

(19)



(11)

EP 3 830 503 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
01.11.2023 Bulletin 2023/44

(21) Application number: **19749138.4**

(22) Date of filing: **22.07.2019**

(51) International Patent Classification (IPC):
F25D 21/02^(2006.01) F25D 21/08^(2006.01)

(52) Cooperative Patent Classification (CPC):
F25D 21/08; F25D 21/02; F25D 11/003; F25D 21/025; F25D 2700/10

(86) International application number:
PCT/US2019/042777

(87) International publication number:
WO 2020/028078 (06.02.2020 Gazette 2020/06)

(54) **DEFROST SYSTEM AND METHOD OF DEFROSTING AN EVAPORATOR SECTION OF A TEMPERATURE CONTROL UNIT**

ABTAUSYSTEM UND VERFAHREN ZUM ABTAUEN EINES VERDAMPFERTEILS EINES TEMPERIERGERÄTS

SYSTÈME DE DÉGIVRAGE ET PROCÉDÉ DE DÉGIVRAGE D'UN ÉVAPORATEUR D'UNE UNITÉ DE COMMANDE DE TEMPÉRATURE

(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

(30) Priority: **30.07.2018 US 201862711973 P**

(43) Date of publication of application:
09.06.2021 Bulletin 2021/23

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Description

[0001] The invention relates to a defrost system for a temperature control unit and to a method of defrosting an evaporator section of a temperature control unit.

[0002] A transport refrigeration system used to control enclosed areas, such as the insulated box used on trucks, trailers, containers, or similar intermodal units, functions by absorbing heat from the enclosed area and releasing heat outside of the box into the environment. Environmental concerns associated with certain refrigerants may lead to mandates for the use of low global warming potential (GWP) refrigerants, but there is a concern for systems that use such refrigerants because, as currently designed, low GWP refrigerants have properties during phase change that may create a temperature glide, or a change in temperature at constant pressure while in the liquid and vapor mixed phase. This creates uneven temperature distribution within evaporator coils that can cause ice buildup on the inlet side of the evaporator coil while the remainder of the evaporator coil stays above freezing temperature. This creates difficulty predicting when to defrost the ice, and ensuring that the coil is fully cleared of ice. Ice buildup undesirably reduces cooling capacity.

[0003] KR 2012 0072779 A relates to a refrigerator equipped with the defrost heater arranged to the evaporator.

[0004] KR 2016 0027761 A relates to a refrigerator frost detection unit and a refrigerator defrosting apparatus.

[0005] JP 2013 079783 A relates to a cooling device provided with a heater for defrosting frost adhering to a cooler.

[0006] Viewed from a first aspect, the present invention provides a defrost system for a temperature control unit, the defrost system comprising: an evaporator section having a refrigerant inlet and a refrigerant outlet, wherein the defrost system is for facilitating defrosting of ice that is only at the refrigerant inlet; a first heating element being dedicated to ice defrosting at the refrigerant inlet; a second heating element, the first heating element located closer to the refrigerant inlet than the second heating element is to the refrigerant inlet; wherein the first heating element is oriented vertically relative to the evaporator section, the second heating element is oriented along a longitudinal direction of the evaporator section; a first sensing device located proximate the refrigerant inlet and being for detecting ice buildup at the refrigerant inlet, wherein heating activation of the first heating element is determined at least in part by ice buildup detection of the first sensing device; and a second sensing device located further from the refrigerant inlet than the distance between the first sensing device and the refrigerant inlet and being for detecting ice buildup along the second heating element, wherein heating activation of the second heating element is determined at least in part by ice buildup detection of the second sensing device.

[0007] Optionally, at least one of the first sensing device and the second sensing device is an air switch for detecting a pressure differential.

5 **[0008]** Optionally, the first heating element and the second heating element are each electric heating elements.

[0009] The first heating element and the second heating element are oriented perpendicular to each other.

10 **[0010]** Optionally, the first heating element may be activated during cooling system operation of the temperature control unit.

15 **[0011]** Optionally, the first heating element is one of a plurality of first heating elements and the second heating element is one of a plurality of second heating elements, each of the first heating elements located closer to the refrigerant inlet than each of the plurality of second heating elements is to the refrigerant inlet.

[0012] Optionally, the temperature control unit is a transport refrigeration unit.

20 **[0013]** Optionally, the first sensing device and the second sensing device are each temperature sensors for detecting a temperature differential.

25 **[0014]** Viewed from a second aspect, the invention provides a method of defrosting an evaporator section of a temperature control unit including means for dedicated defrosting of ice at a refrigerant inlet of the evaporator section, the method comprising: detecting the presence of ice buildup at a first location proximate the refrigerant inlet of the evaporator section with a first sensing device that is located proximate the refrigerant inlet; detecting the presence of ice buildup at a second location of the evaporator section with a second sensing device, wherein the second sensing device is located further from the refrigerant inlet than the distance between the first sensing device and the refrigerant inlet; activating a first heating element upon detection of the presence of ice buildup at the first location, the first heating element being dedicated to ice defrosting at the refrigerant inlet; and activating a second heating element upon detection of the presence of ice buildup at the second location; wherein the first heating element is oriented vertically relative to the evaporator section, the second heating element is oriented along a longitudinal direction of the evaporator section.

35 **[0015]** Optionally, embodiments may include separately controlling the first heating element and the second heating element.

40 **[0016]** Optionally, embodiments may include activating the first heating element without activating the second heating element.

45 **[0017]** Optionally, embodiments may include activating the first heating element during cooling system operation of the temperature control unit.

50 **[0018]** Optionally, detecting the presence of ice buildup at the first location and the second location comprises detecting a first pressure differential at the first location and detecting a first pressure differential at the second location.

[0019] The present disclosure is illustrated by way of example and not limited in the accompanying figures in which like reference numerals indicate similar elements.

FIG. 1 is a temperature control system in use with a transport vehicle;

FIG. 2 is a plot of temperature vs. entropy for various refrigerants within an evaporator section of the temperature control system;

FIG. 3 is a schematic illustration of the evaporation section of the temperature control system; and

FIG. 4 is a schematic illustration of heating elements within the evaporator section.

[0020] Disclosed herein are embodiments associated with defrosting an evaporator section of a temperature control system. Although various refrigeration systems may benefit from the embodiments disclosed herein, FIG. 1 illustrates an application of the embodiments on a transport refrigeration system 10 associated with a trailer 12 pulled by a tractor 14. The trailer 12 includes a cargo container/box 16 defining an interior space 18, wherein perishable product is stowed for transport. The transport refrigeration system 10 is operative to climate control the atmosphere within the interior space 18 of the cargo container/box 16 of the trailer 12. It is to be understood that the system and method disclosed herein may be applied not only to refrigeration systems associated with trailers, but also to refrigeration systems applied to refrigerated trucks, to intermodal containers equipped with gensets, and to other refrigeration systems including a refrigerant unit having an engine driven compressor.

[0021] Conventional refrigeration cycle components, such as a compressor, a refrigerant heat rejection heat exchanger, an expansion device, a refrigerant evaporator section, and a suction modulation valve connected in a closed loop refrigerant circuit may be included in the transport refrigeration system, but are not illustrated in FIG. 1. The transport refrigeration system 10 is mounted as in conventional practice to an exterior wall of the truck, trailer or container.

[0022] FIG. 2 illustrates a temperature glide for three different refrigerants. As shown, a HFC refrigerant 20, such as R404a or the like, is shown to have a low temperature glide, which refers to the slope of the plot of temperature vs. entropy. A HFC "lower GWP" 30 such as R452a or the like has a slightly higher temperature glide, relative to the HFC refrigerant 20. A low GWP refrigerant 40 has a high temperature glide, relative to refrigerants 20 and 30. This illustrates that the low GWP refrigerant 40 has a substantially lower temperature at the inlet of the evaporator section, when compared to the evaporator section outlet temperature. Such a glide results in ice formation at the inlet more frequently than ice formation at the outlet and intermediate locations therebetween.

[0023] Referring now to FIGS. 3 and 4, a portion of the evaporator section 50 is illustrated. The evaporator sec-

tion 50 includes evaporator coils 52 for routing the low GWP refrigerant 40 throughout the evaporator section 50. The embodiments described herein include at least one electric heater element that is dedicated to ice defrosting at the inlet 54 of the evaporator section 50. This avoids the issue of incomplete defrosting at the inlet during a defrost cycle that relies on a single sensing device located away from the inlet, as well as inefficiencies associated with initiating full defrost cycles too frequently if a single sensing device was located at the inlet 54.

[0024] As shown in FIG. 3, a first sensing device 60 is located proximate the inlet 54 of the evaporator section 50. A second sensing device 70 is located further from the inlet 54 than the distance between the first sensing device 60 and the inlet 54. The sensing devices 60, 70 detect the formation of ice. In some embodiments, one or both of the sensing devices 60, 70 are air switches configured to detect a pressure drop in their respective locations. In some embodiments, one or both of the sensing devices 60, 70 are temperature sensors that detect a temperature difference between the two sensors and providing a response, such as turning on the heating elements. As shown in FIG. 3, ice 72 may be present at the inlet 54, but not along any other region of the evaporator section 50. To avoid shutting down the cooling system for a full defrost cycle, the embodiments described herein facilitate defrosting at only the inlet 54.

[0025] FIG. 4 illustrates two sets of heating elements within the evaporator section 50. Although a plurality of each type of heating element is shown, it is to be appreciated that a single heating element may be used in conjunction with each sensing device. In particular, a first heating element 80 (or first plurality of heating elements 80) is located proximate the inlet 54. The first heating element(s) 80 are oriented substantially vertically within the evaporator section 50. The substantially vertical orientation may be advantageous to dominate the heating distribution at the inlet 54.

[0026] A second heating element 82 (or second plurality of heating elements 82) is located further from the inlet 54, when compared to the distance between the first heating element 80 and the inlet 54. The second heating element(s) 82 are oriented substantially along a longitudinal direction of the evaporator section 50, such that the heating elements 80, 82 are arranged substantially perpendicularly to each other.

[0027] The first heating element(s) 80 are electric heaters separately controlled based on the distinct sensing device 60, 70 and with separate contactors 84. The heating elements 80, 82 radiate heat to melt ice. The first heating element(s) 80 is activated when the first sensing device 60 detects the presence of ice formation proximate the inlet 54. The second heating element(s) 82 is activated when the second sensing device 70 detects the presence of ice formation further from the inlet 54. Unlike the first heating element activation, activation of the second heating element 82 requires a full defrost cycle to be initiated.

[0028] The embodiments described herein detect when ice buildup has limited cooling capacity when the second sensing device 60 has not initiated a full defrost cycle. Heating may be provided to the inlet iced area while the remainder of the evaporator coil is continuing to reduce the box temperature and until the airflow is no longer blocked by ice in the inlet region. This reduces the number of full defrost cycles needed if the second sensing device were to be located at the initial point of icing. The embodiments control refrigerant glide effects on system performance until the entire cargo area has been dehumidified.

[0029] While the disclosure has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A defrost system for a temperature control unit (10), the defrost system comprising:
 - an evaporator section (50) having a refrigerant inlet (54) and a refrigerant outlet, wherein the defrost system is for facilitating defrosting of ice (72) that is only at the refrigerant inlet;
 - a first heating element (80) being dedicated to ice defrosting at the refrigerant inlet;
 - a second heating element (82), the first heating element located closer to the refrigerant inlet than the second heating element is to the refrigerant inlet;
 - wherein the first heating element is oriented vertically relative to the evaporator section, the second heating element is oriented along a longitudinal direction of the evaporator section;
 - a first sensing device (60) located proximate the refrigerant inlet and being for detecting ice buildup at the refrigerant inlet, wherein heating activation of the first heating element is determined at least in part by ice buildup detection of the first sensing device; and
 - a second sensing device (70) located further from the refrigerant inlet than the distance between the first sensing device and the refrigerant inlet and being for detecting ice buildup along the second heating element, wherein heating activation of the second heating element is determined at least in part by ice buildup detection of the second sensing device.
2. The defrost system of claim 1, wherein at least one of the first sensing device (60) and the second sensing device (70) is an air switch for detecting a pressure differential.
3. The defrost system of claim 1, wherein the first heating element (80) and the second heating element (82) are each electric heating elements.
4. The defrost system of claim 1, wherein the first heating element (80) may be activated during cooling system operation of the temperature control unit (10).
5. The defrost system of claim 1, wherein the first heating element (80) is one of a plurality of first heating elements and the second heating element (82) is one of a plurality of second heating elements, each of the first heating elements located closer to the refrigerant inlet (54) than each of the plurality of second heating elements is to the refrigerant inlet.
6. The defrost system of claim 1, wherein the temperature control unit (10) is a transport refrigeration unit.
7. The defrost system of claim 1, wherein the first sensing device (60) and the second sensing device (70) are each temperature sensors for detecting a temperature differential.
8. A method of defrosting an evaporator section (50) of a temperature control unit (10) including means for dedicated defrosting of ice (72) at a refrigerant inlet (54) of the evaporator section, the method comprising:
 - detecting the presence of ice buildup at a first location proximate the refrigerant inlet of the evaporator section with a first sensing device (60) that is located proximate the refrigerant inlet;
 - detecting the presence of ice buildup at a second location of the evaporator section with a second sensing device (70), wherein the second sensing device is located further from the refrigerant inlet than the distance between the first sensing device and the refrigerant inlet;
 - activating a first heating element (80) upon detection of the presence of ice buildup at the first location, the first heating element being dedicated to ice defrosting at the refrigerant inlet; and
 - activating a second heating element (82) upon detection of the presence of ice buildup at the second location;
 - wherein the first heating element is oriented vertically relative to the evaporator section, the second heating element is oriented along a longitudinal direction of the evaporator section.
9. The method of claim 8, further comprising separately controlling the first heating element (80) and the second heating element (82).

ond heating element (82).

10. The method of claim 8, further comprising activating the first heating element (80) without activating the second heating element (82).
11. The method of claim 10, further comprising activating the first heating element (80) during cooling system operation of the temperature control unit (10).
12. The method of claim 8, wherein detecting the presence of ice buildup at the first location and the second location comprises detecting a first pressure differential at the first location and detecting a first pressure differential at the second location.

Patentansprüche

1. Abtausystem für ein Temperiergerät (10), wobei das Abtausystem umfasst:

einen Verdampferabschnitt (50) mit einem Kältemiteleinlass (54) und einem Kältemittelauslass, wobei das Abtausystem dazu dient, das Abtauen von Eis (72) zu ermöglichen, das sich nur am Kältemiteleinlass befindet;
 ein erstes Heizelement (80), das dem Eisabtauen am Kältemiteleinlass dient;
 ein zweites Heizelement (82), wobei sich das erste Heizelement näher am Kältemiteleinlass befindet als sich das zweite Heizelement am Kältemiteleinlass befindet;
 wobei das erste Heizelement vertikal zu dem Verdampferabschnitt ausgerichtet ist, das zweite Heizelement entlang einer Längsrichtung des Verdampferabschnitts ausgerichtet ist;
 eine erste Erfassungsvorrichtung (60), die sich in der Nähe des Kältemiteleinlasses befindet und zur Erkennung von Eisbildung am Kältemiteleinlass dient, wobei die Heizaktivierung des ersten Heizelements mindestens teilweise durch die Eisbildungserkennung der ersten Erfassungsvorrichtung bestimmt wird; und
 eine zweite Erfassungsvorrichtung (70), die sich weiter von dem Kältemiteleinlass entfernt als der Abstand zwischen der ersten Erfassungsvorrichtung und dem Kältemiteleinlass befindet und zum Erkennen von Eisbildung entlang des zweiten Heizelements dient, wobei die Heizaktivierung des zweiten Heizelements mindestens teilweise durch Eisbildungserkennung des zweiten Sensors bestimmt wird.

2. Abtausystem nach Anspruch 1, wobei mindestens eine von der ersten Erfassungsvorrichtung (60) und der zweiten Erfassungsvorrichtung (70) ein Luftschalter zum Erkennen einer Druckdifferenz ist.

3. Abtausystem nach Anspruch 1, wobei das erste Heizelement (80) und das zweite Heizelement (82) jeweils elektrische Heizelemente sind.

4. Abtausystem nach Anspruch 1, wobei das erste Heizelement (80) während des Kühlsystembetriebs des Temperiergeräts (10) aktiviert werden kann.

5. Abtausystem nach Anspruch 1, wobei das erste Heizelement (80) eines von einer Vielzahl von ersten Heizelementen ist und das zweite Heizelement (82) eines von einer Vielzahl von zweiten Heizelementen ist, wobei sich jedes der ersten Heizelemente näher am Kältemiteleinlass (54) befindet als sich jedes der mehreren zweiten Heizelemente am Kältemiteleinlass befindet.

6. Abtausystem nach Anspruch 1, wobei das Temperiergerät (10) eine Transportkühleinheit ist.

7. Abtausystem nach Anspruch 1, wobei die erste Erfassungsvorrichtung (60) und die zweite Erfassungsvorrichtung (70) jeweils Temperatursensoren zum Erfassen einer Temperaturdifferenz sind.

8. Verfahren zum Abtauen eines Verdampferabschnitts (50) eines Temperiergeräts (10), einschließlich Mitteln zum gezielten Abtauen von Eis (72) an einem Kältemiteleinlass (54) des Verdampferabschnitts, wobei das Verfahren umfasst:

Erkennen des Vorhandenseins von Eisansammlungen an einer ersten Stelle in der Nähe des Kältemiteleinlasses des Verdampferabschnitts mit einer ersten Erfassungsvorrichtung (60), die sich in der Nähe des Kältemiteleinlasses befindet;

Erkennen des Vorhandenseins von Eisansammlungen an einer zweiten Stelle des Verdampferabschnitts mit einer zweiten Erfassungsvorrichtung (70), wobei die zweite Erfassungsvorrichtung weiter vom Kältemiteleinlass entfernt ist als der Abstand zwischen der ersten Erfassungsvorrichtung und dem Kältemiteleinlass;

Aktivieren eines ersten Heizelements (80) bei Erkennung des Vorhandenseins von Eisbildung an der ersten Stelle, wobei das erste Heizelement für die Eisabtauung am Kältemiteleinlass bestimmt ist; und

Aktivieren eines zweiten Heizelements (82), wenn festgestellt wird, dass an der zweiten Stelle Eisbildung vorliegt;

wobei das erste Heizelement vertikal zu dem Verdampferabschnitt ausgerichtet ist, das zweite Heizelement entlang einer Längsrichtung des Verdampferabschnitts ausgerichtet ist.

9. Verfahren nach Anspruch 8, das ferner separates Steuern des ersten Heizelements (80) und des zweiten Heizelements (82) umfasst.
10. Verfahren nach Anspruch 8, das ferner Aktivieren des ersten Heizelements (80) ohne Aktivieren des zweiten Heizelements (82) umfasst.
11. Verfahren nach Anspruch 10, das ferner Aktivieren des ersten Heizelements (80) während des Kühlsystembetriebs des Temperiergeräts (10) umfasst.
12. Verfahren nach Anspruch 8, wobei Erkennen des Vorhandenseins von Eisansammlungen an der ersten Stelle und der zweiten Stelle Erkennen eines ersten Druckunterschieds an der ersten Stelle und das Erkennen eines ersten Druckunterschieds an der zweiten Stelle umfasst.

Revendications

1. Système de dégivrage pour une unité de régulation de température (10), le système de dégivrage comprenant :

une section évaporateur (50) ayant une entrée de réfrigérant (54) et une sortie de réfrigérant, dans lequel le système de dégivrage est destiné à faciliter le dégivrage de la glace (72) qui se trouve uniquement au niveau de l'entrée de réfrigérant ;

un premier élément chauffant (80) étant dédié au dégivrage de la glace au niveau de l'entrée de réfrigérant ;

un second élément chauffant (82), le premier élément chauffant étant situé plus près de l'entrée de réfrigérant que le second élément chauffant ne l'est de l'entrée de réfrigérant ;

dans lequel le premier élément chauffant est orienté verticalement par rapport à la section évaporateur, le second élément chauffant est orienté le long d'une direction longitudinale de la section évaporateur ;

un premier dispositif de détection (60) situé à proximité de l'entrée de réfrigérant et destiné à détecter l'accumulation de glace au niveau de l'entrée de réfrigérant, dans lequel l'activation du chauffage du premier élément chauffant est déterminée au moins en partie par la détection d'accumulation de glace du premier dispositif de détection ; et

un second dispositif de détection (70) situé plus loin de l'entrée de réfrigérant que la distance entre le premier dispositif de détection et l'entrée de réfrigérant et destiné à détecter l'accumulation de glace le long du second élément chauffant, dans lequel l'activation du chauffage du se-

cond élément chauffant est déterminée au moins en partie par la détection de l'accumulation de glace du second dispositif de détection.

2. Système de dégivrage selon la revendication 1, dans lequel au moins l'un du premier dispositif de détection (60) et du second dispositif de détection (70) est un commutateur d'air pour détecter un différentiel de pression.
3. Système de dégivrage selon la revendication 1, dans lequel le premier élément chauffant (80) et le second élément chauffant (82) sont chacun des éléments chauffants électriques.
4. Système de dégivrage selon la revendication 1, dans lequel le premier élément chauffant (80) peut être activé pendant le fonctionnement du système de refroidissement de l'unité de régulation de température (10).
5. Système de dégivrage selon la revendication 1, dans lequel le premier élément chauffant (80) est l'un d'une pluralité de premiers éléments chauffants et le second élément chauffant (82) est l'un d'une pluralité de seconds éléments chauffants, chacun des premiers éléments chauffants situé plus près de l'entrée de réfrigérant (54) que chacun de la pluralité de seconds éléments chauffants ne l'est de l'entrée de réfrigérant.
6. Système de dégivrage selon la revendication 1, dans lequel l'unité de régulation de température (10) est une unité de réfrigération de transport.
7. Système de dégivrage selon la revendication 1, dans lequel le premier dispositif de détection (60) et le second dispositif de détection (70) sont chacun des capteurs de température pour détecter un différentiel de température.
8. Procédé de dégivrage d'une section évaporateur (50) d'une unité de régulation de température (10) comportant des moyens dédiés au dégivrage de la glace (72) au niveau d'une entrée de réfrigérant (54) de la section évaporateur, le procédé comprenant :
- la détection de la présence d'une accumulation de glace en un premier emplacement à proximité de l'entrée de réfrigérant de la section évaporateur avec un premier dispositif de détection (60) qui est situé à proximité de l'entrée de réfrigérant ;
- la détection de la présence d'une accumulation de glace au niveau d'un second emplacement de la section évaporateur avec un second dispositif de détection (70), dans lequel le second dispositif de détection est situé plus loin de l'en-

- trée de réfrigérant que la distance entre le premier dispositif de détection et l'entrée de réfrigérant ;
 l'activation d'un premier élément chauffant (80) 5
 lors de la détection de la présence d'une accumulation de glace au premier emplacement, le premier élément chauffant étant dédié au dégivrage de la glace au niveau de l'entrée de réfrigérant ; et
 l'activation d'un second élément chauffant (82) 10
 lors de la détection de la présence d'une accumulation de glace au second emplacement ;
 dans lequel le premier élément chauffant est orienté verticalement par rapport à la section évaporateur, le second élément chauffant est orienté le long d'une direction longitudinale de la section évaporateur. 15
9. Procédé selon la revendication 8, comprenant en outre la commande séparée du premier élément chauffant (80) et du second élément chauffant (82). 20
10. Procédé selon la revendication 8, comprenant en outre l'activation du premier élément chauffant (80) sans activer le second élément chauffant (82). 25
11. Procédé selon la revendication 10, comprenant en outre l'activation du premier élément chauffant (80) pendant le fonctionnement du système de refroidissement de l'unité de régulation de température (10). 30
12. Procédé selon la revendication 8, dans lequel la détection de la présence d'une accumulation de glace au premier emplacement et au second emplacement comprend la détection d'un premier différentiel de pression au premier emplacement et la détection d'un premier différentiel de pression au second emplacement. 35

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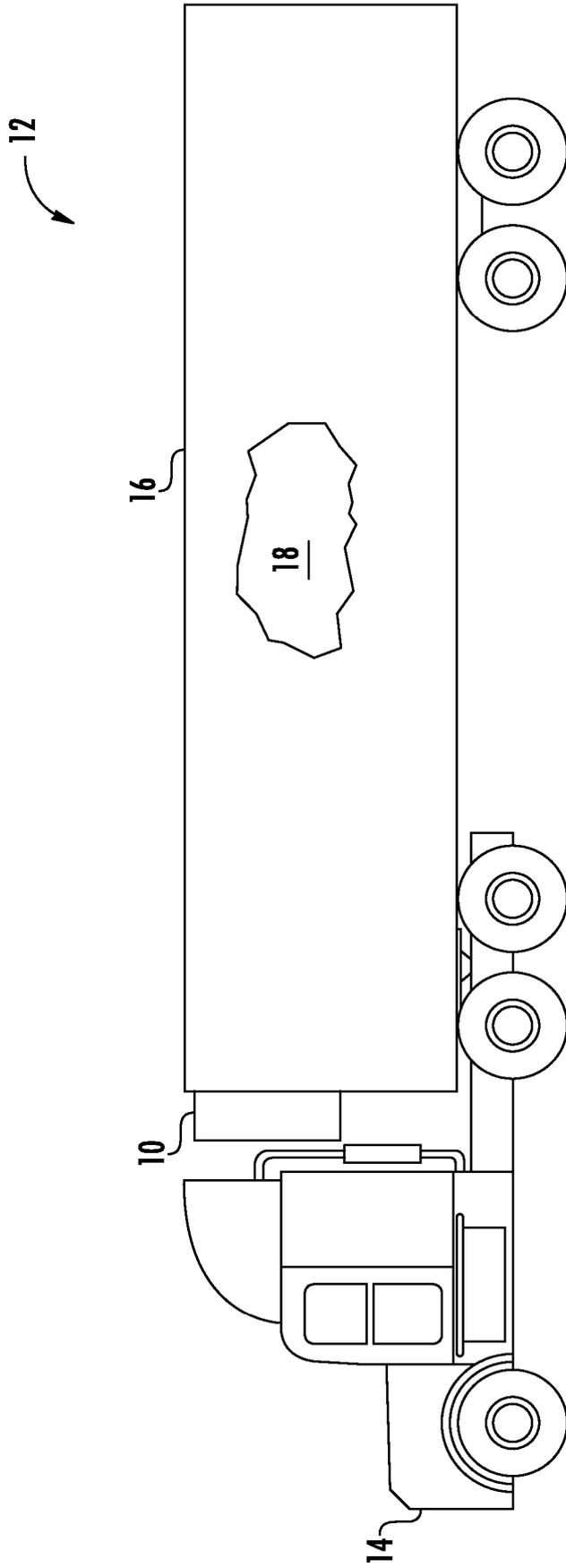


FIG. 1

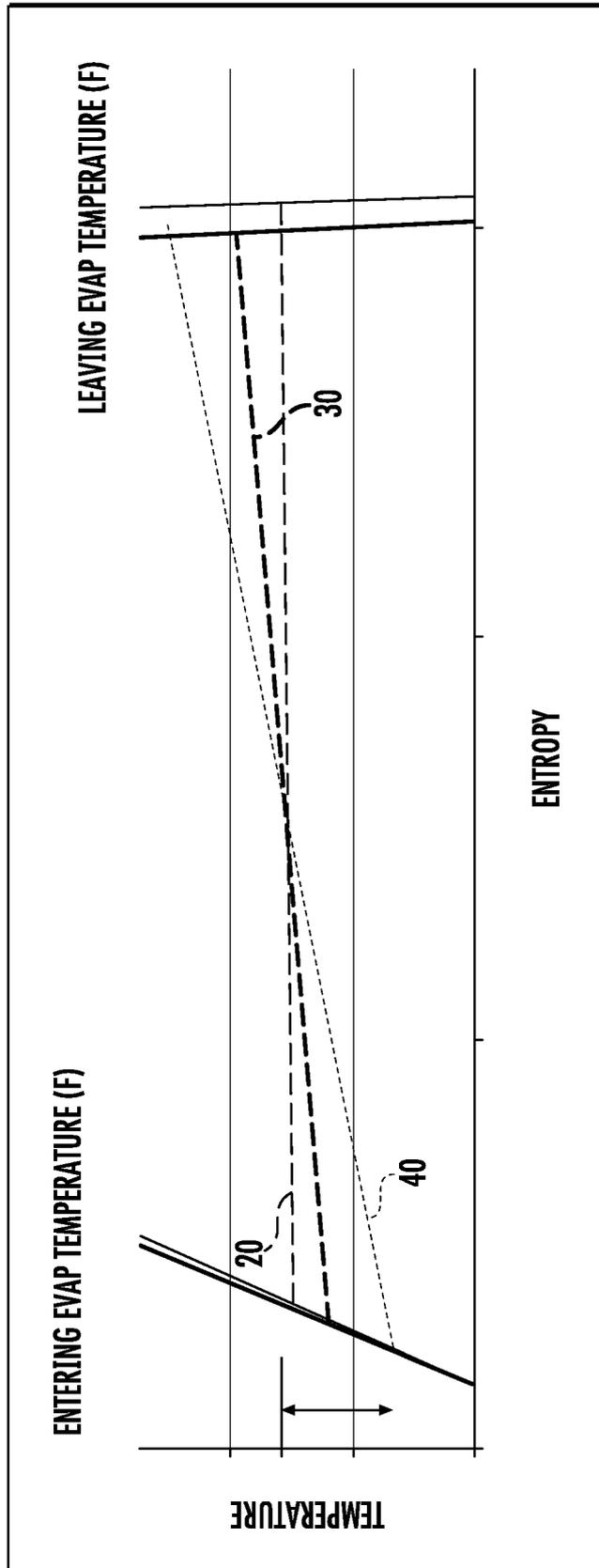
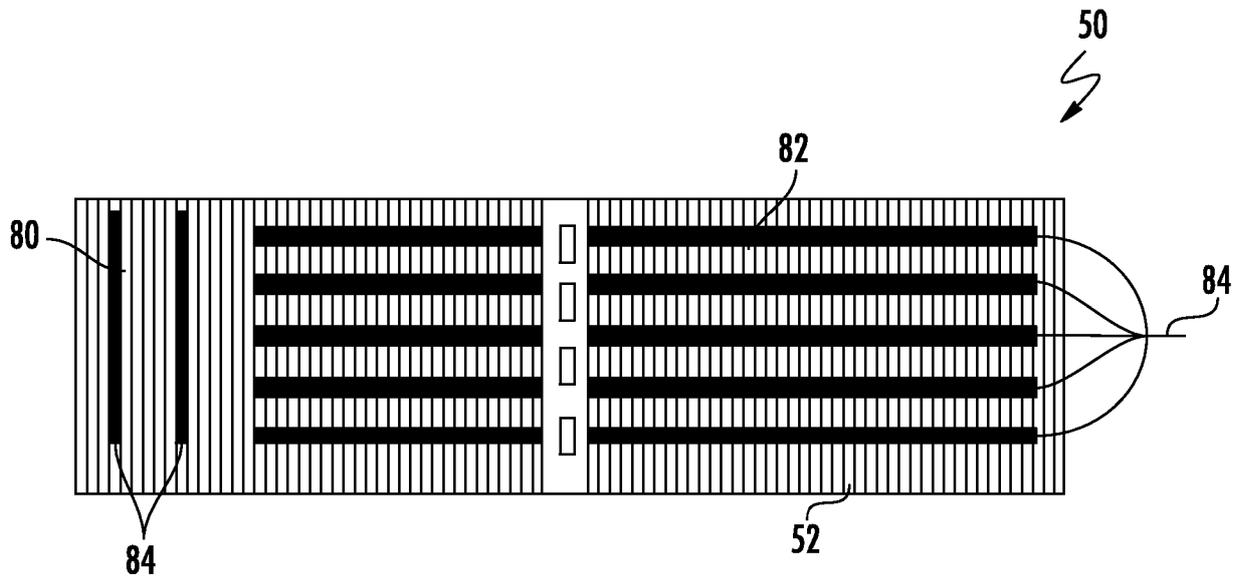
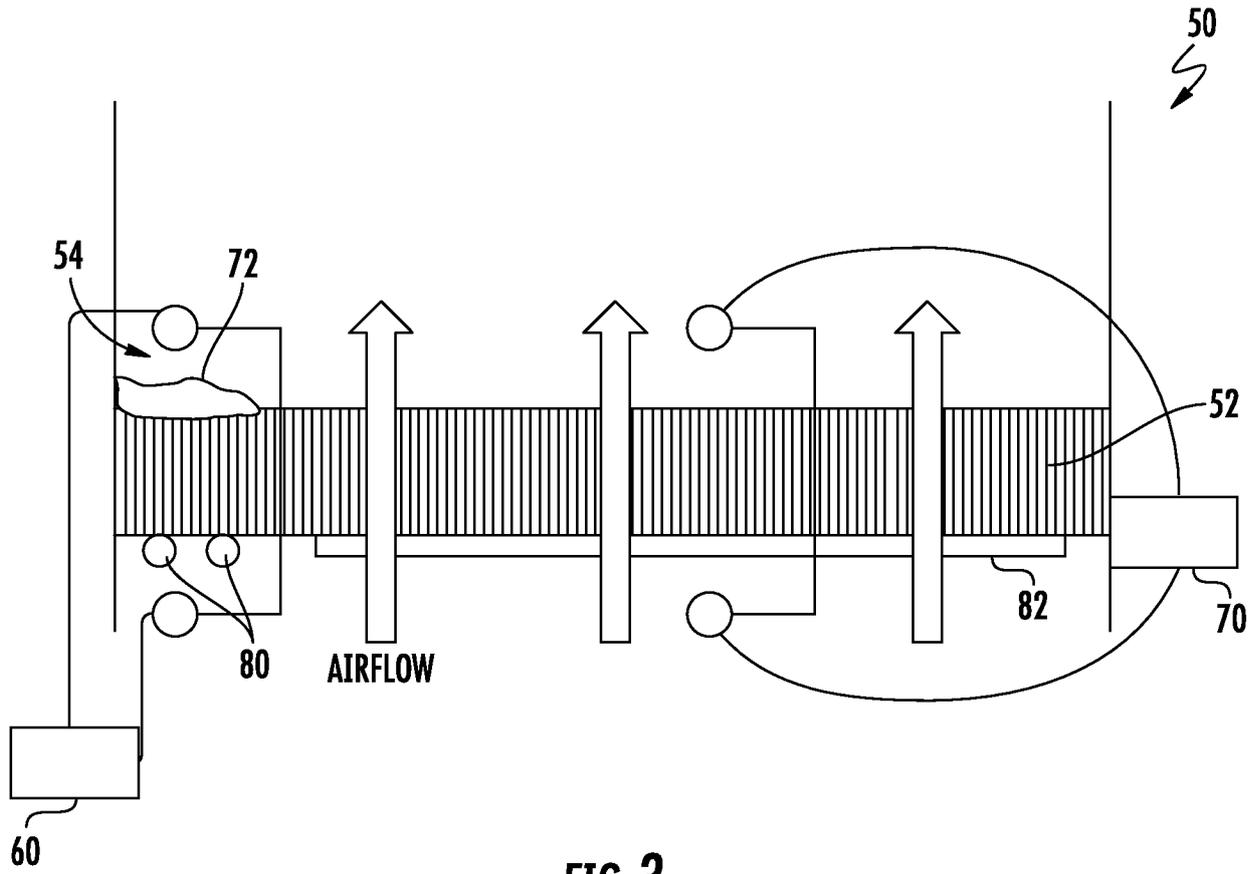


FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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