(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 September 2009 (11.09.2009)

PCT

(10) International Publication Number
WO 2009/109909 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/IB2009/050850

(22) International Filing Date:
3 March 2009 (03.03.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2008/01996 3 March 2008 (03.03.2008) ZA

(71) Applicant *(for MW only)*: **DONALD, Heather, June** [ZA/ZA]; PO Box 454, 0001 Pretoria (ZA).

(71) Applicant and
(72) Inventor: **MAZEREEUW, George, Sjoerd** [GB/GB]; 3 Mason Close, Freckleton Close Lancashire PR4 1RG (GB).

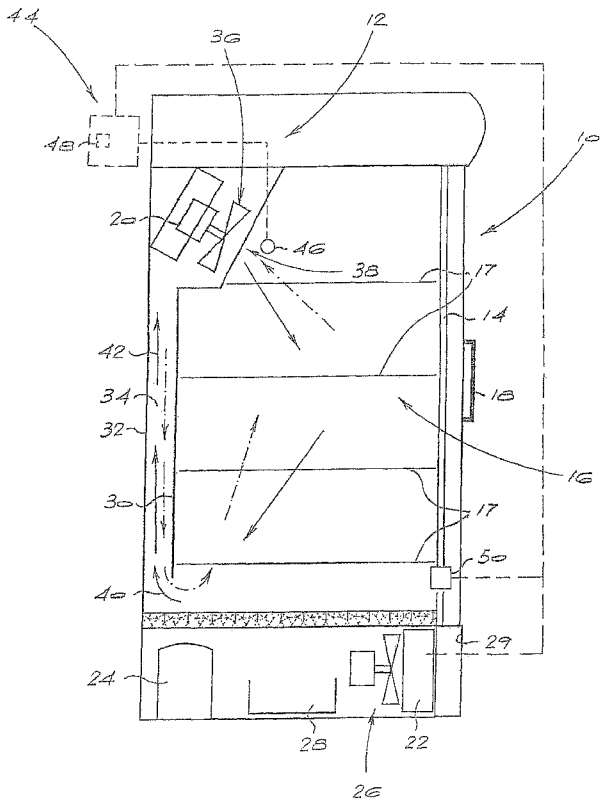
(74) Agents: **SPOOR & FISHER** et al.; P O Box 454, 0001 Pretoria (ZA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: REFRIGERATION SYSTEM



(57) Abstract: The invention concerns a refrigeration system (12) including an evaporator (20) for evaporating a refrigerant and an air displacement arrangement (36) for causing air to be displaced across the evaporator. The system also include a control system (44) for adjusting the volume of air and/or the direction at which air is caused to be moved across the evaporator by the air displacement arrangement. The volume of air and/or the direction at which air is caused to be moved across the evaporator is controlled by the control system in response to measurements taken by a gauge such as a thermometer (46) for measuring the air off temperature of the evaporator and a timer (48). The air displacement arrangement is typically in the form of a fan having pitch-adjustable fan blades. This allows the pitch angle of the fan blades to be adjusted in order to change the air volume and/or the direction of air flow.

WO 2009/109909 A2

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

"REFRIGERATION SYSTEM"

BACKGROUND TO THE INVENTION

THIS invention relates to a refrigeration system.

Many refrigerators make use of a cooling system which comprises an evaporator, a condenser and a compressor. In use, a refrigerant is vapourised inside the evaporator, thereby causing heat to be absorbed from the cooling chamber of the refrigerator. By having the refrigerant absorbing heat from the cooling chamber, the temperature inside the cooling chamber will drop. From the evaporator the refrigerant is fed to the condenser where the gas is condensed to a liquid, whereafter it is fed to the compressor and then back to the evaporator. By running this process continuously, the temperature inside the cooling chamber can be reduced to a desired level.

In the case of a beverage cooler, in order to ensure that their beverages are stored inside a refrigerator at a favourable temperature, producers of beverages often specify certain parameters for refrigerating their products. One well known soft drink producer for example specifies that from a stabilised position of 32°C and within a period of 19 hours of refrigeration, the warmest beverage can in a refrigerator should not be warmer than 7°C while the coldest beverage can should not be colder than 0°C. Also, the average temperature of all the beverage cans should not exceed 3.2°C.
The average temperature of the evaporator of a beverage cooler is in the region of -10°C to -12°C causing air leaving the evaporator to be below

0°C. The result of this is that the beverage bottle or can located nearest the "air off" point of the evaporator will be the coldest container in the cooler, whereas the bottle or can nearest the "air on" position of the evaporator will be the warmest container. Also, during a refrigeration cycle the "air off" temperature will commence at a relatively high temperature and will gradually become colder as the refrigeration cycle progresses.

The reason for the drop in the "air off" temperature is that at the beginning of the refrigeration cycle a large amount of warm air will be held inside the refrigerator, i.e. the availability of a large amount of heat to be extracted from this air as it is allowed to move across the evaporator (which acts as a heat exchanger). However, as the refrigeration cycle progresses less and less heat will be available in the same amount of air and as a result the effectiveness of the refrigeration cycle will deteriorate.

It is accordingly an object of the invention to provide an alternative refrigeration system which will address the efficiency loss experienced during the refrigeration cycle of a conventional refrigerator.

SUMMARY OF THE INVENTION

The invention is defined in the appended claims.

In particular, according to one aspect of the invention there is provided a refrigeration system including an evaporator for evaporating a refrigerant, an air displacement arrangement for causing air to be displaced across the evaporator and a control system for adjusting the volume of air and/or the direction in which air is caused to be moved across the evaporator by the air displacement arrangement. Preferably the air displacement arrangement is switchable between a first configuration in which air can be caused to move across the evaporator in a first direction and a second configuration in which air can be caused to move in an opposite, second direction across the evaporator.

The preferred refrigeration system includes at least one gauge in communication with the control system, the control system being arranged to adjust the air volume and/or air movement direction in response to measurements taken by the gauge. Advantageously the refrigeration system includes two gauges, the first gauge being in the form of a thermometer for measuring the air off temperature of the evaporator and the second gauge being in the form of a timer. The control system may be arranged to cause the air displacement arrangement to switch from its first configuration to its second configuration in response to measurements taken by the timer.

In the preferred embodiment, the air displacement arrangement comprises a fan having variable pitch fan blades.

According to an advantageous feature of the invention, the refrigeration system includes a door sensor for detecting when a door of a refrigerator incorporating the refrigeration system is open and the control system is arranged for the air displacement arrangement to cause no air flow to take place when the door sensor detects that the door is open.

Preferably also the refrigeration system of the invention comprises a condenser and a condenser fan with variabale pitch blades for moving a variable flow of air across the condenser, the condenser fan operating under the control of the control system.

According to another aspect of the invention there is provided a method of refrigerating a space including the steps of:

- providing an evaporator for evaporating a refrigerant;

- providing an air displacement arrangement for causing air to be displaced across the evaporator;

- providing a control system for adjusting the volume of air and/or

the direction at which air is caused to move across the evaporator by the air displacement arrangement;

- providing at least one gauge;

- causing air to be displaced across the evaporator; and

- controlling the volume and/or direction at which air is caused to be displaced across the evaporator in response to measurements taken by the gauge.

The preferred method includes the step of periodically switching the air displacement arrangement between a first configuration in which air is caused to move across the evaporator in a first direction and a second configuration in which air is caused to move across the evaporator in an opposite, second direction. For this purpose there may be provided a gauge in the form of a timer, the method including switching the air displacement arrangement between the respective configurations in response to the timer.

Preferably the method includes the step of providing a gauge in the form of a temperature sensor and controlling the volume of air displaced across the evaporator by the air displacement arrangement in response to an air off temperature of the evaporator measured by the temperature sensor.

The preferred air displacement arrangement is a fan with variable pitch blades and the method includes the step of varying the pitch of the blades in order to control the volume of air displaced across the evaporator.

Advantageously the method includes the steps of providing a door sensor for detecting when a door closing the refrigerated space is open and of causing the air displacement arrangement to cause no air flow to take place when the door sensor detects that the door is open.

The method may also include the steps of providing a condenser in a refrigeration circuit which also includes the evaporator, providing a condenser fan with variable pitch blades for moving a variable flow of air across the condenser, and controlling the operation of the condenser fan by means of the control system.

In one embodiment, the method can be used to refrigerate a refrigeration space in a beverage cooler, but the invention is not limited to this application.

BRIEF DESCRIPTION OF THE DRAWING

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing which diagrammatically illustrates a refrigerator incorporating a refrigeration system in accordance with the teachings of the present invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The drawing diagrammatically illustrates a beverage refrigerator or cooler 10 incorporating a refrigeration system in accordance with the present invention, generally indicated with the reference numeral 12. The refrigerator 10 comprises a body 14 which defines a refrigerator space in the form of a cooling chamber 16 in which beverage bottles and/or cans can be cooled. As shown the beverage refrigerator 10 includes a number of shelves 17 on which the beverage containers can be placed. Access to the cooling chamber 16 can be gained through a glass door 18.

As with a conventional refrigerator the beverage refrigerator 10 includes an evaporator 20, in this embodiment provided in the form of a coil evaporator, wherein a refrigerant will be caused to be vapourised by extracting heat from the cooling chamber 16, thereby leading to a temperature reduction

inside the cooling chamber 16. From the evaporator 20 the gaseous refrigerant is fed to a condenser 22 wherein heat is extracted and it is allowed to condense to a liquid whereafter it is fed to a compressor 24 and then returned to the evaporator 20 via a capillary tube, not shown, which ensures that the refrigerant enters the evaporator 20 as a vapour.

As shown, a condenser fan 26 is provided for drawing air across the condenser 22. In order to deter dust and other unwanted particles from being drawn into the condenser 22 a condenser grill or filter 29 is provided. Also, in order to capture any water leakage resulting from the refrigeration process a tray 28 is provided inside the space holding the condenser 22 and the compressor 24.

The beverage refrigerator 10 is provided with a back panel 30 which is spaced apart from a rear wall 32 of the refrigerator to define a flow path 34. In use, cooled air is caused to move away from the evaporator 20 under the influence of an air displacement arrangement 36, here provided in the form of a fan, at the so called "air off" position 38. From the evaporator 20 the cooled air will move downwardly across the shelves 17 inside the cooling chamber 16 until it reaches the "air on" position 40 at the bottom of the cooling chamber 16. Finally the air passes under the influence of the air displacement arrangement 36 upwardly along the flow path 34 where it will again be caused to move across the evaporator 20 to be cooled. This cycle is indicated with solid arrows 42.

The refrigeration system 10 of the invention differs from conventional refrigeration systems *inter alia* in that it includes a control system 44 for adjusting the volume of air and/or the direction at which the air displacement arrangement 36 can cause air to be moved across the evaporator 20. In particular the air displacement arrangement is provided in the form of a fan having pitch-adjustable fan blades as described in a copending international patent application entitled "Fan", filed simultaneously with the present application by the present applicant and

claiming priority from ZA2008/01995. The disclosure of the copending application is incorporated herein in entirety by way of reference.

The operation of the fan of the co-pending application can be summarised as follows:

The fan comprises a plurality of fan blades which are secured about a drive shaft which is to be driven by an electric motor. The fan blades are pivotally secured inside a fan blade support such that they can be pivoted or rotated about generally radial axes between first and second positions, i.e. the pitch of the fan blades is adjustable.

The fan further includes an actuator which is mounted about the drive shaft and is connected to the fan blades. In use axial movement of the actuator causes the fan blades to move, i.e. rotate or pivot about generally radial axes, between their respective first and second positions. The fan also includes an adjustor which is connected to the actuator. The adjustor in turn is connected to a stepper motor. The stepper motor further is in communication with the control system 44.

In use the stepper motor will be activated by the control system 44, such activation causing the adjustor to move from a first adjustor position to a second adjustor position. Such movement of the adjustor causes the actuator to move axially relative to the drive shaft, as a consequence rotating the fan blades from their first positions to their second positions, thereby altering the blade pitch and accordingly the volume of air displaced per unit time by the air displacement arrangement 36.

The control system 44 operates, in response to the output of gauges or sensors 46 and 48, in order to adjust the volume of air and/or direction in which air is caused to move across the evaporator 20 by the air displacement arrangement 36. In this embodiment of the invention the first gauge is a temperature sensor or thermometer 46 which is positioned in the

cooling chamber 16 to measure the air off temperature of the evaporator 20. The second gauge is a timer.

As will be understood by persons skilled in the field of refrigeration, at the beginning of a refrigeration cycle there will be a substantial quantity of warm air inside the cooling chamber 16, i.e. the cooling chamber contains a substantial amount of heat which can be extracted as the air is caused to move over the evaporator (heat exchanger). However, as the refrigeration cycle progresses, less and less heat is available from the same amount of displaced air. In a conventional refrigerator no adjustment is made for this variation and the air throughput across the evaporator remains constant (typically about 1.7 m/s). As a result the effectiveness of the evaporator will deteriorate and in severe instances the evaporator can even ice up. Persons skilled in the art will appreciate the undesirable cost and time implications of running defrosting cycles necessary to defrost an evaporator which has iced up.

The present invention seeks to address this problem by providing a refrigeration system wherein the volume of air which can be displaced by the air displacement arrangement 36, i.e. evaporator fan, can be adjusted in response to measurements taken by the thermometer 46. Thus, in use, when the thermometer 46 senses a drop in temperature the control system 44 will cause the air displacement arrangement 36 to increase the volume of air which is caused to move across the evaporator 20, thereby compensating for the loss in available heat present in the air displaced.

Similar behavior can be seen at the condenser of a conventional refrigerator, where the fan output remains constant such that in a cold environment the condenser may over condense while in a warm environment it may under condense. All of this occurs at the expense of the efficiency of the refrigeration system.

According to the present invention the condenser fan 26 may also be a fan of the kind described in the aforementioned, international patent

application, so that the volume of air which is caused to be displaced across the condenser by the fan per unit time can also be controlled by the control system 44. By varying the air flow across the condenser at different stages during the refrigeration operation and in response to varying conditions in the refrigerated space, for example the temperature measured therein by the thermometer 46, it is possible to keep the condenser in a clean state leading, it is believed, to enhanced refrigeration efficiency and performance.

The beverage refrigerator or cooler 10 also includes a door sensor 50 which is also in communication with the control system 44. The control system 44 is programmed such that when the door sensor 50 detects that the door 18 of the beverage refrigerator 10 has been opened, the air displacement arrangement 36 is switched to a neutral setting. In this setting of the arrangement 36 no air flow takes place, thereby avoiding a situation that warm, external, ambient air is drawn into the beverage refrigerator 10 through the open door.

The control system 44 is arranged such that once the timer 48 has measured a specific lapse of time, typically of the order of 10 minutes, it switches the air displacement arrangement 36 from its first configuration, as described above, to a second configuration in which the air is caused to move in an opposite direction indicated by broken arrows 52. This may for instance be achieved by reversing the direction of rotation of the motor driving the air displacement arrangement, i.e. the fan 36. It will be appreciated that the air off position 38 now becomes the air on position, while the air on position 40 becomes the air off position. Upon the expiration of a further time lapse, again typically of the order of 10 minutes, the air displacement arrangement 36 is switched back to the first configuration. This cycle, in which the air flow direction is periodically reversed, may be repeated until the thermostat of the refrigerator, not shown, causes the refrigeration system to become dormant.

As a result of the above switching of the air flow direction the temperatures at the top and bottom shelves should in theory be the coldest, with the middle shelves being the warmest. Tests have, however, shown that the system leads to minimal, if any, temperature differentials between the different shelves 17 of the beverage refrigerator 10.

The refrigeration system described ensures that the temperature across the cooling chamber of a refrigerator remains substantially constant. Furthermore, the refrigeration system of the invention will ensure that the evaporator always operates at a positive temperature which will increase the efficiency of the refrigerator, with no beverage container adjacent the evaporator freezing up due to the fact that the temperature of the air off from the evaporator will not drop below zero.

The control system may also be arranged to switch the condenser fan 26 periodically so that the air flow direction across the condenser is periodically reversed. It is perceived that this feature will assist in ensuring that the condenser is maintained in a clean condition contributing to a high level of condenser efficiency.

Also, as the temperature of the evaporator is always positive there can be a reduced requirement for defrosting cycles as ice will not develop in these conditions, potentially leading to less downtime and increased cost savings.

Although specific mention has been made of a refrigeration system used in a glass front refrigerator or cooler, it will be understood that the principles of the invention are equally applicable to other types of refrigerator or cooler in which there is a refrigeration space that has to be cooled.

CLAIMS

1.

A refrigeration system including an evaporator for evaporating a refrigerant, an air displacement arrangement for causing air to be displaced across the evaporator and a control system for adjusting the volume of air and/or the direction in which air is caused to be moved across the evaporator by the air displacement arrangement.

2.

A refrigeration system according to claim 1, wherein the air displacement arrangement is switchable between a first configuration in which air can be caused to move across the evaporator in a first direction and a second configuration in which air can be caused to move in an opposite, second direction across the evaporator.

3.

A refrigeration system according to either claim 1 or 2, wherein the refrigeration system includes at least one gauge in communication with the control system, the control system being arranged to adjust the air volume and/or air movement direction in response to measurements taken by the gauge.

4.

A refrigeration system according to claim 3, wherein the refrigeration system includes two gauges, the first gauge being in the form of a thermometer for measuring the air off temperature of the evaporator and the second gauge being in the form of a timer.

5.

A refrigeration system according to claim 4, wherein the control system is arranged to cause the air displacement arrangement to switch from its first configuration to its second configuration in response to measurements taken by the timer.

6.

A refrigeration system according to any one of the preceding claims, wherein the air displacement arrangement comprises a fan having pitch-adjustable fan blades.

7.

A refrigeration system according to any one of the preceding claims, wherein the refrigeration system includes a door sensor for detecting when a door of a refrigerator incorporating the refrigeration system is open and the control system is arranged for the air displacement arrangement to cause no air flow to take place when the door sensor detects that the door is open.

8.

A refrigeration system according to any one of the preceding claims and comprising a condenser and a condenser fan with variabale pitch blades for moving a variable flow of air across the condenser, the condenser fan operating under the control of the control system.

9.

A method of refrigerating a space including the steps of:

- providing an evaporator for evaporating a refrigerant;

- providing an air displacement arrangement for causing air to be displaced across the evaporator;

- providing a control system for adjusting the volume of air and/or the direction at which air is caused to move across the evaporator by the air displacement arrangement;
- providing at least one gauge;

- causing air to be displaced across the evaporator; and

- controlling the volume and/or direction at which air is caused to be displaced across the evaporator in response to measurements taken by the gauge.

10.
A method according to claim 9 and including the step of periodically switching the air displacement arrangement between a first configuration in which air is caused to move across the evaporator in a first direction and a second configuration in which air is caused to move across the evaporator in an opposite, second direction.

11.
A method according to either claim 9 or claim 10 and including the steps of providing a gauge in the form of a timer and switching the air displacement arrangement between the respective configurations in response to the timer.

12.
A method according to any one of claims 9 to 11 and including the step of providing a gauge in the form of a temperature sensor and controlling the

volume of air displaced across the evaporator by the air displacement arrangement in response to an air off temperature of the evaporator measured by the temperature sensor.

13.

A method according to claim 12 wherein the air displacement arrangement is a fan with variable pitch blades and the method includes the step of varying the pitch of the blades in order to control the volume of air displaced across the evaporator.

14.

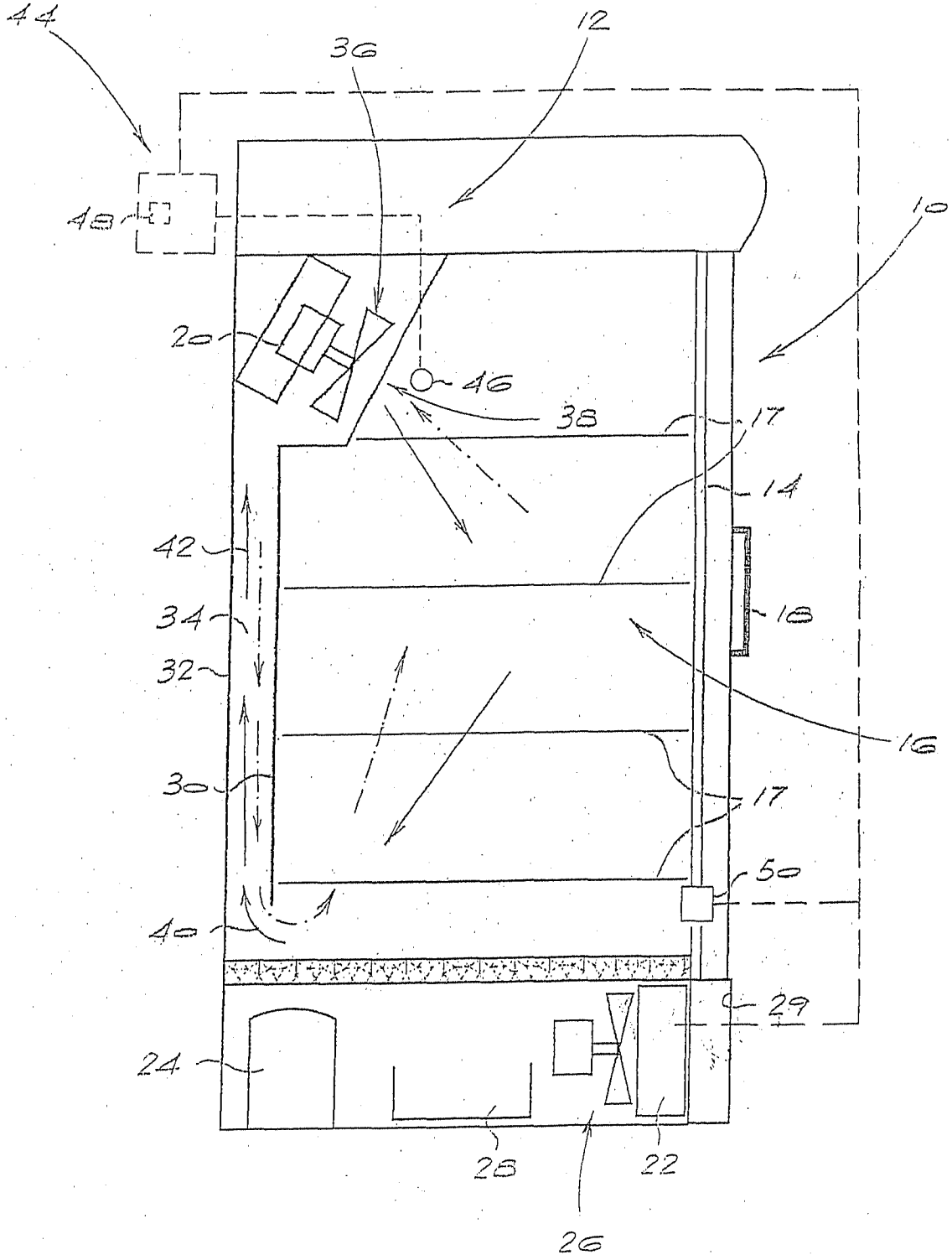
A method according to any one of claims 9 to 13 including the steps of providing a door sensor for detecting when a door closing the refrigerated space is open and of causing the air displacement arrangement to cause no air flow to take place when the door sensor detects that the door is open.

15.

A method according to any one of claims 9 to 14 including the steps of providing a condenser in a refrigeration circuit which also includes the evaporator, providing a condenser fan with variable pitch blades for moving a variable flow of air across the condenser, and controlling the operation of the condenser fan by means of the control system.

16.

A method according to any one of claims 9 to 15 when used to refrigerate a refrigeration space in a beverage cooler.


44
36
12
48
10
20
46
38
17
14
42
18
34
32
16
30
17
50
40
29
24
28
22
26