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(54) REFRIGERATION SYSTEM AND METHOD

KÜHLSYSTEM UND -VERFAHREN

SYSTÈME ET PROCÉDÉ DE RÉFRIGÉRATION

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Description

TECHNICAL FIELD

[0001] The invention relates to a refrigeration system and a corresponding method.

BACKGROUND

[0002] Although applicable to any system that needs to cool or freeze in particular food within a compartment the present invention will be mainly be described in conjunction with refrigerator or freezer. The here described refrigeration system can for example be used in home appliances.

[0003] Conventional refrigerators are configured to use a fan or ventilator to distribute cooled air, for example. Therefore, in particular a heat exchanger is configured to adjust a predetermined temperature of the air within a compartment.

[0004] Typical refrigerators comprise in general two compartments, in particular called refrigerator and freezer, respectively. The cooled air, which is generated by the heat exchanger, is distributed within the refrigerator and freezer, respectively, wherein a temperature gradient can be obtained. That means that the temperature on the opposite side of the heat exchanger of the refrigerator or freezer can be higher than a temperature adjacent to the fan or ventilator, wherein the fan or ventilator is typically arranged adjacent to the heat exchanger. Therefore, stored food adjacent to the heat exchanger experiences a colder temperature as in an area adjacent to a door of the refrigerator or freezer. Therefore, the food can freeze which in particular leads to spoilage of the food, for example.

[0005] Document US 4,009,591 relates to a single evaporator, single fan combination refrigerator. The single evaporator, single fan combination refrigerator includes a temperature control system, which thermostatically maintains the fresh food compartment at a desired temperature by cycling the refrigerator system on and off as required.

[0006] The documents JP S62 87700 A and DE 10 2011 082063 A1 disclose piezoelectric fans for cooling.

[0007] Accordingly, there is a need for an improved refrigeration system.

SUMMARY

[0008] The present invention provides a refrigeration system with the features of claim 1 and a refrigeration method with the features of claim 10.

[0009] The refrigeration system comprises a heat exchanger configured to adjust a predetermined temperature of a gas mixture within a compartment, wherein the heat exchanger comprises or is in connection with a plurality of first vibration activators and wherein the plurality of the first vibration activators is configured to excite the

gas mixture with a first frequency. The compartment of the refrigeration system further comprises a plurality of second vibration actuators, wherein the plurality of the second vibration actuators is configured to envelop the said excited gas mixture of the first frequency with the second frequency within the compartment. For example, the here described refrigeration system comprises at least one compartment. That is, that the here described refrigeration system can comprise one, two or more individual compartments, wherein each of the compartments can comprise the heat exchanger or the compartments are connected to each other via an air channel, wherein the temperature within the different compartments can be regulated by a temperature sensor, for example. The heat exchanger is a device used in transfer heat between a solid object and a fluid, or between two or more fluids, for example.

[0010] The refrigeration method comprises the steps of adjusting a predetermined temperature of a gas mixture via a heat exchanger within the compartment. The method further comprises activating a plurality of first vibration actuators on the heat exchanger and the step activating a plurality of second vibration actuators within the compartment. The method further comprises the step exciting the gas mixture with a first frequency via the plurality of first vibration actuators for example piezoelectric elements and the step enveloping the said excited gas mixture of the first frequency with a second frequency within the compartment via the plurality of second vibration actuators.

[0011] The present invention uses the finding that by enveloping the first frequency of the excited gas mixture, for example by varying the amplitude of the second frequency, the gas mixture can be guided and homogeneously distributed within the compartment by using the second frequency.

[0012] Therefore, the present invention provides two different frequencies wherein the first frequency can be provided by the gas mixture excited by the first frequency and the second frequency can be provided by the compartment and components of the compartment, respectively, for example by excitation of walls of the compartment. Therefore, the gas mixture within the compartment can be homogeneously distributed within the compartment in a cost-efficient manner.

[0013] It is understood, that at least one of the here described refrigeration system can be provided in a refrigerator or freezer.

[0014] Further embodiments of the present invention are subject of the further sub-claims and of the following description, referring to the drawings.

[0015] In one embodiment, the first frequency can comprise or can be a resonance frequency of the compartment and the second frequency can comprise or can be an envelope frequency configured to guide and distribute the said excited gas mixture of the resonance frequency with the envelop frequency within the compartment. Therefore, by using the here described two differ-

ent frequencies, namely the first frequency (resonance frequency or close to the resonance frequency) and the second frequency (envelope frequency) the gas mixture, in particular air, can be homogeneously and fast and therefore effectively distributed in the compartment.

[0016] In physics and engineering, the envelope frequency, so-called the envelope, of an oscillating signal is a smooth curve. The envelope frequency thus generalizes the concept of a constant frequency. An envelope function may be a function of time, space, angle, or indeed of any variable.

[0017] In one embodiment, the maximum level of the envelope frequency can be configured to be equal to the resonance frequency and the minimum level of the envelope frequency can be configured to be between 20% and 30% of the resonance frequency. Therefore by changing the envelope frequency from area to area the gas mixture with the predetermined temperature within the compartment can be guided from the corresponding area to the corresponding area whereby a homogeneous distribution of the gas mixture can be efficiently conducted by changing or varying the second frequency and the envelope frequency, respectively.

[0018] The here described second frequency or envelope frequency can vary in its amplitude depending on its start point. It is conceivable that the amplitude of the second frequency or envelope frequency increases in a direction from the lower surface to the upper surface as well as vice versa. That is, that the second frequency or envelope frequency in particular can also increase its amplitudes in a direction from the upper surface to the lower surface. Therefore, a homogeneous distribution or circulation of the gas mixture, which can be air, with the predetermined temperature can be ensured.

[0019] In one embodiment the plurality of the second vibration actuators can be configured to be individually controllable within an array, wherein the array can comprise the plurality of the second vibration actuators for example piezoelectric elements. That is, that the envelope frequency can be increased or decreased by actuation of certain points of the array, for example. For example, the second vibration actuators can be controlled or can function in dependence of the temperature sensor, which can be located in the compartment. In other words, not all of the plurality of the second vibration actuators has to be excited simultaneously. The plurality of the second vibration actuators can be controlled or can be excited by the temperature sensor, accordingly.

[0020] In one embodiment the heat exchanger can be configured to be arranged on a back surface of the compartment and the compartment can further comprise an upper surface, a lower surface, a closeable front cover and two opposite side surfaces connecting at least the upper surface with the lower surface and wherein the plurality of the second vibration actuators can be arranged on the upper surface, the lower surface and/or the two opposite side surfaces. Preferably, the plurality of the second vibration actuators can be arranged on the

upper surface, the lower surface and the two opposite side surfaces. It is further possible that the closeable front cover comprises the plurality of the second vibration actuators. As here described, the plurality of the second vibration actuators can be arranged in the array, for example. That is that the upper surface, and the lower surface and/or the two opposite side surfaces can each comprise the array, which comprises the plurality of the second vibration actuators. Therefore, a homogeneous distribution of the gas mixture with the predetermined temperature within the compartment can be ensured.

[0021] For example, by arranging the heat exchanger on the back surface of the compartment the predetermined temperature of the gas mixture can be easily provided, wherein the plurality of first vibration actuators excite the gas mixture with its resonance frequency.

[0022] In one embodiment the closeable front cover can be configured to be a door and the compartment can be configured to be thermally insulated to an ambient atmosphere. Therefore, the refrigeration system can be conducted in an energy saving manner and cost-efficient manner, respectively.

[0023] In one embodiment, the predetermined temperature can comprise a range of -20°C to 5°C. Therefore, the here described refrigeration system provides compartments which are configured to store food at low temperature, for example 1°C to 5°C and/or freeze food in a range between 0°C and -20°C.

[0024] In one embodiment the first vibration actuators and the second vibration actuators can comprise electromechanical vibration actuators. Therefore, the excitation or a vibration of the corresponding first and second vibration actuators of the compartment as well as of the heat exchanger can be easily conducted.

[0025] In one embodiment the refrigeration system can be a refrigerator or a freezer.

[0026] In one embodiment, exciting the gas mixture with the first frequency via the plurality of first vibration actuators can comprise the resonance frequency and wherein enveloping the said excited gas mixture of the first frequency with the second frequency within the compartment can comprise the envelope frequency.

[0027] In one embodiment, enveloping the said excited gas mixture of the first frequency can comprise guiding and distributing the said excited gas mixture of the resonance frequency with the envelope frequency.

[0028] The here disclosed features for the refrigeration system are also disclosed for the refrigeration method as well as vice versa.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] For a more complete understanding of the present invention and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings. The invention is explained in more detail below using exemplary embodiments, which are specified in the schematic figures of

the drawings, in which:

- Fig. 1A shows an embodiment of a refrigeration system according to the present patent application;
- Fig. 1B shows a graph for illustrating a cooling performance of the refrigeration system of Fig. 1A;
- Fig. 2A shows a refrigeration system according to the state of the art;
- Fig. 2B shows a corresponding cooling performance of the refrigeration system according to the state of the art;
- Fig. 3 shows a graph for illustrating different types of envelope frequencies;
- Fig. 4 shows a flow diagram of an embodiment of a method according to the present patent application; and
- Fig. 5 shows a graph for illustrating an example of different types of envelope frequencies.

[0030] In the figures like reference signs denote like elements unless stated otherwise.

DETAILED DESCRIPTION OF THE DRAWINGS

[0031] Fig. 1A shows an embodiment of a refrigeration system 100 according to the invention. The refrigeration system 100 comprises a heat exchanger 15 configured to adjust a predetermined temperature of a gas mixture in form of air 30 within a compartment 2, wherein the heat exchanger 15 comprises a plurality of first vibration actuators 11, 12, 13, 14 and wherein the plurality of the first vibration actuators 11, 12, 13, 14 is configured to excite the gas mixture 30 with a first frequency. The compartment 2 of the refrigeration system 100 further comprises a plurality of second vibration actuators 21, 22, 23, 24, wherein the plurality of the second vibration actuators 21, 22, 23, 24 is configured to envelop the said excited gas mixture 30 of the first frequency with the second frequency within the compartment 2.

[0032] In particular, the first frequency can comprise a resonance frequency and the second frequency can comprise an envelope frequency E1, E2 configured to guide and distribute the said excited gas mixture 30 of the resonance frequency with the envelope frequency within the compartment 2.

[0033] In Fig. 1A the heat exchanger 15 which comprises the plurality of first vibration actuators 11, 12, 13, 14 and an array 20 of the plurality of the second vibration actuators 21, 22, 23, 24 are illustrated separately in a refrigeration compartment RE1 and a freezer compart-

ment F1 in order to better illustrate a setup of the refrigeration system 100.

[0034] Fig. 1A in particular illustrates that the heat exchanger 15 of the refrigeration system 100 is arranged on a back surface 3 of the compartment 2 and the compartment 2 further comprises an upper surface 4, a lower surface 5, a closeable front cover 6 and two opposite side surfaces 7, 8 connecting at least the upper surface 4 with the lower surface 5. The closeable front cover 6 in Fig. 1A can be a door, for example. The door of the compartment 2 can be configured to thermally insulate the compartment 2 of the refrigeration system 100 to an ambient atmosphere.

[0035] As illustrated in Fig. 1A the plurality of second vibration actuators 21, 22, 23, 24 are arranged in the array 20, wherein the array 20 are arranged or mounted on the opposite side surfaces 7, 8. The arrangement of the array 20, which comprises the array 20 with the plurality of the second vibration actuators 21, 22, 23, 24, is not limited to the embodiment shown in Fig. 1A. It is also conceivable that the plurality of the second vibration actuators 21, 22, 23, 24 is arranged on the upper surface 4, the lower surface 5 and/or the two opposite side surfaces 7, 8 to ensure an efficient distribution of the gas mixture 30 with the predetermined temperature within the compartment 2.

[0036] As illustrated in Fig. 1A the refrigeration system 100 comprises an air channel 40, which can be understood as an optional feature. In other words each of the here shown compartments RE1, F1, namely the refrigerator compartment RE1 and the freezer compartment F1 can comprise the here described refrigeration system 100 with the heat exchanger 15 and the compartment 2 with the corresponding first vibration actuators 11, 12, 13, 14 and the second vibration actuators 21, 22, 23, 24.

[0037] The envelope frequencies E1, E2 are illustrated by sinusoidal waves, for example, wherein amplitudes of the envelope frequency E1 increases in a direction from the lower surface 5 to the upper surface 4. And in contrast the envelope frequency E2 increases in a direction from the upper surface 4 to the lower surface 5 of the compartment 2 so that the air circulates within the refrigerator compartment RE1 as indicated by the arrows which effectively supports the distribution of cold air within the refrigerator compartment RE1. Therefore, the refrigeration system can be driven in an energy efficient manner.

[0038] Fig. 1B shows a graph G1 to illustrate the cooling performance of the refrigeration system 100 as described in connection with Fig. 1A.

[0039] In graph G1 the time is shown on the horizontal axis (x-axis) and a cooling performance of the refrigeration system 100 is shown on the vertical axis (y-axis). As can be seen the cooling performance of the refrigeration system 100 maintains substantially constant after starting the heat exchanger 15, first vibration actuators 11, 12, 13, 14 and second vibration actuators 21, 22, 23, 24, wherein the first vibration actuator 11, 12, 13, 14 are in particular homogeneously arranged on the heat ex-

changer 15 and the second vibration actuators 21, 22, 23, 24 can be homogeneously distributed within the array 20, wherein the array 20 is mounted or arranged on the upper surface 4, the lower surface 5, the closeable front door cover 6 and/or the opposite side surfaces 7, 8. That means that the cooling performance increases in shorter time than in conventional systems due to efficient distribution of the gas mixture 30 according to the invention.

[0040] Fig. 2A illustrates the refrigeration system 1 according to the state of the art.

[0041] The refrigeration system 1 of Fig. 2A is based on Fig. 1A. In contrast to the refrigeration system 100 of Fig. 1A, the refrigeration system 1 according to the state of the art comprises two fans 41, 41' instead of in particular the first vibration actuators 11, 12, 13, 14 and the second vibration actuators 21, 22, 23, 24. For example, the fan 41 is arranged in the refrigeration compartment RE1 and the fan 41' is arranged in the freezer compartment F1. The fan 41 is further arranged adjacent the air channel 40 and thus in an upper region of the refrigeration compartment RE1. Therefore, the refrigeration compartment RE1 provides a colder region 42 (indicated by the points) and a cold region 43. In addition, a temperature adjacent to the fans 41, 41' is lower than in direction to the closable front cover 6. Therefore, food can freeze which in particular leads to spoilage of the food, for example.

[0042] Fig. 2B shows a graph G2 to illustrate the cooling performance of the refrigeration system 1 according to the state of the art as described in connection with Fig. 2A.

[0043] In graph G2 the time is shown on the horizontal axis (x-axis) and the cooling performance of the refrigeration system 1 is shown on the vertical axis (y-axis). As can be seen in Fig. 2B the cooling performance increases much slower than in comparison to the graph G1 of Fig. 1B. This is based on a slower distribution of the gas mixture 30 when using the fan 41.

[0044] Consequently, the refrigeration system 100 of Fig. 1A distributes the gas mixture 30 fast and in efficient manner.

[0045] Fig. 3 illustrates a graph G3 for illustrating different types of envelope frequencies.

[0046] In graph G3 the time is shown on the horizontal axis (x-axis) and vibration amplitude of the envelope frequency is shown on the vertical axis (y-axis).

[0047] In Graph G3 three levels of envelope frequencies are shown R1, R2, R3. For example, the envelope frequencies can comprise three levels R1, R2, R3. The first level of envelope frequency R1 can be equal to the resonance frequency, for example. The second level of envelope frequency R2 can be 50% of the resonance frequency, for example. And the third level of envelope frequency R3 can be 30% of the resonance frequency, for example. The different levels of the envelope frequencies R1, R2, R3 are separated by the dotted lines in Fig. 3, accordingly.

[0048] Fig. 4 shows a flow diagram of an embodiment

of a refrigeration system.

[0049] The refrigeration method starts with adjusting S1 a predetermined temperature of a gas mixture 30 via a heat exchanger 50 within a compartment 2. Further steps comprise activating S2 a plurality of first vibration actuators 11, 12, 13, 14 on the heat exchanger 15 and activating S3 a plurality of second vibration actuators 21, 22, 23, 24 within the compartment 2. The method further comprises the step exciting S4 the gas mixture 30 with a first frequency via the plurality of first vibration actuators 11, 12, 13, 14 and in the final step enveloping S5 the said exciting gas mixture 30 of the first frequency with the second frequency within the compartment 2 via the plurality of second vibration actuators 21, 22, 23, 24.

[0050] The step exciting S4 the gas mixture 30 with the first frequency via the plurality of first vibration actuators 11, 12, 13, 14 comprises the resonance frequency and the step enveloping the said excited gas mixture 30 of the first frequency with the second frequency within the compartment 2 comprises the envelope frequency E1, E2. Enveloping S5 the said exciting gas mixture 30 of the first frequency comprises guiding and distributing the said excited gas mixture 30 of the resonance frequency with the envelope frequency.

[0051] Fig. 5 shows an example for an embodiment of different types of envelope frequencies according to the invention which is a more detailed example in view of the graph of Fig. 3.

[0052] Frequency F1 is the envelope frequency and the frequency F2 is a follower frequency. The frequency F1 is determined according to mechanical properties of refrigerator and is in interval certain values (for example minimum 50 Hz -maximum 200Hz) and is variable in different locations of the compartment RE1. The amplitude of frequency F1 can be constant and is determined by cooling experiments. In particular, this amplitude must distribute the cool air more efficient and wherein it should not be disturbed by the user as a sound noise.

[0053] F2 is determined again by mechanical properties of refrigerator. and frequency F2 is constant and bigger than frequency F1. The amplitude of frequency F2 is changeable (0-1 kHz) according to the envelope frequency F1.

[0054] In particular, the frequency F1 can change in different locations of cabin as for example shown in Fig. 3 and frequency F2 follows frequency F1 which is not shown in Fig. 3 and only shown in Fig. 5.

[0055] Fig. 5 shows at A a maximum frequency F1 of for example 200Hz which can be the resonance frequency resulting in a maximum cooling and which can be used for a maximum distribution of air. On the other side, at B the frequency F1 has a minimum frequency F1 of for example 50Hz which is 25% of the resonance frequency which results in minimum cooling and which can be used for a minimum distribution of air within a compartment RE1. As an example, the follower frequency F2 can be 1kHz.

[0056] As the envelope frequency G3 of Fig. 3 is used

as an embodiment of the invention to generate an air circulation as shown by arrow 30 in Fig. 1a, the envelope frequency F1 of Fig. 5 could also be used as a further embodiment of the invention to generate an air circulation within the compartment RE1.

[0057] The present invention provides a refrigeration system 100. The refrigeration system 100 comprises a heat exchanger 15 configured to adjust a predetermined temperature of a gas mixture 30 within a compartment 2, wherein the heat exchanger 15 comprises a plurality of first vibration actuators 11, 12, 13, 14 and wherein the plurality of the first vibration actuators 11, 12, 13, 14 is configured to excite the gas mixture 30 with a first frequency. The compartment 2 comprises a plurality of second vibration actuators 21, 22, 23, 24, wherein the plurality of the second vibration actuators 21, 22, 23, 24 is configured to envelope the said excited gas mixture 30 of the first frequency with a second frequency within the compartment 2. The present invention further provides a corresponding method.

List of reference signs

[0058]

1	refrigeration system (state of the art)	
100	refrigeration system of the invention	
2	compartment	
3	back surface	
4	upper surface	
5	lower surface	
6	closeable front cover	
7, 8	two opposite side surfaces	
11, 12, 13, 14	first vibration actuators	
15	heat exchanger	
20	array	
21, 22, 23, 24	second vibration actuators on each side of the side surfaces	
30	gas mixture	
40	air channel	
41, 41'	fan	
42	colder region	
43	cold region	
E1, E2	envelope frequencies	
R1-R3	different levels of envelope frequencies	
S1 - S5	method steps	
G1, G2, G3	graphs	
RE1	refrigeration compartment	
F1	freezer compartment	

Claims

1. Refrigeration system (100), the system comprising:

a heat exchanger (15) configured to adjust a predetermined temperature of a gas mixture (30)

within a compartment (2), wherein the heat exchanger (15) is in connection with a plurality of first vibration actuators (11, 12, 13, 14), wherein the plurality of the first vibration actuators (11, 12, 13, 14) is configured to excite the gas mixture (30) with a first frequency; and **characterised in that** the compartment (2) comprises a plurality of second vibration actuators (21, 22, 23, 24), wherein the plurality of the second vibration actuators (21, 22, 23, 24) are configured to envelope said excited gas mixture (30) of the first frequency with a second frequency within the compartment (2).

2. Refrigeration system (100) according to claim 1, wherein the first frequency comprises a resonance frequency and the second frequency form an envelope frequency (E1, E2) configured to guide and distribute the said excited gas mixture (30) of the resonance frequency with the envelope frequency within the compartment (2).
3. Refrigeration system (100) according to any one of the preceding claims, wherein the maximum level of the envelope frequency is configured to be equal to the resonance frequency and the minimum level of the envelope frequency is configured to be between 20% and 30% of the resonance frequency.
4. Refrigeration system (100) according to any one of the preceding claims, wherein the plurality of the second vibration actuators (21, 22, 23, 24) are configured to be individually controllable within an array (20), wherein the array (20) comprises the plurality of the second vibration actuators (21, 22, 23, 24).
5. Refrigeration system (100) according to any one of the preceding claims, wherein the heat exchanger (15) is configured to be arranged on a back surface (3) of the compartment (2) and the compartment (2) further comprises an upper surface (4), a lower surface (5), a closeable front cover (6) and two opposite side surfaces (7, 8) connecting at least the upper surface (4) with the lower surface (5), and wherein the plurality of the second vibration actuators (21, 22, 23, 24) is configured to be arranged on the upper surface (4), the lower surface (5) and/or the two opposite side surfaces (7, 8).
6. Refrigeration system (100) according to any one of the preceding claims, wherein the closable front cover (6) is configured to be a door and the compartment (2) is configured to be thermally insulated to an ambient atmosphere.
7. Refrigeration system (100) according to any one of the preceding claims, wherein the predetermined

temperature comprises a range of -25°C to 10°C.

8. Refrigeration system (100) according to any one of the preceding claims, wherein the first vibration actuators (11, 12, 13, 14) and second vibration actuators (21, 22, 23, 24) comprises electromechanical vibration actuators. 5
9. Refrigeration system (100) according to any one of the preceding claims, wherein the refrigeration system (100) is a refrigerator or a freezer. 10
10. Refrigeration method, the method comprising:
adjusting (S1) a predetermined temperature of a gas mixture (30) via a heat exchanger (15) within a compartment (2);
activating (S2) a plurality of first vibration actuators (11, 12, 13, 14) on the heat exchanger (15), **characterised by** further comprising: 15
activating (S3) a plurality of second vibration actuators (21, 22, 23, 24) within the compartment (2);
exciting (S4) the gas mixture (30) with a first frequency via the plurality of first vibration actuators (11, 12, 13, 14), and
enveloping (S5) the said excited gas mixture (30) of the first frequency with a second frequency within the compartment (2) via the plurality of second vibration actuators (21, 22, 23, 24). 20 25 30
11. Refrigeration method according to claim 10, wherein exciting the gas mixture (30) with the first frequency via the plurality of first vibration actuators (11, 12, 13, 14) comprises a resonance frequency and wherein enveloping the said excited gas mixture (30) of the first frequency with the second frequency within the compartment (2) comprises an envelope frequency. 35 40
12. Refrigeration method according to any one of the preceding claims 10 and 11, wherein enveloping the said excited gas mixture (30) of the first frequency comprises guiding and distributing the said excited gas mixture (30) of the resonance frequency with the envelope frequency. 45 50

Patentansprüche

1. Kühltssystem (100), wobei das System aufweist:
einen Wärmetauscher (15), der so konfiguriert ist, dass er eine vorbestimmte Temperatur eines Gasgemischs (30) innerhalb eines Fachs (2) einstellt, wobei 55

der Wärmetauscher (15) in Verbindung mit einer Vielzahl von ersten Vibrationsaktuatoren (11, 12, 13, 14) steht, wobei die Vielzahl der ersten Vibrationsaktuatoren (11, 12, 13, 14) so konfiguriert ist, dass sie das Gasgemisch (30) mit einer ersten Frequenz anregt; und **dadurch gekennzeichnet, dass**

das Fach (2) eine Vielzahl von zweiten Vibrationsaktuatoren (21, 22, 23, 24) aufweist, wobei die Vielzahl der zweiten Vibrationsaktuatoren (21, 22, 23, 24) konfiguriert ist, um das angeregte Gasgemisch (30) der ersten Frequenz innerhalb des Fachs (2) mit einer zweiten Frequenz einzuhüllen.

2. Kühltssystem (100) gemäß Anspruch 1, wobei die erste Frequenz eine Resonanzfrequenz aufweist und die zweite Frequenz eine Hüllfrequenz (E1, E2) bildet, die konfiguriert ist, um das angeregte Gasgemisch (30) der Resonanzfrequenz mit der Hüllfrequenz innerhalb des Fachs (2) zu führen und zu verteilen.
3. Kühltssystem (100) gemäß einem der vorhergehenden Ansprüche, wobei der maximale Pegel der Hüllfrequenz so konfiguriert ist, dass er gleich der Resonanzfrequenz ist, und der minimale Pegel der Hüllfrequenz so konfiguriert ist, dass er zwischen 20% und 30% der Resonanzfrequenz liegt.
4. Kühltssystem (100) gemäß einem der vorangehenden Ansprüche, wobei die Mehrzahl der zweiten Vibrationsaktuatoren (21, 22, 23, 24) innerhalb eines Arrays (20) individuell ansteuerbar ausgebildet sind, wobei das Array (20) die Mehrzahl der zweiten Vibrationsaktuatoren (21, 22, 23, 24) aufweist.
5. Kühltssystem (100) gemäß einem der vorhergehenden Ansprüche, wobei der Wärmetauscher (15) ausgebildet ist, um an einer Rückfläche (3) des Fachs (2) angeordnet zu werden, und das Fach (2) weiterhin eine obere Fläche (4), eine untere Fläche (5), eine verschließbare Frontabdeckung (6) und zwei gegenüberliegende Seitenflächen (7, 8) aufweist, die zumindest die obere Fläche (4) mit der unteren Fläche (5) verbinden, und wobei die Mehrzahl der zweiten Vibrationsaktuatoren (21, 22, 23, 24) dazu ausgebildet ist, an der oberen Fläche (4), der unteren Fläche (5) und/oder den beiden gegenüberliegenden Seitenflächen (7, 8) angeordnet zu sein.
6. Kühltssystem (100) gemäß einem der vorhergehenden Ansprüche, wobei die verschließbare Frontabdeckung (6) als Tür ausgebildet ist und das Fach (2) gegenüber einer Umgebungsatmosphäre thermisch isoliert ausgebildet ist.
7. Kühltssystem (100) gemäß einem der vorangehenden

Ansprüche, wobei die vorgegebene Temperatur einen Bereich von -25°C bis 10°C aufweist.

8. Kühltssystem (100) gemäß einem der vorhergehenden Ansprüche, wobei die ersten Vibrationsaktuatoren (11, 12, 13, 14) und zweiten Vibrationsaktuatoren (21, 22, 23, 24) elektromechanische Vibrationsaktuatoren aufweisen. 5
9. Kühltssystem (100) gemäß einem der vorangehenden Ansprüche, wobei das Kühltssystem (100) ein Kühltschrank oder ein Gefrierschrank ist. 10
10. Verfahren zur Kühlung, wobei das Verfahren aufweist: 15

Einstellen (S1) einer vorbestimmten Temperatur eines Gasgemisches (30) über einen Wärmetauscher (15) innerhalb eines Fachs (2);
Aktivieren (S2) einer Mehrzahl von ersten Vibrationsaktuatoren (11, 12, 13, 14) an dem Wärmetauscher (15), **dadurch gekennzeichnet, dass** es ferner aufweist:

Aktivieren (S3) einer Mehrzahl von zweiten Vibrationsaktuatoren (21, 22, 23, 24) innerhalb des Fachs (2);

Erregen (S4) des Gasgemisches (30) mit einer ersten Frequenz über die Vielzahl der ersten Vibrationsaktuatoren (11, 12, 13, 14), und

Einhüllen (S5) des angeregten Gasgemisches (30) der ersten Frequenz mit einer zweiten Frequenz innerhalb des Fachs (2) über die Vielzahl der zweiten Vibrationsaktuatoren (21, 22, 23, 24). 20 25 30 35

11. Verfahren zur Kühlung gemäß Anspruch 10, wobei die Anregung des Gasgemisches (30) mit der ersten Frequenz über die Mehrzahl von ersten Vibrationsaktuatoren (11, 12, 13, 14) eine Resonanzfrequenz aufweist und wobei das Einhüllen des angeregten Gasgemisches (30) der ersten Frequenz mit der zweiten Frequenz innerhalb des Fachs (2) eine Hüllfrequenz aufweist. 40 45
12. Verfahren zur Kühlung gemäß einem der vorangehenden Ansprüche 10 und 11, wobei das Einhüllen des angeregten Gasgemisches (30) der ersten Frequenz das Führen und Verteilen des angeregten Gasgemisches (30) der Resonanzfrequenz mit der Hüllfrequenz aufweist. 50

Revendications 55

1. Système de réfrigération (100), le système comprenant :

un échangeur de chaleur (15) configuré pour ajuster une température prédéterminée d'un mélange gazeux (30) à l'intérieur d'un compartiment (2), où

l'échangeur de chaleur (15) est en connexion avec une pluralité de premiers actionneurs de vibration (11, 12, 13, 14), dans lequel la pluralité des premiers actionneurs de vibration (11, 12, 13, 14) est configurée pour exciter le mélange gazeux (30) avec une première fréquence ; et **caractérisé en ce que**

le compartiment (2) comprend une pluralité de seconds actionneurs de vibration (21, 22, 23, 24), dans lequel la pluralité des seconds actionneurs de vibration (21, 22, 23, 24) est configurée pour envelopper ledit mélange gazeux excité (30) de la première fréquence avec une seconde fréquence à l'intérieur du compartiment (2).

2. Système de réfrigération (100) selon la revendication 1, dans lequel la première fréquence comprend une fréquence de résonance et la deuxième fréquence forme une fréquence d'enveloppe (E1, E2) configurée pour guider et distribuer ledit mélange gazeux excité (30) de la fréquence de résonance avec la fréquence d'enveloppe dans le compartiment (2). 20 25
3. Système frigorifique (100) selon l'une quelconque des revendications précédentes, dans lequel le niveau maximal de la fréquence enveloppe est configuré pour être égal à la fréquence de résonance et le niveau minimal de la fréquence enveloppe est configuré pour être compris entre 20% et 30% de la fréquence de résonance. 30 35
4. Système de réfrigération (100) selon l'une quelconque des revendications précédentes, dans lequel la pluralité des deuxièmes actionneurs vibratoires (21, 22, 23, 24) sont configurés pour être contrôlables individuellement au sein d'un réseau (20), dans lequel le réseau (20) comprend la pluralité des deuxièmes actionneurs vibratoires (21, 22, 23, 24). 40 45
5. Système de réfrigération (100) selon l'une quelconque des revendications précédentes, dans lequel l'échangeur de chaleur (15) est configuré pour être agencé sur une surface arrière (3) du compartiment (2) et le compartiment (2) comprend en outre une surface supérieure (4), une surface inférieure (5), un couvercle avant fermable (6) et deux surfaces latérales opposées (7, 8) reliant au moins la surface supérieure (4) à la surface inférieure (5), et dans lequel la pluralité des seconds actionneurs de vibration (21, 22, 23, 24) est configurée pour être disposée sur la surface supérieure (4), la surface inférieure (5) et/ou les deux surfaces latérales opposées (7, 8). 50 55
6. Système de réfrigération (100) selon l'une quelcon-

que des revendications précédentes, dans lequel le capot frontal fermable (6) est configuré pour être une porte et le compartiment (2) est configuré pour être isolé thermiquement d'une atmosphère ambiante.

7. Système de réfrigération (100) selon l'une quelconque des revendications précédentes, dans lequel la température prédéterminée comprend une plage de -25°C à 10°C. 5
8. Système de réfrigération (100) selon l'une quelconque des revendications précédentes, dans lequel les premiers actionneurs de vibration (11, 12, 13, 14) et les seconds actionneurs de vibration (21, 22, 23, 24) comprennent des actionneurs de vibration électromécaniques. 10
9. Système de réfrigération (100) selon l'une quelconque des revendications précédentes, dans lequel le système de réfrigération (100) est un réfrigérateur ou un congélateur. 15
10. Méthode de réfrigération, la méthode comprenant : 20
 - le réglage (S1) d'une température prédéterminée d'un mélange gazeux (30) via un échangeur de chaleur (15) à l'intérieur d'un compartiment (2) ; 25
 - l'activation (S2) d'une pluralité de premiers actionneurs de vibration (11, 12, 13, 14) sur l'échangeur de chaleur (15), **caractérisé en ce qu'il** comprend en outre : 30
 - l'activation (S3) d'une pluralité de seconds actionneurs de vibration (21, 22, 23, 24) à l'intérieur du compartiment (2) ; 35
 - l'excitation (S4) du mélange gazeux (30) avec une première fréquence via la pluralité de premiers actionneurs de vibration (11, 12, 13, 14), et 40
 - envelopper (S5) ledit mélange gazeux excité (30) de la première fréquence avec une seconde fréquence à l'intérieur du compartiment (2) par l'intermédiaire de la pluralité de seconds actionneurs de vibration (21, 22, 23, 24). 45
11. Méthode de réfrigération selon la revendication 10, dans laquelle l'excitation du mélange gazeux (30) avec la première fréquence via la pluralité de premiers actionneurs de vibration (11, 12, 13, 14) comprend une fréquence de résonance et dans laquelle l'enveloppement dudit mélange gazeux excité (30) de la première fréquence avec la seconde fréquence à l'intérieur du compartiment (2) comprend une fréquence d'enveloppe. 50
12. Méthode de réfrigération selon l'une quelconque des 55

revendications précédentes 10 et 11, dans laquelle l'enveloppement dudit mélange gazeux excité (30) de la première fréquence comprend le guidage et la distribution dudit mélange gazeux excité (30) de la fréquence de résonance avec la fréquence enveloppe.

Fig. 1A

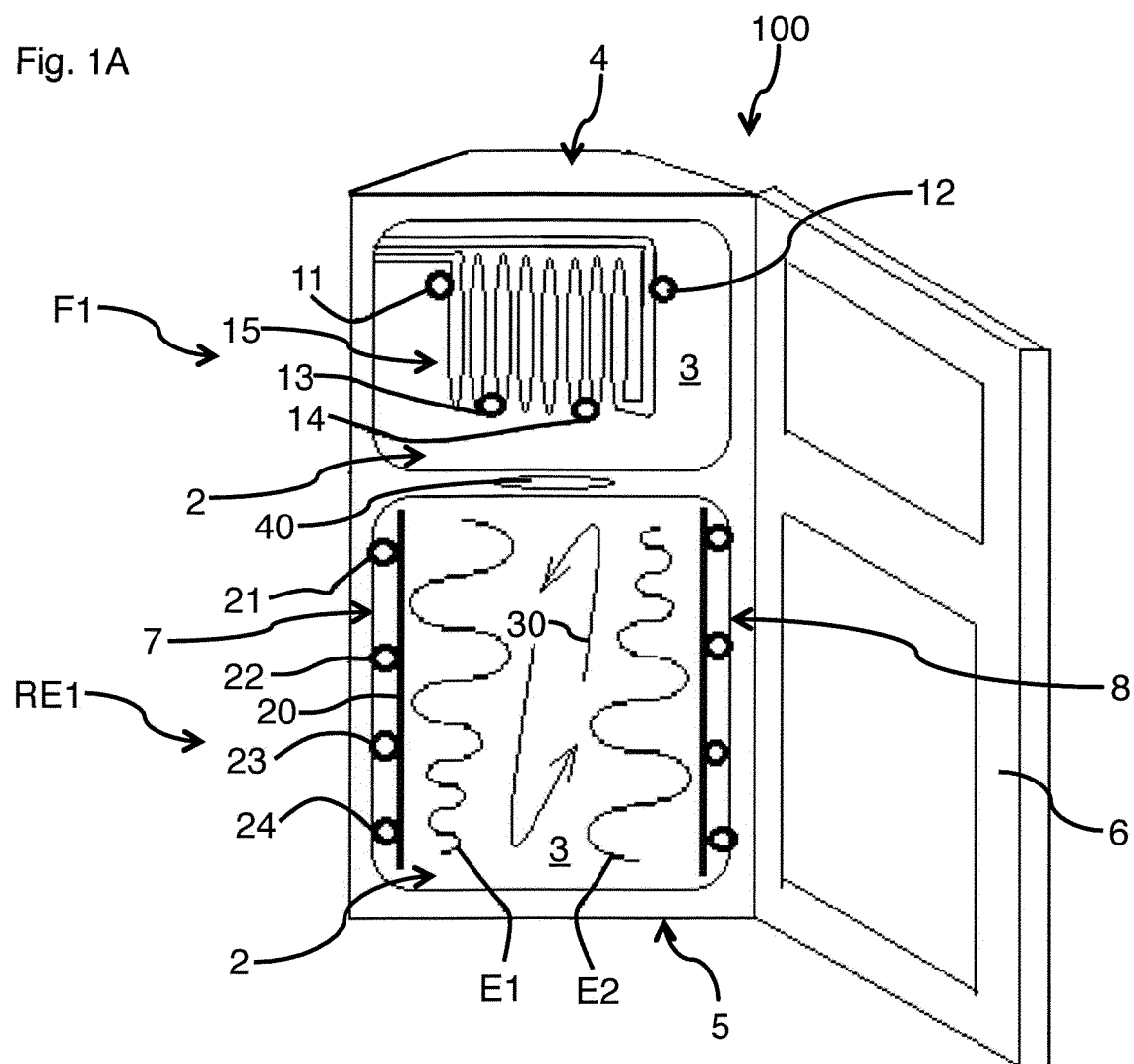


Fig. 1 B



Fig. 2A

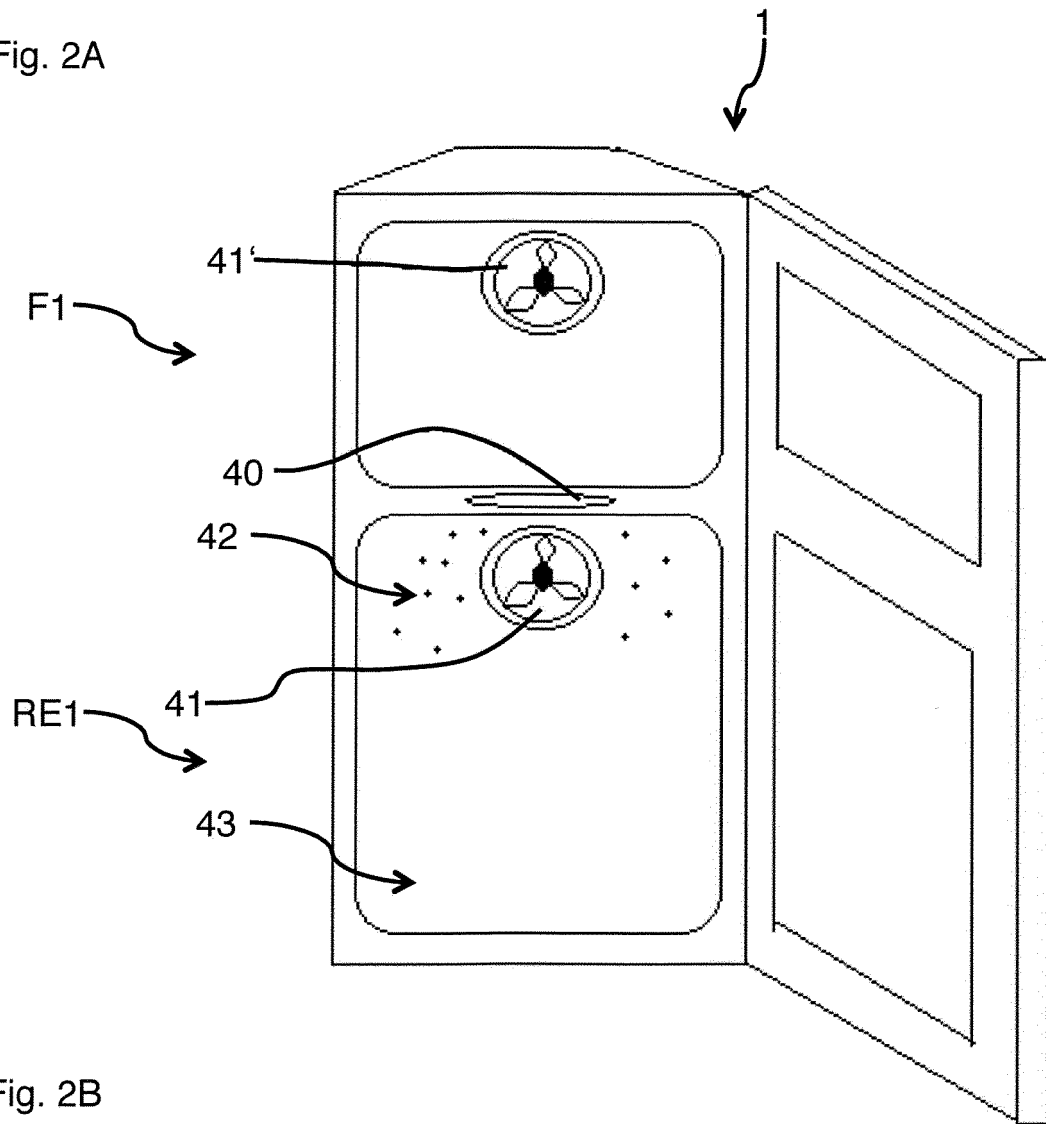


Fig. 2B

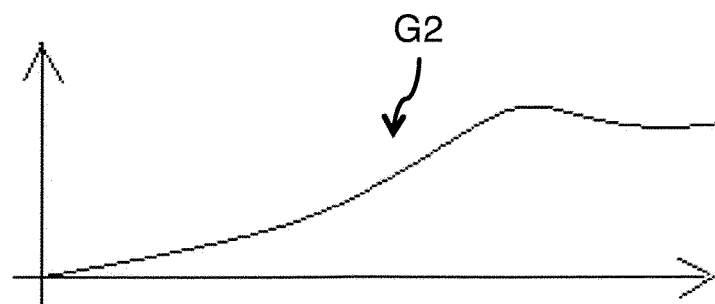


Fig. 3

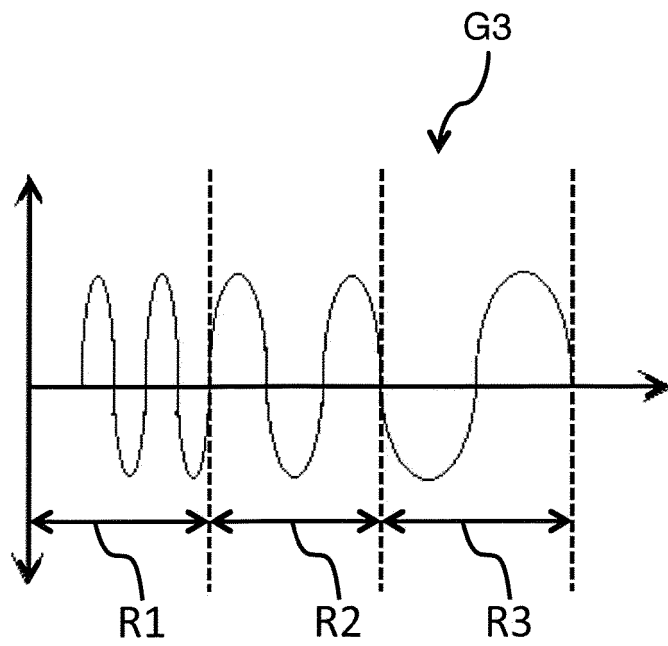
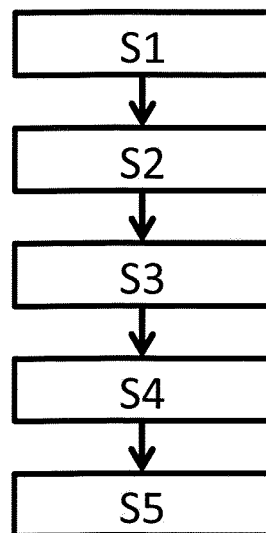
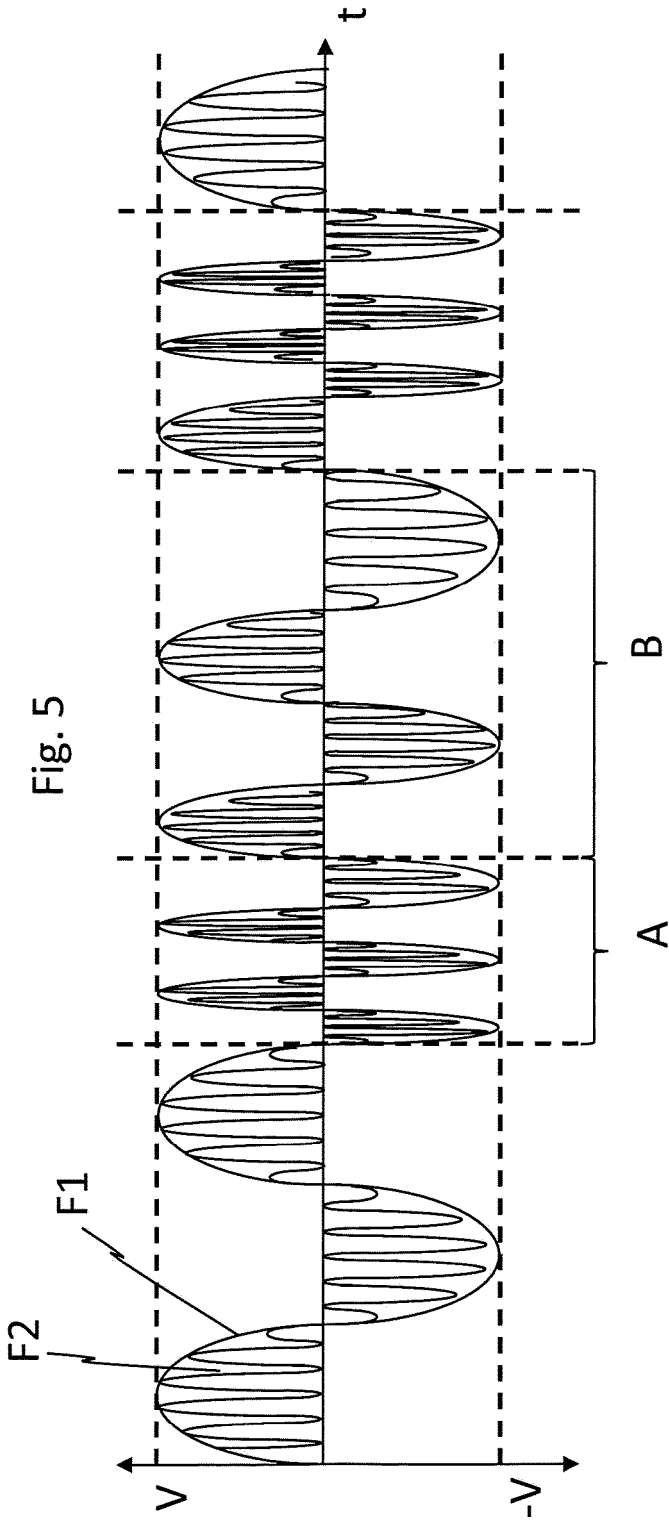


Fig. 4





REFERENCES CITED IN THE DESCRIPTION

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