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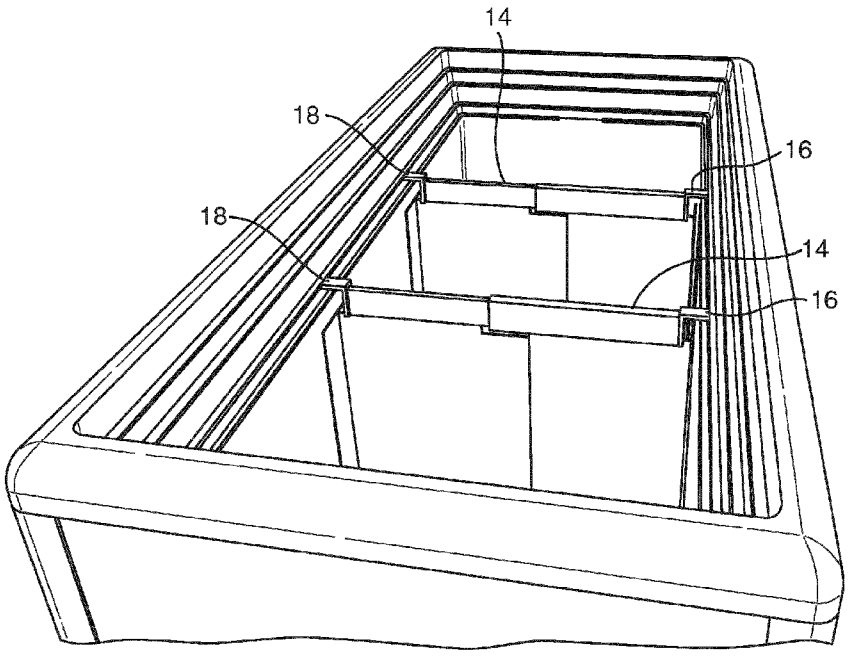
[Continued on next page]

(54) Title: A FREEZER

Fig. 4



(57) Abstract: A freezer comprising a substantially sealed openable chamber for storing frozen confectionery products, the chamber defined by a surrounding outer wall containing refrigerated refrigerant fluid, the chamber further comprising at least two intruding heat transfer surfaces (14) in thermal contact with the refrigerant fluid.

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A FREEZER

Technical Field

The present invention relates to a freezer for containing frozen confectionery products.

Background and Prior Art

Retail outlets for frozen confectionery typically store the frozen confectionery in a freezer. Such freezers are essentially the same as domestic freezer appliances, having a chamber in which the frozen confectionery is stored, which is chilled by refrigeration apparatus.

Most frozen confectionery products are to be stored within narrow temperature ranges, in order to maintain product quality. However one drawback of such freezers is that they tend to suffer from large temperature gradients. Such temperature gradients are established due to fact that warm air is less dense than cold air and also because the majority of the heat ingress occurs through the upper surface of the chamber, as the walls and base are typically thermally insulated.

Often this temperature gradient is merely tolerated, and large temperature differences can exist between the average product temperature and the coolant to compensate the heat entering the cabinet through the lid. Additionally in order to ensure that the maximum allowable product temperature is not breached, the refrigeration temperature needs to be set much lower than the temperature of the products, especially those near the surface of the chamber.

Alternatively, steps can be taken to circulate the air within the freezer to ensure turbulent mixing of air, e.g. by installing ventilator fans, and thus eliminating the temperature gradients within the freezer by bulk movement of air. This can provide a homogeneous temperature within the freezer. However, even though the freezer can be operated closer to the maximum tolerance temperature than in

the stagnant case, this surprisingly comes at the cost of increased energy consumption. This is due firstly to the energy requirement of agitating the air, and secondly because the bulk flow of the air near the surface of the freezer increases the rate of transport of heat through the surface, increasing the load on the refrigeration unit.

Thus improvements in the operation of such freezers would be highly desirable.

Summary of the invention

The present invention relates to a freezer comprising a substantially sealed openable chamber for storing frozen confectionery products, the chamber defined by a surrounding outer wall containing refrigerated refrigerant fluid, the chamber further comprising at least two intruding heat transfer surface in thermal contact with the refrigerant fluid.

The chamber typically comprises a base, side walls and an upper surface. The surrounding outer wall is typically made up of the base and side walls but may also include all or a part of the upper surface. The chamber also comprises an opening to enable a consumer to extract the chosen product. In a typical arrangement the chamber has a rectangular base.

A common arrangement is for the upper surface to comprise a viewing window so that the consumer can view the frozen confectionery before opening the chamber to take the chosen product. In many cases the viewing window takes up the entire upper surface of the freezer in so-called glass-lid freezers. In this case the surrounding wall comprises the base and side walls but not the upper surface.

It is also common for the chamber to comprise baskets, which contain the frozen confectionery product and prevent them contacting the cold walls of the chamber.

It has been found that the at least two intruding heat transfer surfaces provide a significant increase in the effectiveness of extracting heat from the chamber. This has the effect that the thermal gradient within the chamber is reduced.

The reduction in the gradient means that the temperature at the base of the freezer does not need to be so low and thus the heat load on the refrigeration means is reduced and less energy is consumed.

For a typical ice-cream product freezer the maximum tolerable product temperature is -18°C. Thus the temperature at the upper end of the chamber is typically from -20 to -18°C. At the lower end of the chamber the temperature is typically from -24 to -22°C.

The temperature gradient in the freezer is such that the difference in average temperature between the upper end of the chamber and the lower end of the chamber is less than 5.0°C, more preferably less than 4.0°C.

In this invention 'substantially sealed' means that that the chamber is completely or nearly completely sealed from the ambient air. However it may be possible that there are minor breaches in the sealed nature of the chamber, for example by the presence of ventilation holes or passages through attached fans or other equipment. In any case, such openings will be minor and not capable of inducing bulk flow of movement of air within the chamber and merely provide a diffusion channel for the air.

In this invention 'in thermal contact with the refrigerant fluid' means that the intruding heat transfer surface is at least in physical contact to the outer wall. The intruding heat transfer surface may also be in physical contact with the refrigerant fluid, although this is not essential.

The at least two intruding heat transfer surfaces preferably substantially extend into the chamber. Thus the at least two heat transfer surfaces preferably extend

at least 50% of the distance from its contact with the refrigerant fluid to an opposing outer wall. Preferably the at least two heat transfer surfaces extend at least 75%, more preferably at least 90% and most preferably fully reaches an opposing outer wall.

Thus, optimally each of the at least two intruding heat transfer surfaces is in thermal contact with the refrigerant fluid in two opposed regions of the chamber. This provides two points of thermal contact with the refrigerant fluid and ensures that the heat transfer surface extends fully across the chamber, exposing it to more relatively warmer air.

When the heat transfer surface extends nearly or fully across the chamber then it has the effect of creating a partition within the chamber.

In a preferred embodiment the chamber comprises up to 5 intruding heat transfer surfaces, more preferably from 2 to 4.

The intruding heat transfer surface is capable of transferring heat from the interior of the chamber to the surrounding outer wall of the chamber more effectively. Thus it is important that is arranged to efficiently transfer heat from the interior to the refrigerant fluid in the surround wall.

For example this can be achieved if the intruding heat transfer surface comprises refrigerant fluid, optimally in fluid communication with the refrigerant fluid in the surrounding wall. Alternatively the heat transfer surface may comprise a thermally conductive material, e.g. metal, in thermal contact with the refrigerant fluid.

As the intruding heat transfer surface assists in the heat flow from the chamber to the surrounding wall, more benefit will be provided from a heat transfer surface located in the upper region of the chamber than in the lower region of the chamber.

As discussed above, the temperature in the upper region of the chamber is higher, therefore there is a greater temperature difference between the interior of the chamber and the surrounding wall in the upper region than in the lower region.

Therefore, preferably the at least two intruding heat transfer surfaces are located at least in an upper region of the chamber, preferably at least at or near the upper surface thereof.

In one embodiment it may be advantageous to ensure that the intruding heat transfer surface not only extends fully across the chamber but also extends from the upper region of the chamber to the lower region of the chamber. Such a heat transfer surface would create a distinct partition. The advantage of such a heat transfer surface is that it presents the maximum heat transfer area and covers both the thermally efficient upper region as well as the less thermally efficient lower region.

The chamber can optionally include air circulation means, e.g. built into the chamber walls or into the product baskets, if they are present. However other methods of inducing air circulation could be envisaged.

The invention will now be illustrated by the following examples and with reference to the following figures, in which:

Figure 1 is a graphical representation of the results of a CFD computer simulation of the temperature of frozen confectionery products in a prior art freezer.

Figure 2 is a graphical representation of the results of a CFD computer simulation of the temperature of frozen confectionery products in the freezer of figure 1 wherein two thermally conductive partitions have been introduced to form a freezer according to the present invention.

Figure 3 is an image of the inside of a chamber of a freezer according to the present invention for containing frozen confectionery products.

Figure 4 is an image of the same chamber as in figure 3 but rotated and without the baskets.

Figure 5 is a schematic representation of the side view of a freezer according to the present invention showing the location of thermocouples.

Figure 6 is a schematic representation of a plan view of the freezer shown in figure 5 showing the location of thermocouples.

Examples

Example 1

The temperatures of the surface of the outer wall of a known VT 300 ice cream cabinet were measured and used as inputs into a computational fluid dynamics model. Known measurements of heat loss were used to calibrate the CFD simulation until there was agreement between the simulation and the real freezer. The results are shown in figure 1.

The simulation was then run again but with the introduction of thermally conductive partitions. The results are shown in figure 2.

Although the colour scale cannot be seen in the figures, the scale to the left of the figures indicates the maximum and minimum temperatures present in the simulation.

Therefore it can be seen that the temperature range of the products in the prior art freezer is from 18.6 to -24.9 °C, whereas the temperature range for the freezer according to the invention is from -23.3 to -26.1°C.

In the latter case the refrigeration load could be reduced until the maximum temperature was closer to -18°C, thus reducing electrical power consumption for a given maximum product temperature.

Example 2

A standard Rio H 125G cabinet freezer (manufactured by AHT) was tested for its thermal performance both unmodified and with an aluminium partition dividing the chamber into two.

All experiments were carried out at 25 °C and 60%RH. Baskets were inserted into the freezer and frozen confectionery products placed within them randomly, in order to simulate a retail environment.

Images of the baskets in the chamber are shown in figures 3 and 4. Figure 3 shows a first basket 10, a second basket 11 and a third basket 12. Also shown are 3mm aluminium plates 14 which is bent at both ends to create two extended surfaces 16,18 so that it can be attached to the sides of the walls of the chamber.

Figure 4 is an image of the same basket as shown in figure 3 but wherein the chamber is rotated by 90° to show the aluminium partition more clearly.

A series of twenty thermocouples were placed in the chamber to measure the temperature distribution inside. A side view of the chamber showing the thermocouple placement is shown in figure 5. An equivalent top view is shown in figure 6.

In figures 5 and 6 the dotted lines 22, 24 represent the baskets and the hashed region represent a 3mm thick aluminium partition, with its thickness exaggerated for clarity of the thermocouple placement.

Thermocouples T1 to T3 are probes within frozen confectionery products. Thermocouples T11 to T13 are probes within frozen confectionery products near

to the aluminium partition. The highest products (T3 and T13) are approximately 8 cm from the top of the baskets.

Thermocouples T9 and T10 are positioned either side of the aluminium partition. Thermocouples T4 and T5 replicate T9 and T10 on the basket without aluminium. Thermocouples T6 and T7 measure the air temperatures at the bottom and top of the baskets respectively.

Thermocouples T17 to T19 are touching the aluminium partition at the top, middle and bottom respectively.

Thermocouple T20 touches the cabinet's back wall next to the top edge of the aluminium.

In the plan view shown in Figure 6 some of the thermocouples are not shown because they are directly above another thermocouple. In figure 6 T3 represents T1 to T3, T13 represent T11 to T13, T8 represents T8 and T14, T16 represents T16 and T15 and T7 represents T7, T17, T18 and T19.

The results for both arrangements with and without the aluminium partition are shown below in Table 1.

Table 1

		Energy Consumption (kWh/day)	Vertical Temperature Range T17-T19 (°C)	Maximum T19 value (°C)	Warmest Product temperature T3 & T13 (°C)
Comparative	Setting 5	2.56	5.7	-14.6	-17.2
	Setting 5 Repeat	2.59	5.6	-14.5	-17.3
	Setting 6	3.21	6.2	-18.2	-21
Example	Setting 5	2.6	2.7	-18.4	-17.8
	Setting 6	3.33	2.7-3.0	-	-21.6
	Setting 7	4.36	3.0	-27.3	-26.3

As can be seen, without the aluminium partition the power consumption needs to be 3.21 kWh/day to maintain a maximum product temperature of -18°C. However, with the aluminium partition a power consumption of 2.6 kWh/day can achieve the same maximum product temperature.

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Claims

1. A freezer comprising a substantially sealed openable chamber for storing frozen confectionery products, the chamber defined by a surrounding outer wall containing refrigerated refrigerant fluid, the chamber further comprising at least two intruding heat transfer surfaces in thermal contact with the refrigerant fluid.

2. A freezer according to claim 1, wherein the chamber has a base, walls and an upper surface comprising a viewing window, the base and walls constituting the surrounding outer wall.

3. A freezer according to any one of the preceding claims, wherein the at least two intruding heat transfer surface substantially extend into the chamber.

4. A freezer according to claim 3, wherein the at least two heat transfer surface extend at least 50% of the distance from its contact with the refrigerant fluid to an opposing outer wall.

5. A freezer according to claim 4, wherein the at least two heat transfer surface extend at least 75%, preferably at least 90%, of the distance from its contact with the refrigerant fluid to an opposing outer wall.

6. A freezer according to claim 5, wherein the at least two intruding heat transfer surface are in thermal contact with the refrigerant fluid in opposed regions of the chamber.

7. A freezer according to any one of the preceding claims, wherein the chamber comprises up to 5 intruding heat transfer surfaces, more preferably from 2 to 4.

8. A freezer according to any one of the preceding claims, wherein the intruding heat transfer surface comprises refrigerant fluid, preferably in fluid communication with the refrigerant fluid in the surrounding wall.

9. A freezer according to any one of the preceding claims, wherein the heat transfer surface comprises a thermally conductive material in thermal contact with the refrigerant fluid.

10. A freezer according to any one of the preceding claims, wherein the at least two intruding heat transfer surfaces are located at least in an upper region of the chamber, preferably at least at or near the upper surface thereof.

11. A freezer according to any one of the preceding claims wherein the intruding heat transfer surface not only extends fully across the chamber but also extends from the upper surface to the lower surface.

12. A freezer according to any one of the preceding claims, wherein the temperature gradient in the freezer is such that the difference in average temperature between those products at the top of the chamber and those at the bottom of the chamber is less than 5.0°C.

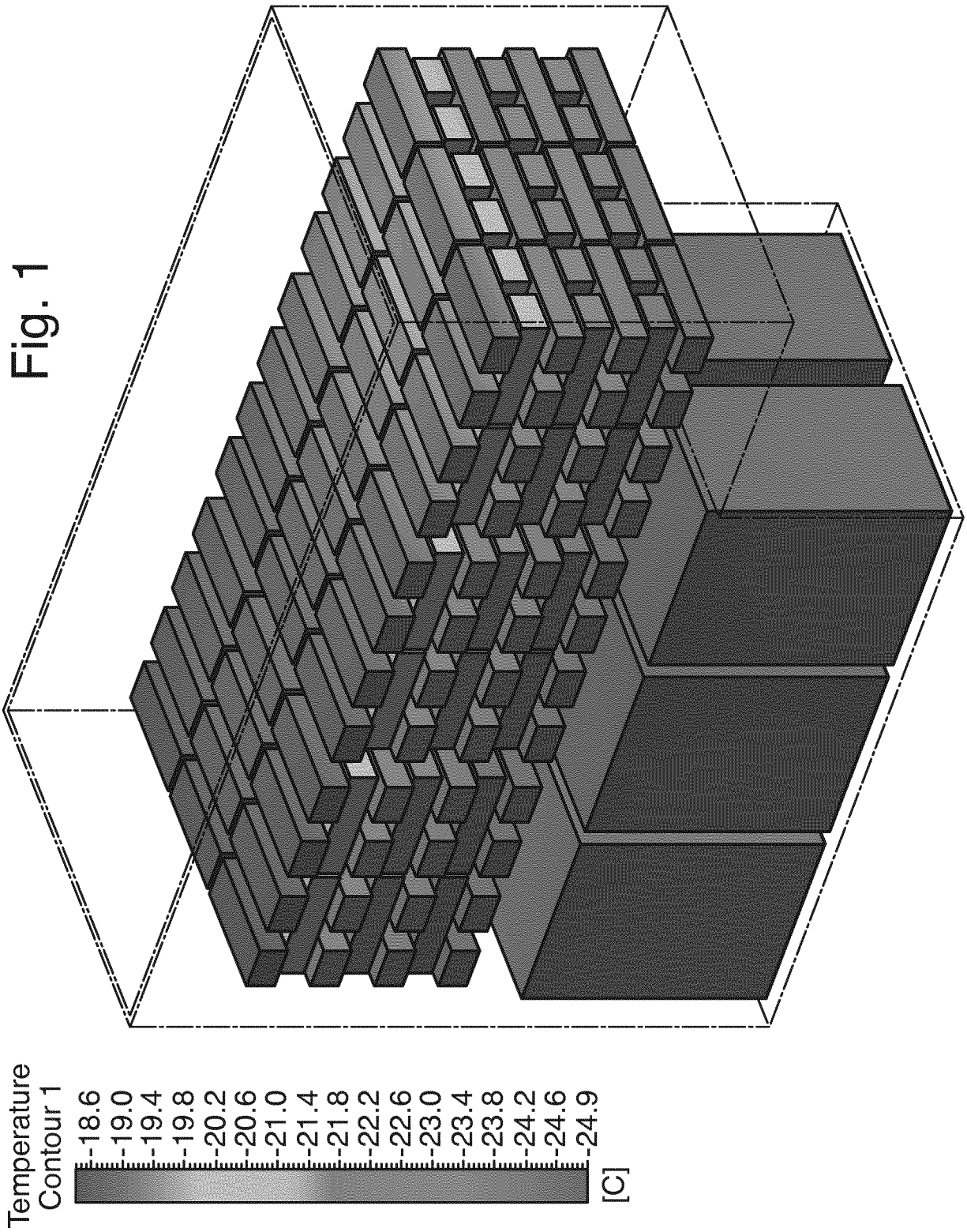
13. A freezer according to claim 12, wherein the difference in average temperature between the upper end of the chamber and the lower end of the chamber is less than 4.0°C.

14. A freezer according to any one of the preceding claims, wherein the temperature at the upper end of the chamber is from -20 to -18°C.

15. A freezer according to any one of the preceding claims, wherein the temperature at the lower end of the chamber is from -24 to -22°C.

16. A freezer according to any one of the preceding claims, comprising a plurality of frozen confectionery products.

Fig. 1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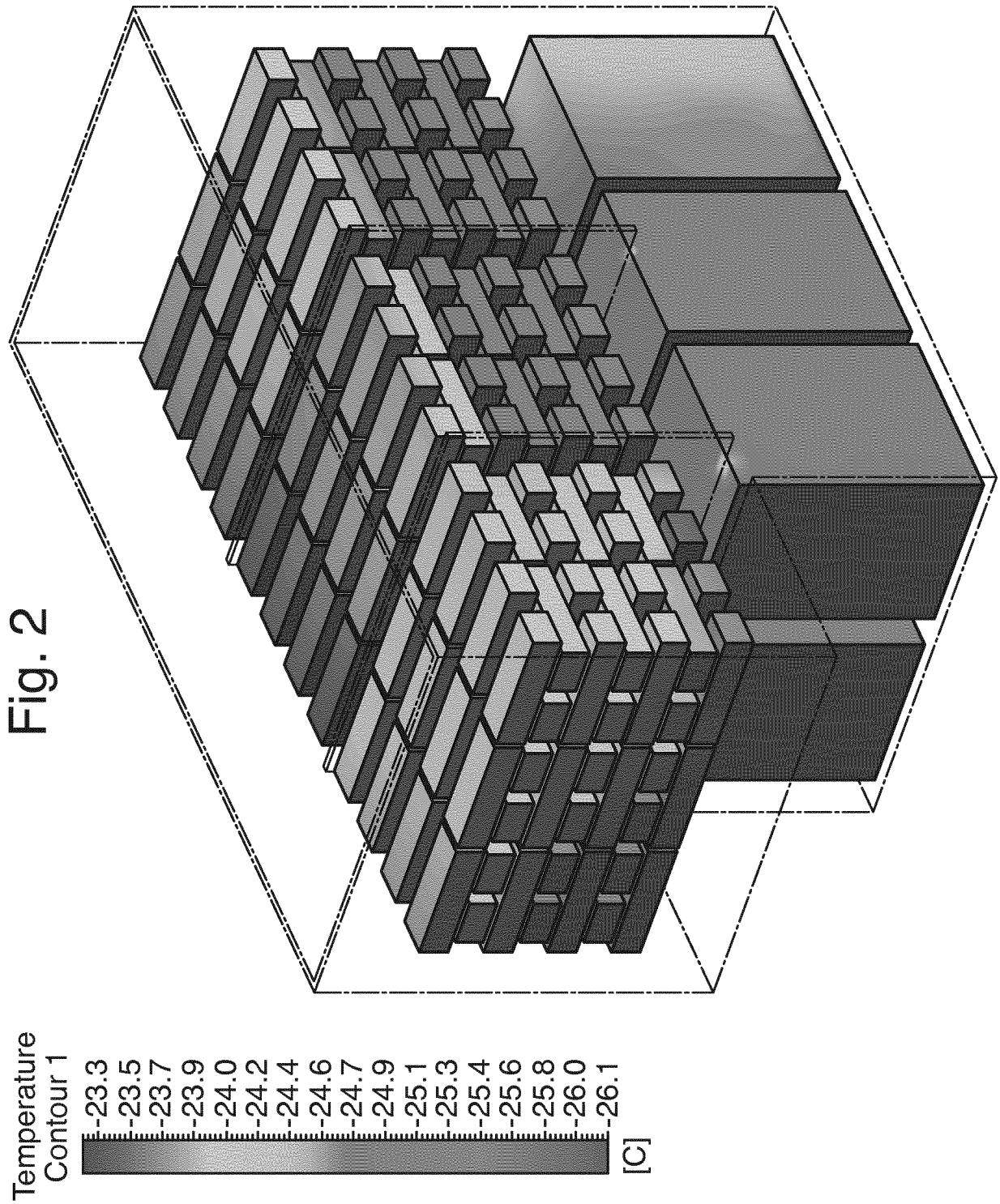
-19.0
-19.4
-19.8
-20.2
-20.6
-21.0
-21.4
-21.8
-22.2
-22.6
-23.0
-23.4
-23.8
-24.2
-24.6
-24.9
[C]

Fig. 2


Temperature
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-23.3
-23.5
-23.7
-23.9
-24.0
-24.2
-24.4
-24.6
-24.7
-24.9
-25.1
-25.3
-25.4
-25.6
-25.8
-26.0
-26.1
[C]

Fig. 3

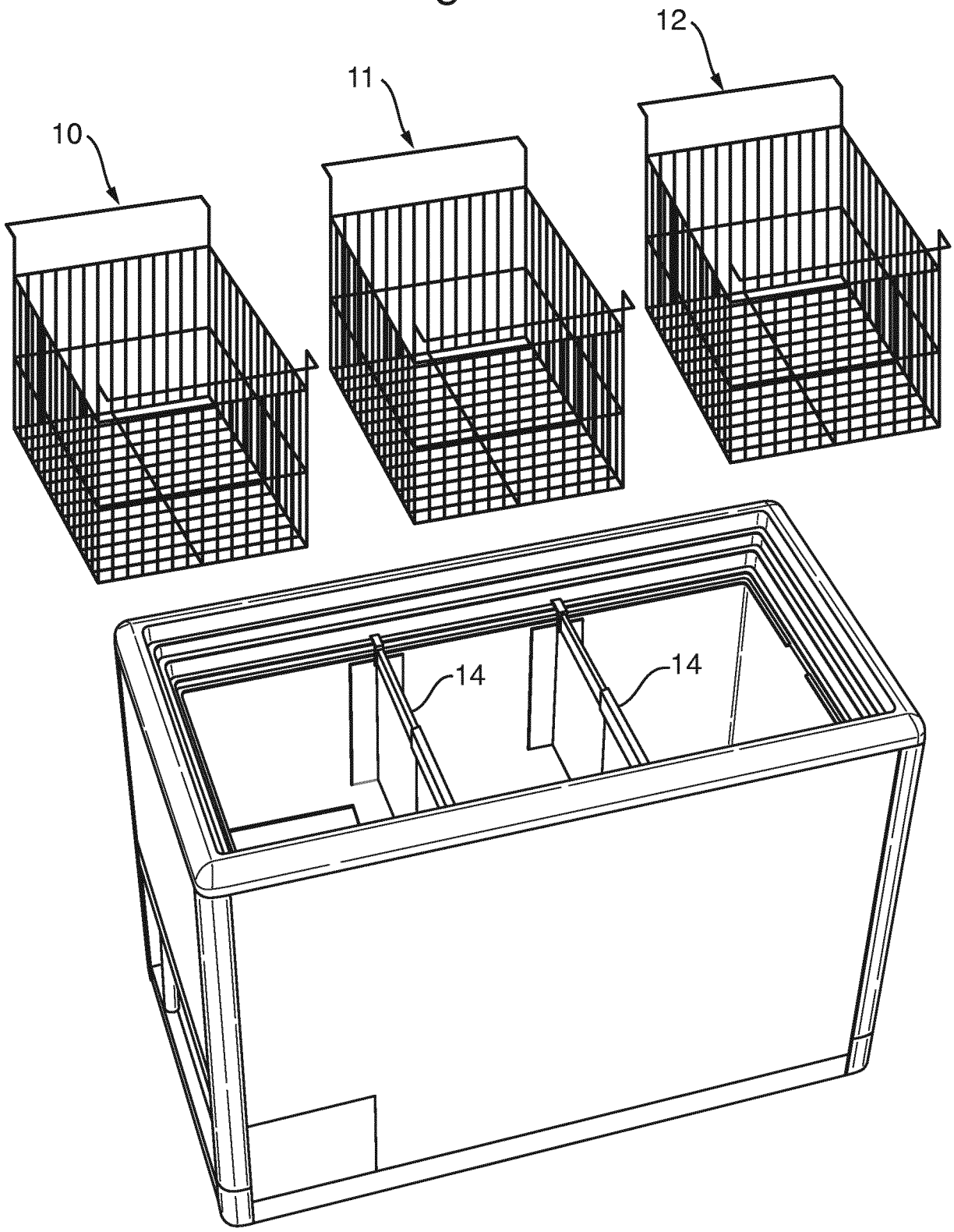


Fig. 4

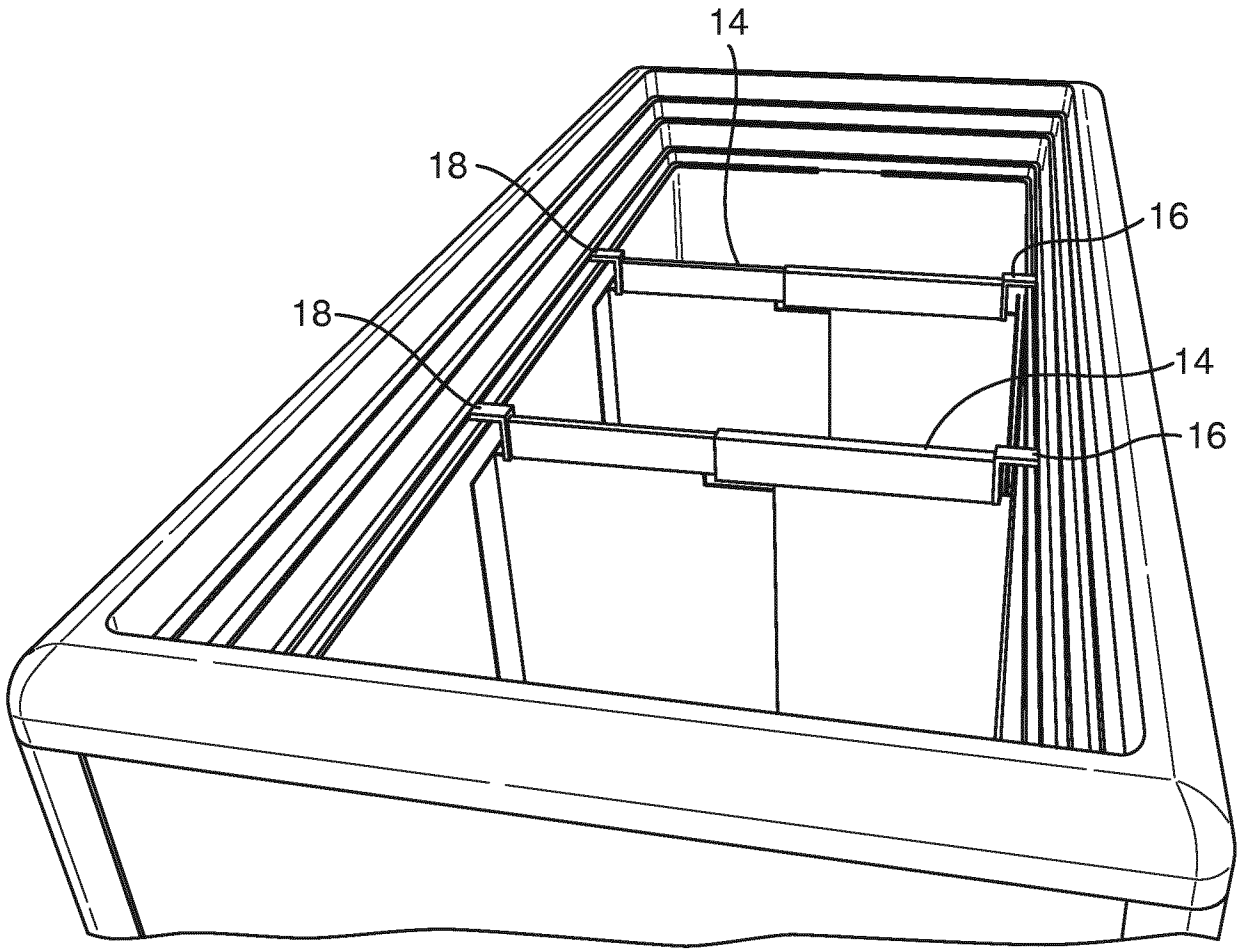
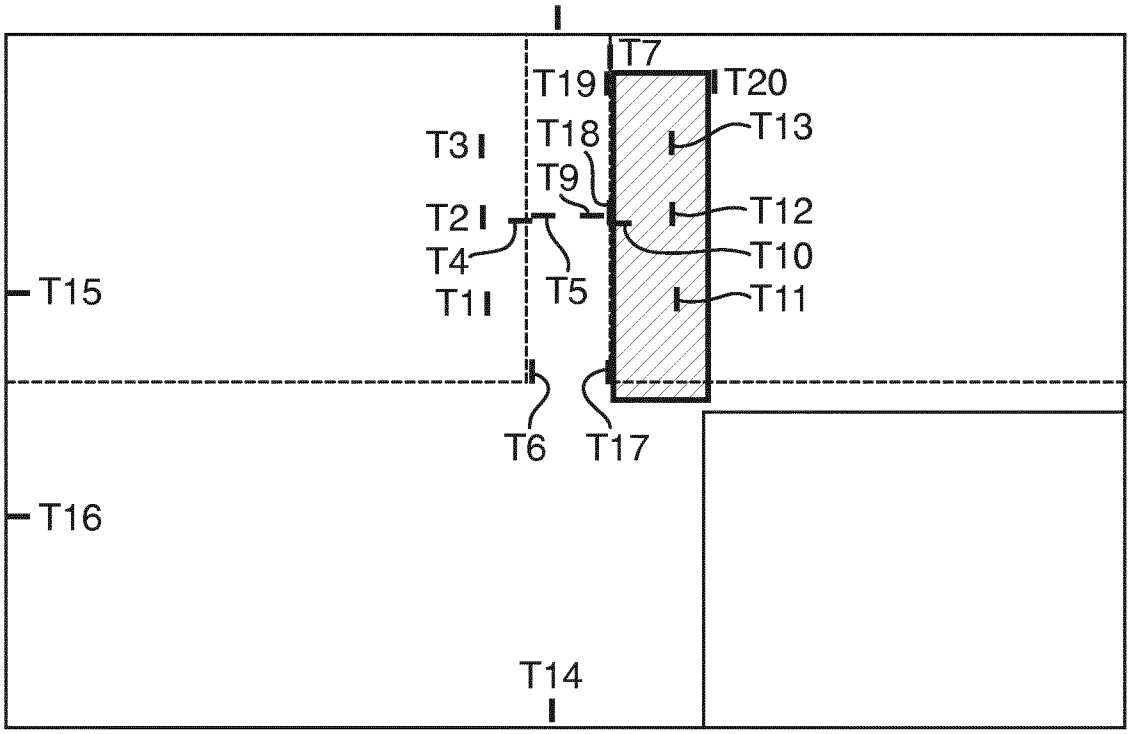


Fig. 5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T18
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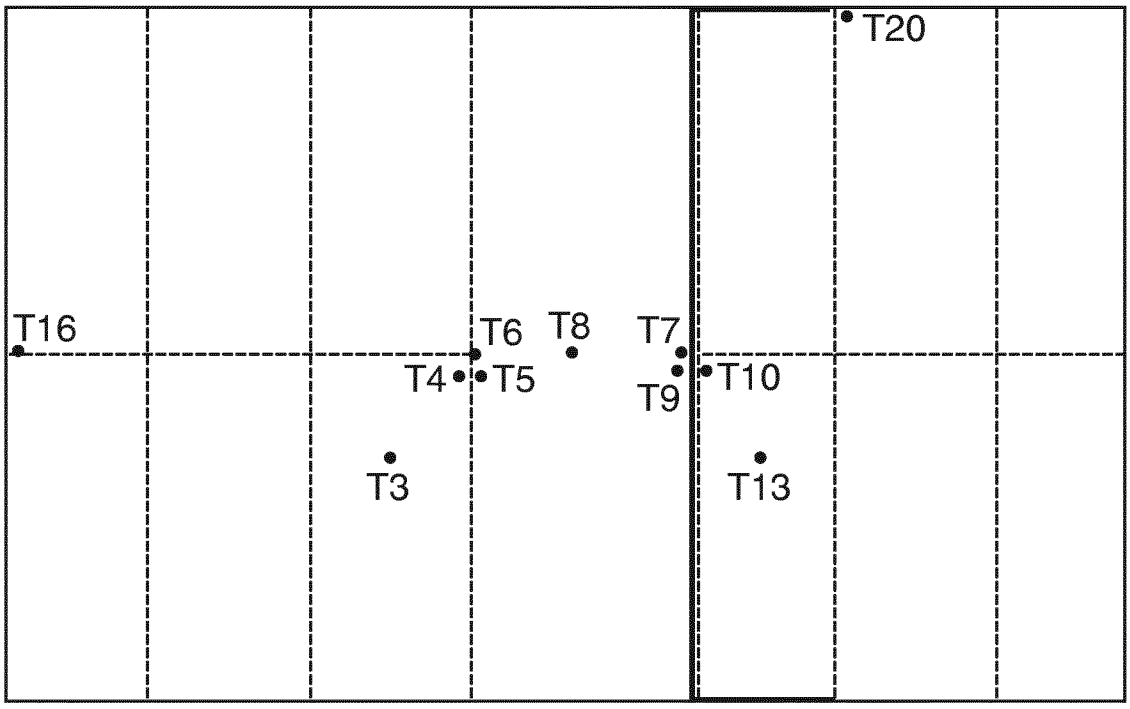
T15
T1
T5
T11
T6
T17
T16
T14

Fig. 6


T20
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T6
T8
T7
T4
T5
T9
T10
T3
T13

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F25D23/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DE 20 2006 009540 U1 (IPV INHEIDENER PRODUKTIONS UND [DE]) 12 October 2006 (2006-10-12) paragraphs [0011] - [0015], [0020] - [0022], [0027] - [0031]; figures 1,2	1,3-7, 9-16

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A	FR 1 465 255 A (BOSCH GMBH ROBERT) 6 January 1967 (1967-01-06) figures 1-10	1-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
24 January 2014	05/02/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Léandre, Arnaud

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/076383

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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