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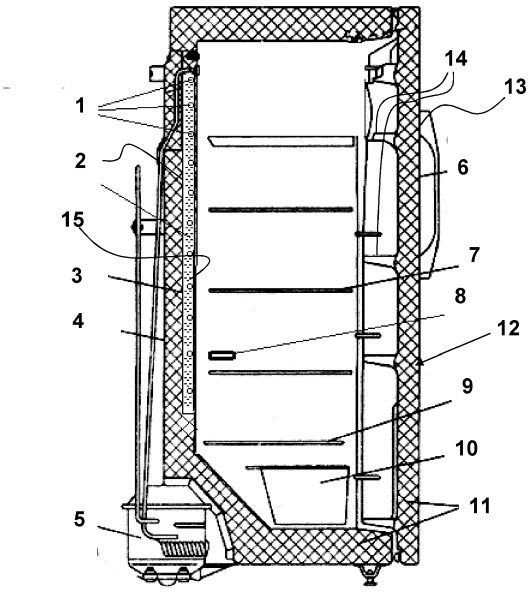
(54) **AUTONOMOUS REFRIGERATING/FREEZING UNIT WITH SUPPLY DC OR AC VOLTAGE POWER SUPPLY**

(57) This device differs is built with heat insulating walls. It comprises a compressor (5) with control unit and in its inner sidewalls or trays, cold accumulators (2) are built in which are in close contact with the pipes (1) of an evaporator coil. The sole power source is at least one solar panels when there is no access to a regular electrical net. In particular. The device provides cooling and maintaining the desired temperature of the substance placed inside chamber, powered from solar panels, without additional electrical devices over a wide DC voltage range 10 to 45V or at constant voltage. The unit enhances autonomy over long time periods and produces cold, regardless of the region of electrification, as well as in regions with frequent prolonged disruptions in the power supply.

Fig. 2



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Description

[0001] This refrigerating / freezing unit is powered by solar panels and is equipped with variable voltage supply systems in order to function autonomously, and it is having an evaporator connected to cold accumulators, and it refers to the refrigeration for cooling and storage, including a low-temperature cooling and storage. It can be used for cooling and storing in the range from minus 30° C to plus 12° C, using power from solar panels, without additional electrical devices, for example an electric battery or an electric generator etc. Therefore, it can be operated in regions with frequent long electrical power interruptions and allows to ensure the necessary temperature conditions in the absence of solar power and power failures, and this for at least 12 hours.

[0002] Known refrigerating and freezing equipments are characterized as follows:

- for operation by a solar panel, they require additional equipment such as electrical batteries, inverters, etc. and the battery controllers operate in a narrow range of voltages;
- They have a merely a small or short autonomy, that is after a relatively short time period the temperature in their interior increases;
- Cold accumulators are absent or when present they do not have intimate contact with the evaporators and occupy useful volume.

[0003] It is therefore the task of this invention to provide a suitable device or unit for ensuring the cooling and storage of food and/or other substances by the use of power only of solar panels, without additional electrical devices, and even in cases of frequent prolonged power outage when connected to a centralized electricity, as well as providing the desired temperature in the chamber/chambers of the device or unit for a certain period of time in the absence of solar power and power at all. Such device or unit needs to offer time autonomy even while the outside temperature is raising. This unit should operate with an improved contact with ice packs as cold source using an evaporator coil to improve the heat transfer and increase energy savings and the generated cold.

[0004] The task of this invention is solved by a refrigerating/freezing unit for storing food and other substances which need to be kept at temperatures of minus 30° C to plus 12° C, powered by constant voltage power from at least one solar panel and having an AC voltage supply systems, *characterized in that* it comprises heat insulation walls all around its interior, and either incorporated into these walls cold accumulators which are penetrated by pipes of an evaporator, and/or cold accumulators designed as trays with slits in which the pipes of the evaporator coil extend and are tightly attached to the cold accumulators for efficient exchange of heat, with cold batteries located in the side foam, and that the unit further comprises a compressor with controller outside the useful volume of the unit, and that the cold accumulators and evaporators are operable simultaneously.

[0005] The device or unit, its features and its functioning will be described and explained in the following, relating to the figures. These show:

Fig. 1: Schematic representation of the concept - without solar controller for the control of the solar panel, and without electrical battery;

Fig. 2: Schematic view of the unit with cold accumulator arrangement in close contact with the evaporator part of the device or unit in foam of the side walls;

Fig. 3: a cold accumulator battery as shelves, shown in upside down position;

Fig. 4: the cold accumulator battery of figure 3 in position to be used as a tray within the interior of the unit;

Fig. 5: The unit with open door providing a view into its interior;

Fig. 6: Sectional view of a unit in form of a foamed type Junkbox, seen from one narrow side;

Fig. 7: Sectional view of the unit in form of a foamed type Junkbox of figure 6, seen from the back side;

Fig. 8: Specifications of typical suitable compressors for using R134A as cooling medium;

Fig. 9: Specifications of typical suitable compressors for using R600A as cooling medium.

[0006] This device or unit is suitable for household and/or industrial use. It may have a structure that comprises a vertical rack and comprises a horizontal chest-type single-chamber or multi-chamber and a combined refrigeration and

freezer compartment. The cooling device can offer several optional cooling performances: In the range from 0° C to plus 12° C, from -30° C to 0° C and from -30° C to +12° C, including various embodiments of temperature combinations in specified ranges. Cold batteries are located close to the cold evaporator coil. They are foamed in into a part on the wall and/or inner walls of the enclosure so that the foam provides an efficient heat insulation. Trays are being formed on the battery evaporator within the compartment.

[0007] A compressor with the necessary cooling capacity and a **c**hip **o**n **b**oard COP, a system where semiconductor dice are mounted directly on a PC board, and connected with either bonded wires or solder bumps, cooperates with the power supply and controls and operates on direct current (DC) voltage in the range of 10 to 45 volts without "failures" issued by a solar panel or by several solar panels. The compressor is connected directly to the device without additional electric devices. For example, neither an electric battery nor a generator etc. is needed. As an option, the device can be designed to operate at constant voltage. Alternatively, the system can operate on alternate current (AC) voltage which can transformed to 10 to 45 volts and changed into direct current DC, without "failures" issued by a solar panel or by several solar panels. The compressor - be it powered by AC or DC current is connected directly to the device without additional electric devices. For example, neither an electric battery nor a generator etc. is needed. As an option, the device can be designed to operate at constant voltage.

[0008] The compartment of this unit has a necessary and sufficient insulation thickness and/or the **v**acuum **i**nsulation **p**anels VIP are used in the construction. In the device or unit, cold accumulators are present in the form of containers filled with liquid, that is water, brines, glycols, with or without the addition of cellulosic thickener, in one and/or in two-components with different freezing temperature. The amount of cold fluid and the cold batteries therein are selected depending on the volume of the chamber, the required temperature conditions and the required time of autonomy. This concerns the volume, freezing temperature, with or without addition of cellulosic thickener in one and/or two-components, etc. The cold accumulator holds a "cold storage". In the light period of the day and/or when there is a power supply from the solar panels and/or power from the regular electrical power net, the cold accumulator is being charged and provides the required temperature values within the compartment of the unit, and in the dark and/or when power is absent, it also provides the required temperature values within the compartment of the unit. The cold accumulator provides autonomy for the required time period while maintaining the required temperatures for the substances inside the compartment of the unit. The ice packs of the cold accumulator inside the device are closely located to the evaporator or the evaporator is even an integral part of the cold accumulator. The side walls of the unit and its compartment are made of a particular laminate construction comprising the cold accumulator and evaporator. The design further incorporates an outdoor evaporator inside the compartment. Cold accumulators are being used and designed as shelves, that is containers filled with liquid such as water, brines, glycols, with or without addition of cellulosic thickener, one and/or two-component freezing temperature which spend "accumulation cold" when there is a power supply, and provide the required temperature values within the chamber when the power supply is missing, while performing the function. There is shelf space for storing refrigerated/frozen objects and substances.

[0009] This refrigeration/freezer unit with the power supply from solar panels and AC voltage from the power grids is further disclosed in the accompanying figures and will now be described in further detail. It comprises a particular design of the evaporator with cold accumulators. The basic principle to illustrate the advantage is shown in figure 1, making it obvious that neither an electrical battery nor a solar controller is needed by this design. Therefore, this unit can be used in regions with frequent long power interruptions and nevertheless ensures the necessary temperature conditions in the absence of solar power and power failure, and this for at least 12 hours. The device can be used in households and/or for industrial use.

[0010] Figure 2 shows a sectional section view of the unit with its cold accumulator arrangement in close contact with the evaporator 1 part of the device in a foam 2 which functions as a cold battery. The device may have a structure that forms a vertical rack as shown. On the right side of the figure 2 one can see the door 12 which can be opened like a conventional refrigerator door with a handle 13. On the inner side of the door 12 there are trays 14 installed. The unit forms a cabinet-like box with a relatively thick and highly effective thermal insulation layer 11 all around, and a cold storage tank as cold battery 2 is built into the thermal insulation layer 11 on at least one inner side. This cold accumulator 2 or cold storage battery is penetrated by a pipe coil as evaporator 1. The cold accumulator 2 is a vessel containing a suitable liquid, eg. water, brines, glycols, with or without addition of cellulosic thickener, one and/or two-components with different freezing temperatures.

[0011] The cold accumulators 2, depending on the purpose of the unit, contain one of the following compositions of aqueous solutions for phase transition:

Solution 1:	0.5-0.8% carboxymethyl cellulose, or
Solution 2:	7-9% NaCl (sodium chloride) and 0.5-0.8% carboxymethyl cellulose, or
Solution 3:	13-17% NaCl (sodium chloride) and 0.5-0.8% carboxymethyl cellulose, or
Solution 4:	17-20,5% NaCl (sodium chloride) and 0.5-0.8% carboxymethyl cellulose.

Solutions 1 and 2 are used with cold accumulators 2 for the fridges with the storage temperatures from 0°C to 12°C. Solution 3 and 4 are used with cold accumulators 2 for the freezer with the storage temperatures from 30°C to 0°C. Important: All these solutions are not hazardous to humans.

[0012] The inner surface side of the compartment is designated with numeral 3, the outer surface side with numeral 4. In the lower left corner of the unit as shown in figure 2, a compressor 5 is located with an associated electronic control unit. At the bottom of the compartment one can see another small container 10 for receiving particular items. Inside the compartment of the unit, there is a row of trays 7 and at the bottom a tray 9 made of glass to allow a view into the lower container 10. A sensor 8 is also visible inside the compartment, which continuously measures the temperature and transmits the data to the control unit of the compressor 5.

[0013] The attached sheets 18 of material on the cold accumulator 2 do allow heat transfer from the interior to the cold accumulator 2 and ensure an increase of the cooling area. They are placed on and fastened to the evaporator coil 1 and cold batteries 2. Further, this design with foamed parts provides an accurate, tight and dense interposition and contact of the evaporator 1 pipes with the cold accumulators 2. This unit can have optional cooling performances in the range from 0 ° C to plus 12 ° C, from -30 ° C to 0 ° C and from -30 ° C to plus 12 ° C, including all of the various embodiments of temperature combinations specified ranges.

[0014] In another design of the unit there are accumulator containers as shown in Figure 3. They are filled with liquid, e.g. water, brines, glycols, with or without addition of cellulosic thickener, one and/or two-components with different freezing temperature. The amount of cold fluid and the batteries therein, concerning volume, freezing temperature, with or without addition of cellulosic thickener one and/or two-components, etc. are selected depending on the volume of the chamber or chambers in the device and the required temperature conditions and the required time period of autonomy.

[0015] Figure 3 shows a cold accumulator battery 2 as a single block, formed as a shelve with the lower side up with slits 15 which are suitable for inserting the pipes of an evaporator coil. The block contains water, brines, glycols, with or without addition of cellulosic thickener, one and/or two-components with different freezing temperatures. They can be part of a cold accumulator circuit arrangement as shelve-cold-batteries into the appliance open evaporator.

[0016] Figure 4 shows this cold accumulator 2 battery of Figure 3 in the position to be mounted as a tray. This flat and even side is then the upper side of the tray or shelve to receive the items to be kept cool in the interior of the unit.

[0017] Figure 5 shows a particular design of the unit, namely a scheme of a cold accumulator arrangement in close contact with the evaporator 1 part of the device in foam type Junkbox. The pipes of the evaporator 1 coil are being lead along the outer edges of the trays or shelves 9 and through them and each tray is designed as a cold accumulator 2 itself, as shown in figures 3 and 4.

[0018] Figure 6 shows a box-like cooling unit in sectional view from one of the narrow sides. The unit is accessible from the top, by a swivelable cover 14 hinged on the higher side, that is here the right side of the unit. There is a hinge 17 with horizontal axis. Again, all sides and the bottom wall comprise an efficient heat insulation 11. Evaporator coils 1 are led through the inner side of the cold accumulator 2. Layer 4 envelopes the insulation material of the unit, and an inner layer 3 is covering the interior walls for leading the heat equally from the interior to the cold accumulators 2. The unit stands on rolls.

[0019] In Figure 7, this box-like cooling unit is shown with a sectional view, seen from the backside. One can see the compressor 5 with its controller in the right lower corner of the unit in this figure 7. All four interior walls are built from thermal insulation material 11 equipped with cold accumulators 2, and pipes 1 of the evaporator coil are led through all these cold accumulators 2. In this figure 7, only the two narrow side walls left and right can be seen in this section view, while the front and back wall are not shown.

[0020] In general, the cold batteries or accumulators are located close to the cold evaporator coil, either

- foamed in part on the wall and/or inner walls of the enclosure as shown in Figures 2, 6 and 7 or along the shelve edges as shown in figure 5, or
- within the compartment, designed as trays as shown in Figures 3 and 4.

[0021] The device or unit works with power from a solar panel and is equipped with a compressor with the necessary cooling capacity and COP and the supply and control unit, operating on a direct current (DC) voltage in all ranges of 10 to 45 volts with no "failures", issued by the solar panels. There can be one or more pieces of solar panels such as shown in figure 1. As an alternative, the compressor can be powered by alternate current AC. For this purpose, either a separate AC-compressor is installed, or the AC power from the public power grid will be transformed down to 10 to 45 volts for powering the DC-compressor and charging the battery. When assembling the device, on the outer wall of the inner cabinet is mounted an evaporator in form of a sheet tube or rolling welded, closely attached on top of the evaporator and the cold accumulators are foamed into the whole construction, as shown in figures 2, 6 and 7, providing precise, rigid and dense parts interposition and evaporator 1 contact with the cold accumulators 2. In some models, vacuum insulation panels (VIP) are being used in the construction.

[0022] For the fridge with a useful volume up to 150 liters, a compressor can be used, for temperatures as low as

-23,3° C. Such compressor runs at variable rotational speeds of 2000 to 3500 rpm, and it allows to cut the power consumption when the refrigeration system is stable. The power consumption of such compressor is up to 55 W while the cooling capacity up to 72 W. Old compressors used to be not efficient and consumed more electricity than producing cold. But modern compressors are characterized that they offer an efficiency coefficient above 1 as can be seen from the performance table in figure 8 under COP. In this figure 8, various specifications are given in a table for available compressors running on R134A as cooling medium and manufactured and offered by Zhejiang Maidi Refrigeration Technology Co., Ltd., Jinger Road, Dalu Industrial Park, Liangzhu Town, Yuhang District, Hangzhou, Zhejiang, China 311113. All these compressors for different performance are CE-certified for the European Union. Some of these modern compressors even have an efficiency of up to 2. The compressors suitable for this unit have a coefficient of between 1.3-1.5. ASHRAE LBP designates the methodology used to compare compressors under the same conditions, whereby the Coefficient of efficiency of a given compressor is determined. The controller can work within the full range of power supply of 10-45 V of direct electricity. This allows the use of solar panels within their full output capacity from 12 to 44 V and at their potential of 120-150 W, without any extra electronics used such as electric accumulators, resisters, transistors, controllers, etc. An example of a product performance of a suitable compressor is indicated below:

- operated by DC voltage, 12V and 24V
- refrigerant medium: R134A
- Cooling type: ST or FAN
- Application: Low Back Pressure, Middle Back Pressure
- Maximal cooling capacity 72W
- Suitable for freezer/refrigerator capacities of less 100 litres

Also suitable is a compressor of the same manufacturer which runs on R600A as cooling medium. In figure 9, various specifications for such compressors are given in a table for available compressors running on R600A as cooling medium and manufactured and offered also by Zhejiang Maidi Refrigeration Technology. Of course, compressors with similar data can be installed which are operated by AC power.

[0023] For the freezer with a useful volume up to 150 liters, a compressor can be implemented, for temperatures down to -23,3°C. With the variable rotational speed of 2000 to 3500 rpm and again, this allows to cut the power consumption when the refrigeration system is stable. Such compressor has a power consumption of up to 100 W and a the cooling capacity up to 131 W. The controller can work within the full range of power supply of 10-45 V of direct electricity. Again, this allows to use solar panels within its full output capacity from 12 to 44 V and at the potential of 180-200 W, without any extra electronics used such as electric accumulators, resisters, transistors, controllers etc.

[0024] In devices having an outdoor evaporator, cold accumulators 2 as shown in Figures 3 and 4 are mounted on the vaporizer 1, and simultaneously perform the function as both shelf space for objects, substances to be cooled or kept frozen, and their cooling.

[0025] After manufacture and installation of the unit at the operating site, it is connected to a power source prepared for operation. At the time when the appliance is operated, ie, available power occurs and is simultaneously cooling the inner volume of the device and "charging" of the cold accumulators 2 or cold batteries, e.g. the ice packs. The preparatory period is depending on the ambient temperature and lasts for 2 to 5 days. Further operated, the device begins to load for cooling and storing objects and substances. Automatic control of the compressor 5 provides the desired temperature inside the device by means of a temperature sensor 8 and a controller, pertaining to the compressor control unit. During periods of time when power is absent, the cold accumulators 2 of the device construction as shown in Figures 3 and 4 is such that "the accumulated cold" in the light of the day and/or when there is power from the solar panels and/or AC power provides the required temperature values inside the device. The cold accumulators of the device provide autonomy for a required period of time and prevent an increase of the internal temperature in this time period and therefore preserving the stored substances inside the unit on required temperatures. The autonomy is to a great deal reached due to the efficient heat insulation and thicknesses to keep high ambient temperature (up to + 43 ° C) away from the interior.

List of Numerals

[0026]

1 evaporator
2 cold battery
3 inner side closet
4 outer side cabinet
5 compressor with controller
6 cabinet door

7 shelf
8 sensor
9 glass shelf
10 container
11 thermal insulation
12 door
13 handle
14 tray in door
15 slits in trays
16 top door, svivelable around horizontal axis.
17 hinge for top door

Claims

1. Refrigerating/freezing unit for storing food and other substances which need to be kept at temperatures of minus 30° C to plus 12° C, powered by constant voltage power DC from at least one solar panel and having an AC voltage supply systems, ***characterized in that*** it comprises heat insulation walls all around its interior, and either incorporated into these walls cold accumulators (2) which are penetrated by pipes (1) of an evaporator, and/or cold accumulators (2) designed as trays with slits in which the pipes (1) of the evaporator coil extend and are tightly attached to the cold accumulators (2) for efficient exchange of heat, with cold batteries located in the side foam, and that the unit further comprises a compressor (5) with controller outside the useful volume of the unit, and that the cold accumulators (2) and evaporators (1) are operable simultaneously.

2. Refrigerating/freezing unit according to claim 1, ***characterized in that*** the unit comprises a DC compressor (5) running on either R134A or R600A as cooling medium.

3. Refrigerating/freezing unit according to claim 1, ***characterized in that*** the unit comprises an AC compressor (5) running on either R134A or R600A as cooling medium.

4. Refrigerating/freezing unit according to claim 1, ***characterized in that*** the unit comprises in addition a transformer for transforming AC current from the public power grid down to 10-45 Volts and a rectifier for transforming the AC into DC current for powering a DC compressor.

5. Refrigerating/freezing unit according to one of the preceding claims, ***characterized in that*** the cold accumulators (2) are containers filled with either water, brines, glycols, with or without the addition of cellulosic thickener, in one and/or in two-components with different freezing temperatures.

6. Refrigerating/freezing unit according to one of the preceding claims, ***characterized in that*** the wall panels are made partly or completely of vacuum insulation panels (VIP).

7. Refrigerating/freezing unit according to one of the preceding claims, ***characterized in that*** it is powered by constant voltage power from at least one connected solar panel and having an AC voltage supply systems with in cooperation with the evaporator (1) and cold accumulators (2), and further that

    • the cold accumulators (2) are part of the structure of an evaporator (1) and are tightly attached to the evaporator coil of the evaporator (1),
    • cold batteries (2) are located in the cold side foam without using useful volume of the unit,
    • cold accumulators (2) in the side walls are operable simultaneously or commonly with the cold accumulator in the shelfs,
    • the device is able to be connected to and run directly on photovoltaic solar panels, with no additional electrical devices in a voltage range of 10-45V DC,
    • the device is able to provide a high level of autonomy and maintaining the required temperature inside the device during the absence of power for up to 12 hours.

Fig. 1

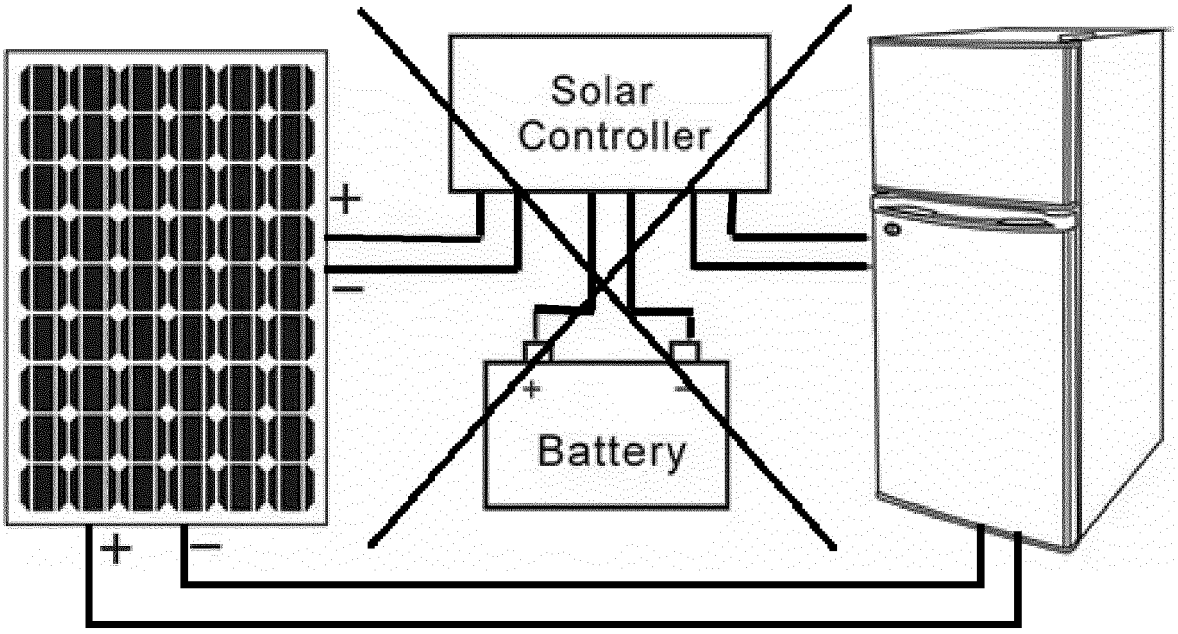

Fig. 2

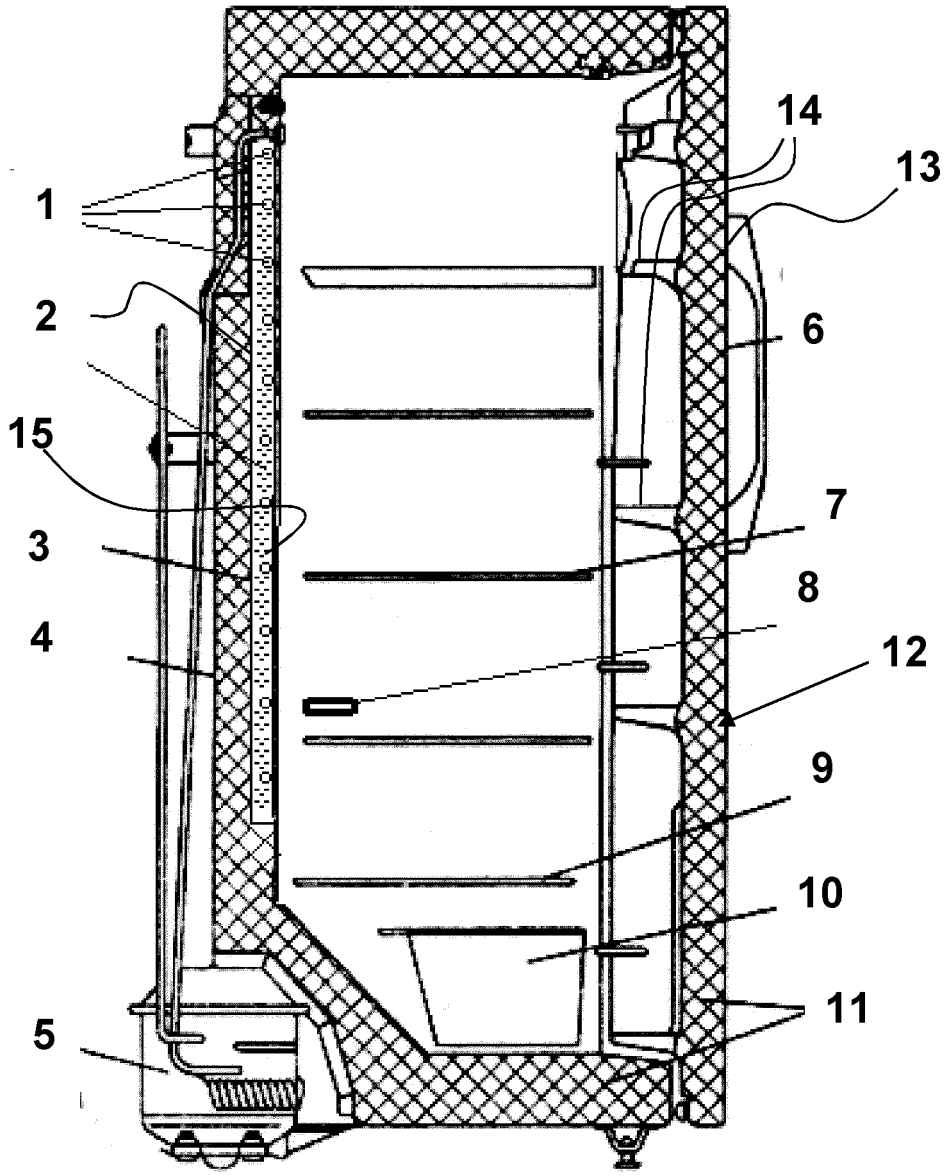

Fig. 3

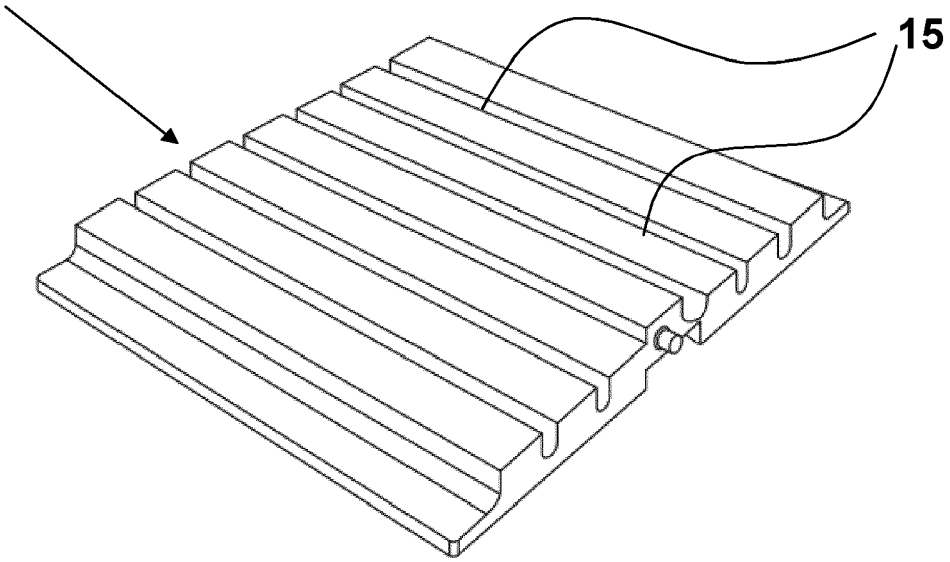

Fig. 4

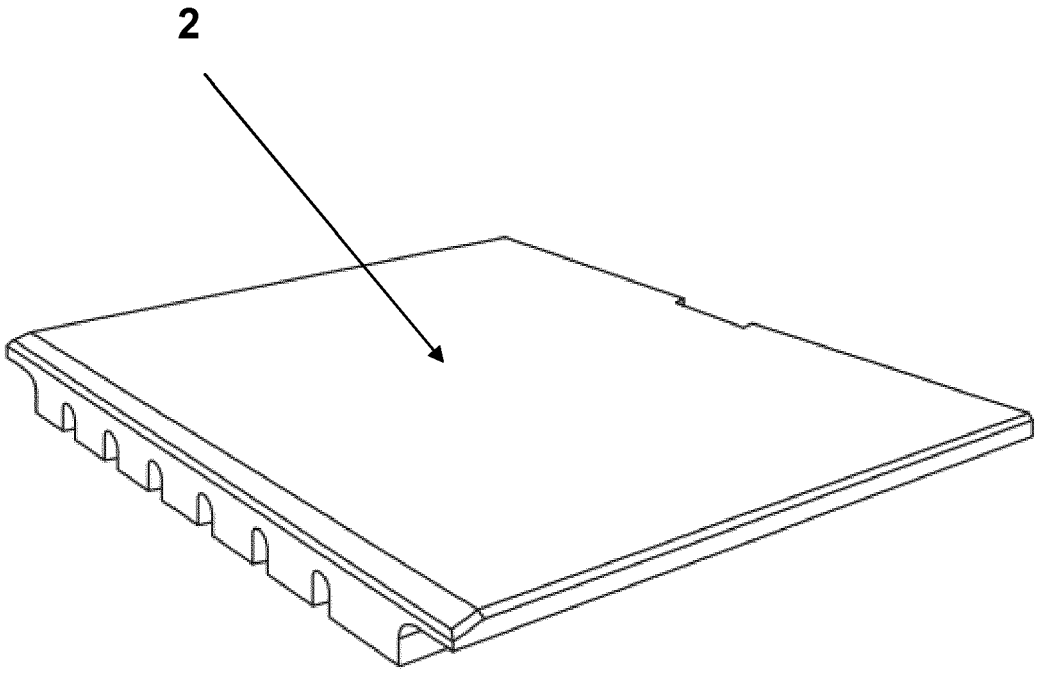

Fig. 5

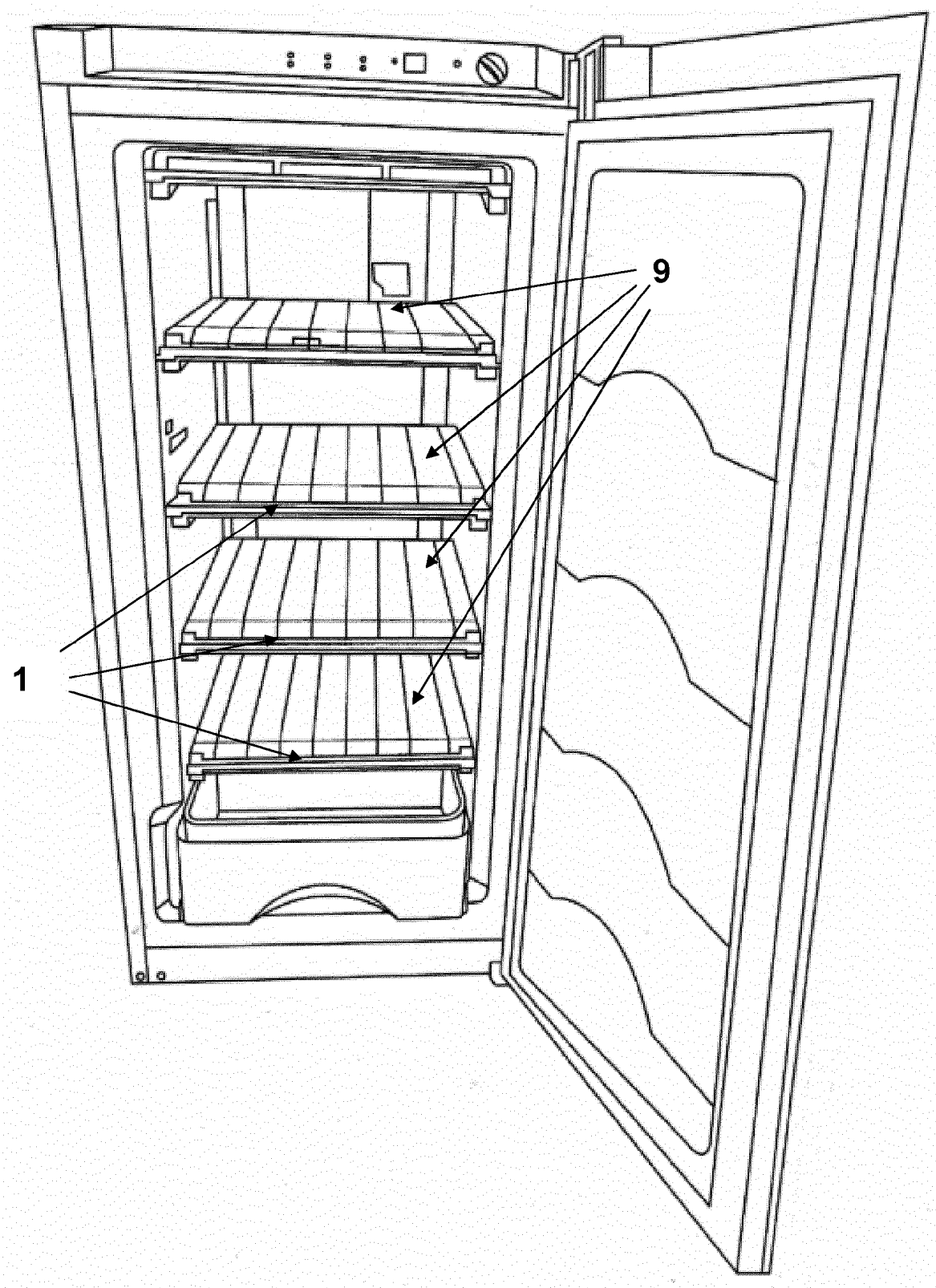

Fig. 6

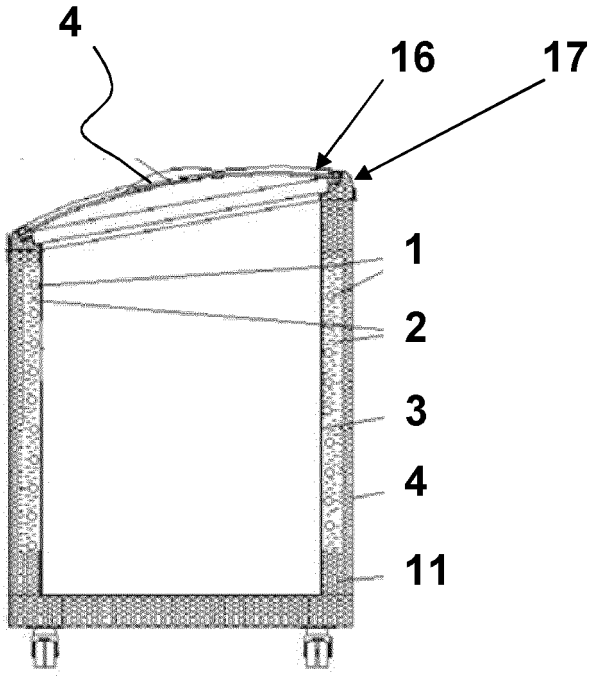

Fig. 7

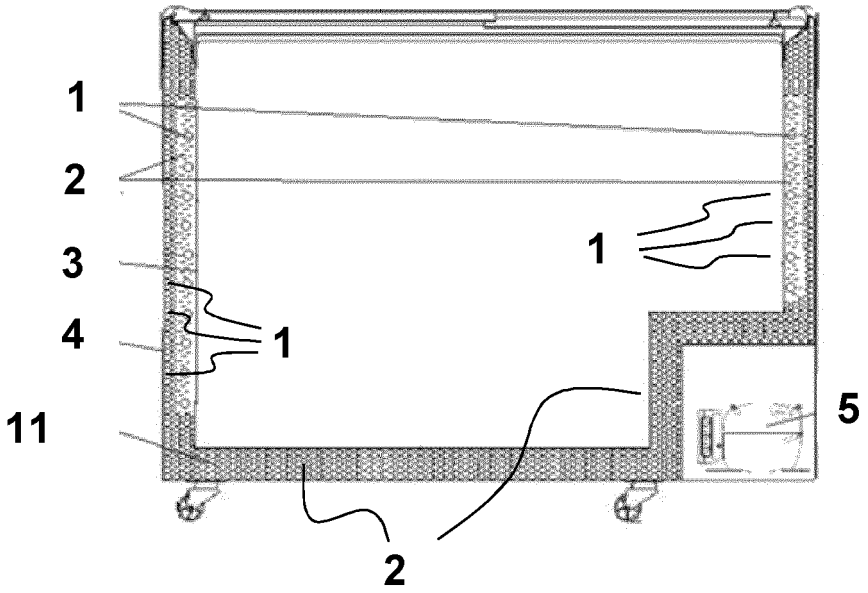

Fig. 8

Serial	Model	Displacement (cm3)	Rotate Speed (rpm)	Capacity -23.3°C (ASHRAE)			COP	EER	Oil charge
				W	Kcal/h	Btu/h	W/W	Btu/W.h	ml
L	QDZH 25G	2.5	2000	43.0	37.2	146.0	1.08	3.68	130
			2500	53.0	45.8	186.0	1.05	3.58	
			3000	62.0	53.5	211.0	1.06	3.62	
			3500	72.0	62.2	245.0	1.04	3.55	
	QDZH 30G	3.0	2000	52.0	44.6	176.0	1.05	3.58	
			2500	64.0	55.0	217.0	1.05	3.58	
			3000	75.0	64.3	254.0	1.06	3.62	
			3500	87.0	74.7	295.0	1.04	3.55	
	QDZH 35G	3.5	2000	60.0	51.9	204.6	1.08	3.68	
			2500	73.0	63.1	248.9	1.07	3.65	
			3000	86.0	74.4	293.2	1.06	3.62	
			3500	100.0	86.5	341.0	1.05	3.58	
	QDZH 43G	4.3	2000	80.0	69.1	273.0	1.15	3.92	
			2500	96.0	82.9	327.6	1.2	4.09	
			3000	115.0	99.4	392.4	1.25	4.27	
			3500	138.0	119.2	470.9	1.25	4.27	
MK	QDZH 50G	5.0	2000	87.0	75.2	296.8	1.17	3.99	180
			2500	104.0	89.9	354.8	1.13	3.86	
			3000	130.0	112.3	443.6	1.35	4.61	
			3500	163.0	140.8	556.2	1.2	4.09	
	QDZH 65G	6.5	2000	120.0	103.6	409.4	1.2	4.09	
			2500	150.0	129.6	511.8	1.2	4.09	
			3000	180.0	155.5	614.2	1.2	4.09	
			3500	210.0	181.4	716.5	1.2	4.09	

Fig. 9

Serial	Model	Displacement	Rotate Speed (rpm)	Capacity -23.3°C (ASHRAE)			COP	EER	Oil charge	Cooling type	Power Supply	Certificate
				W	Kcal/h	Btu/h	W/W	Btu/W.h	Ml			
L	QDZY35G	3.5	2000	42,0	36,3	143.3	1.15	3.92	130	FC	(12/24 V DC)	CE
			2500	50,0	42,3	170,6	1.25	4.27				
			3000	60.0	51,8	204,7	1.35	4.61				
			3500	72,0	62,2	245,7	1.3	4.44				
	QDZY43G	4.3	2000	49.0	42,3	167,2	1.15	3.92				
			2500	61,0	52,7	208,1	1.25	4.27				
			3000	76,0	65,7	259.3	1.35	4.61				
			3500	95,0	82.1	324.1	1.3	4.44				
	QDZY50G	5.0	2000	60.0	51,8	204,7	1.15	3.92				
			2500	72,0	62,2	245,7	1.25	4.27				
			3000	86,0	74,3	293.4	1.35	4.61				
			3500	108.0	93,3	368,5	1.3	4.44				
	QDZY65G	6.5	2000	67.0	57,9	228,6	1.15	3.92				
			2500	93,0	80.4	317.3	1.25	4.27				
			3000	110,0	95,0	375.3	1.35	4.61				
			3500	131,0	113,2	447.0	1.3	4.44				
	QDZY75G	7.5	2000	91,0	78.6	310,5	1.15	3.92				
			2500	108.0	93,3	368,5	1.25	4.27				
			3000	130,0	112.3	443.6	1.35	4.61				
			3500	156,0	134,8	532.3	1.3	4.44				

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 September 2020	Vigilante, Marco

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