evaporator coil.

7. The refrigerated device of claim 6, wherein the controller is configured such that a next defrost operation, following the last defrost operation, is carried out by activating the heat source sooner if the approximated amount of water is high verses if the approximated amount of water is low.

8. The refrigerated device of claim 1, wherein the heat source is associated with a condensate pan that collects condensate from the evaporator coil.

9. The refrigerated device of claim 8, wherein the controller is configured such that the heat source is activated for a longer period of time if the approximated amount of water is high verses if the approximated amount of water is low.

10. A method of controlling a defrost operation of a refrigerated device including a cooled compartment that is closeable by at least one door, comprising:

approximating an amount of water that enters cooled compartment as a result of door open conditions; and
 initiating a defrost operation based at least in part upon the approximated amount of water.

11. The method of claim 10, wherein the step of approximating involves taking into account both a number of door openings and duration of such door openings.

12. The method of claim 11, wherein the step of approximating involves taking into account a dew point of an ambient environment in which the refrigerated device is located.

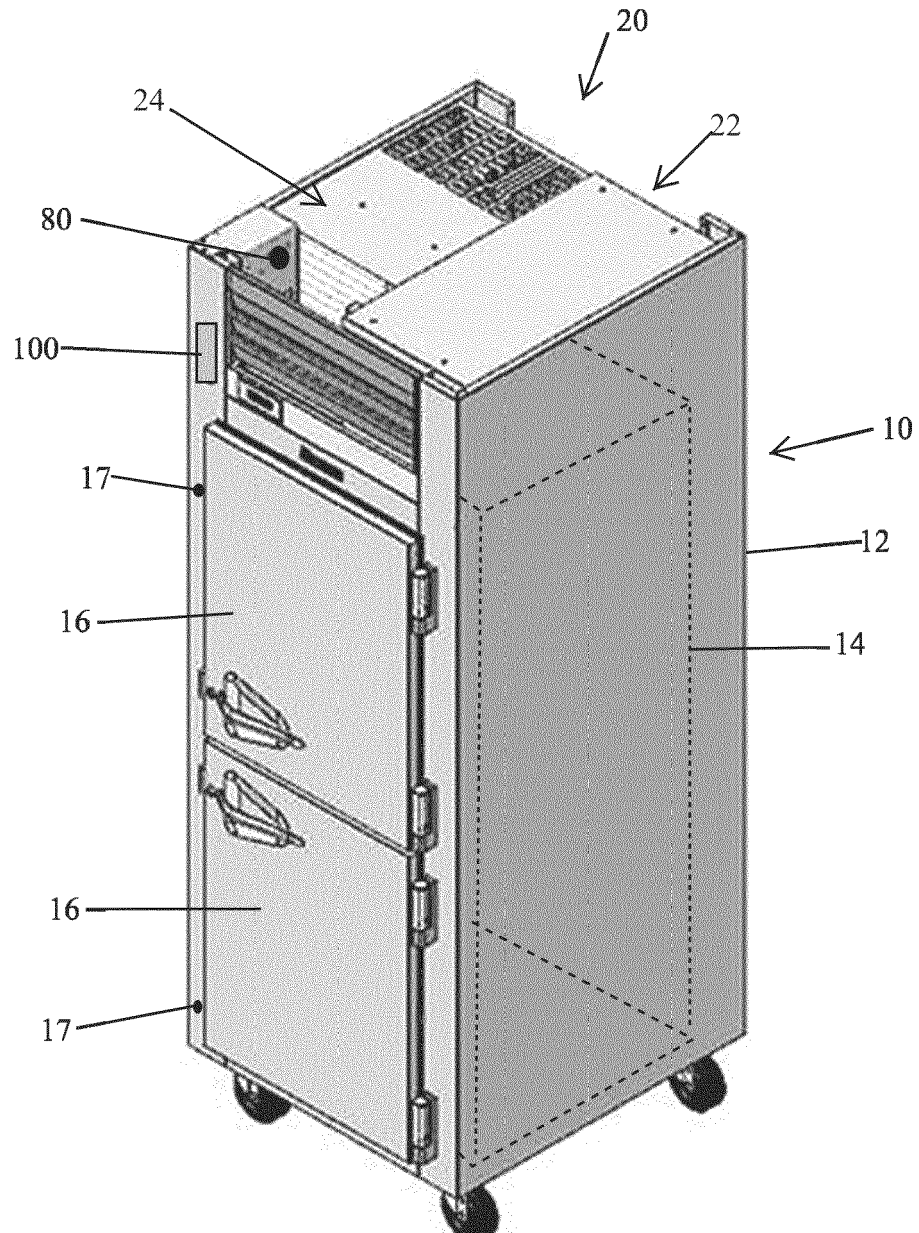


Fig. 1

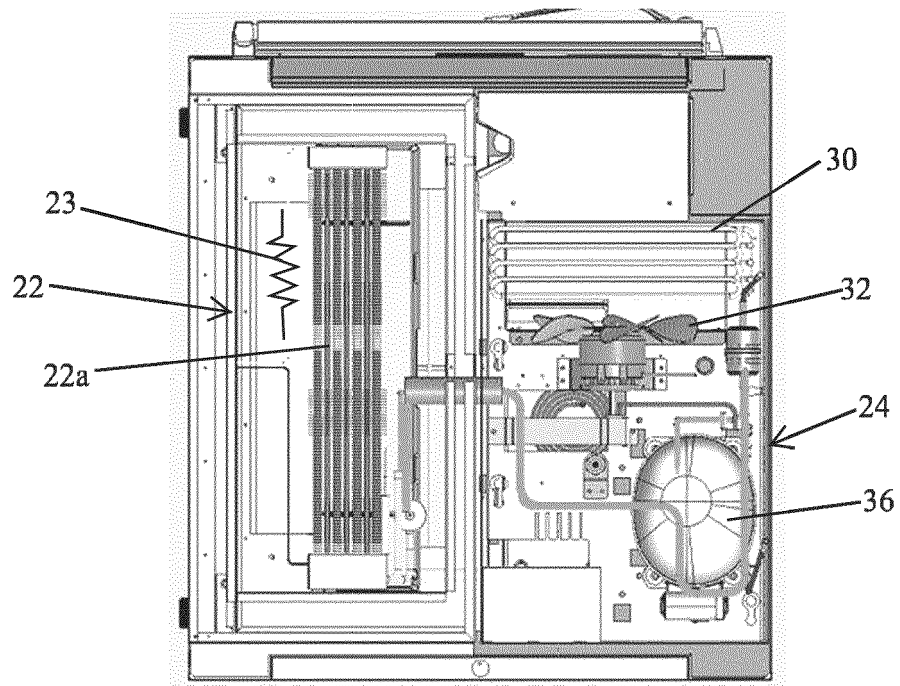
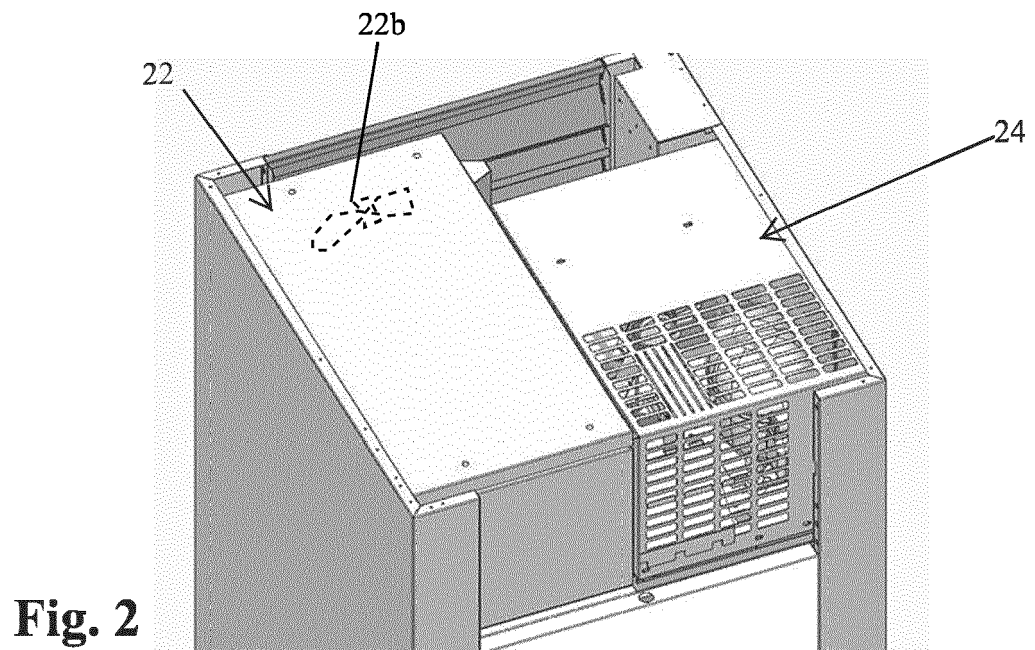


Fig. 3

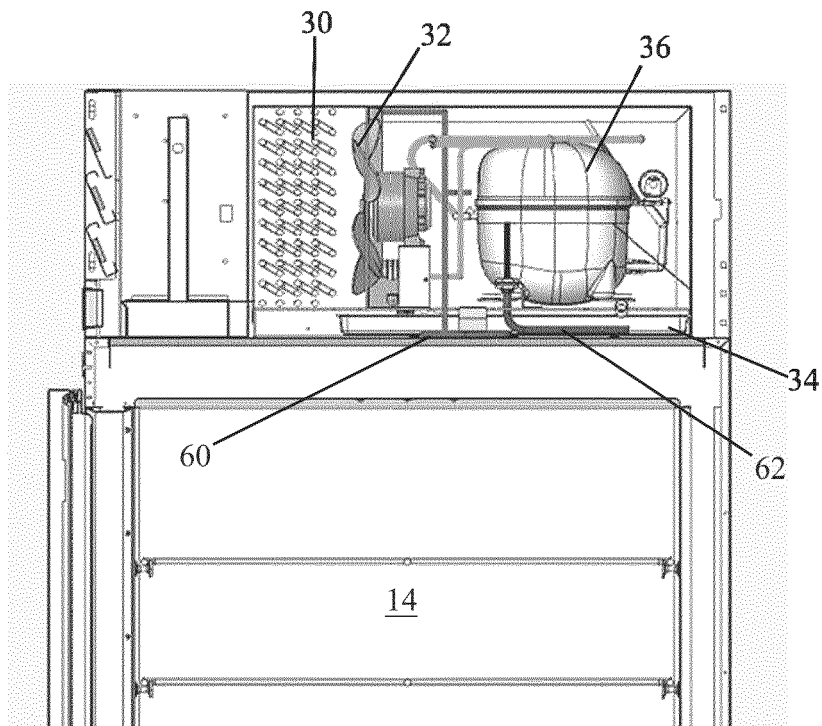


Fig. 4

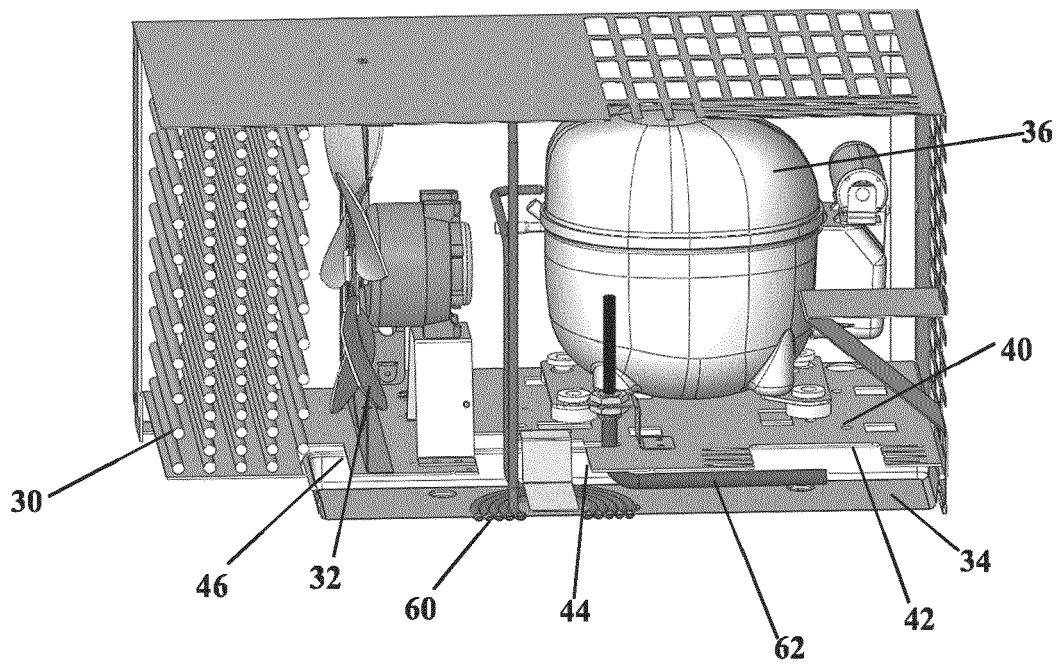


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 21 19 8534

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EPO FORM 1503 03.82 (P04C01)

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 10 2011 078324 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 3 January 2013 (2013-01-03) * figures 1,2,7-11 *	1-5, 8-12	INV. F25D21/08 F25D21/12 F25D21/14
X	DE 10 2011 085153 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 25 April 2013 (2013-04-25) * figures 1-4 *	1-5, 8-12	
X	US 2013/098074 A1 (HEGEDUS RALPH [US] ET AL) 25 April 2013 (2013-04-25) * paragraph [0040] - paragraph [0042] *	1-7, 10-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 February 2022	Examiner Kuljis, Bruno
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	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 19 8534

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07-02-2022

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102011078324 A1	03-01-2013	NONE	

DE 102011085153 A1	25-04-2013	CN 103906985 A	02-07-2014
		DE 102011085153 A1	25-04-2013
		WO 2013060633 A2	02-05-2013

US 2013098074 A1	25-04-2013	CN 103062970 A	24-04-2013
		DE 102012020112 A1	25-04-2013
		GB 2496948 A	29-05-2013
		US 2013098074 A1	25-04-2013

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EPO FORM P0459

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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Patent documents cited in the description

- US 10323875 B [0004] [0011]