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Laing

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[54] **NEW FREEZING CHAMBER WITH REFRIGERATION STORAGE**

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[52] **U.S. Cl.** **62/430,** 62/433, 62/439, 62/434

[51] **Int. Cl.** **F25d 11/00**

[58] **Field of Search** 62/431, 432, 439, 62/438, 430, 433, 446, 530, 457

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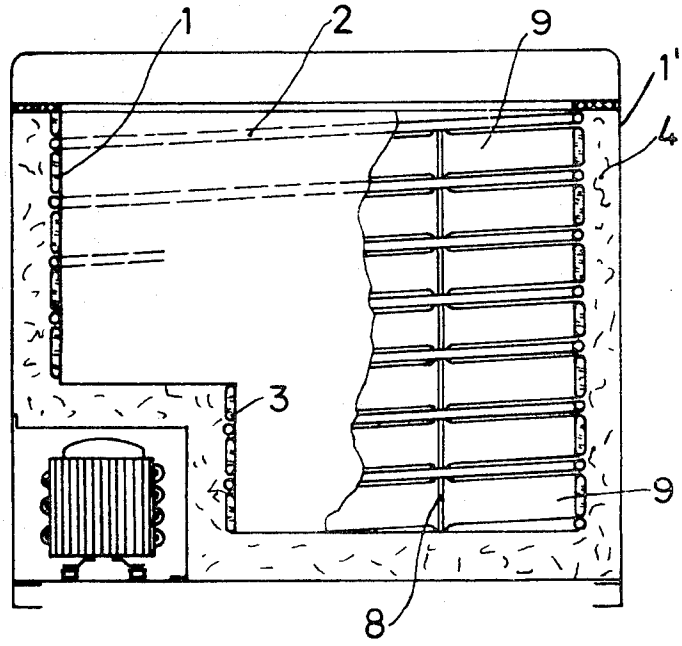
[57] **ABSTRACT**

A freezing chest or freezing shelf comprising a compressor, heat exchangers and a heat storage arrangement with a heat storage material having a crystallization temperature above the temperature of the evaporator and below the maximum permissible temperature of the goods to be refrigerated. The heat storage material is arranged in containers formed from thin walled plastics, and the containers are disposed between the container of the goods to be refrigerated and the insulating layer, and are in contact with the wall of the former over approximately half the total surface. Further, the containers of the heat storage material have recesses for the evaporator tubes which are equally in contact with the wall of the container of the goods.

14 Claims, 5 Drawing Figures



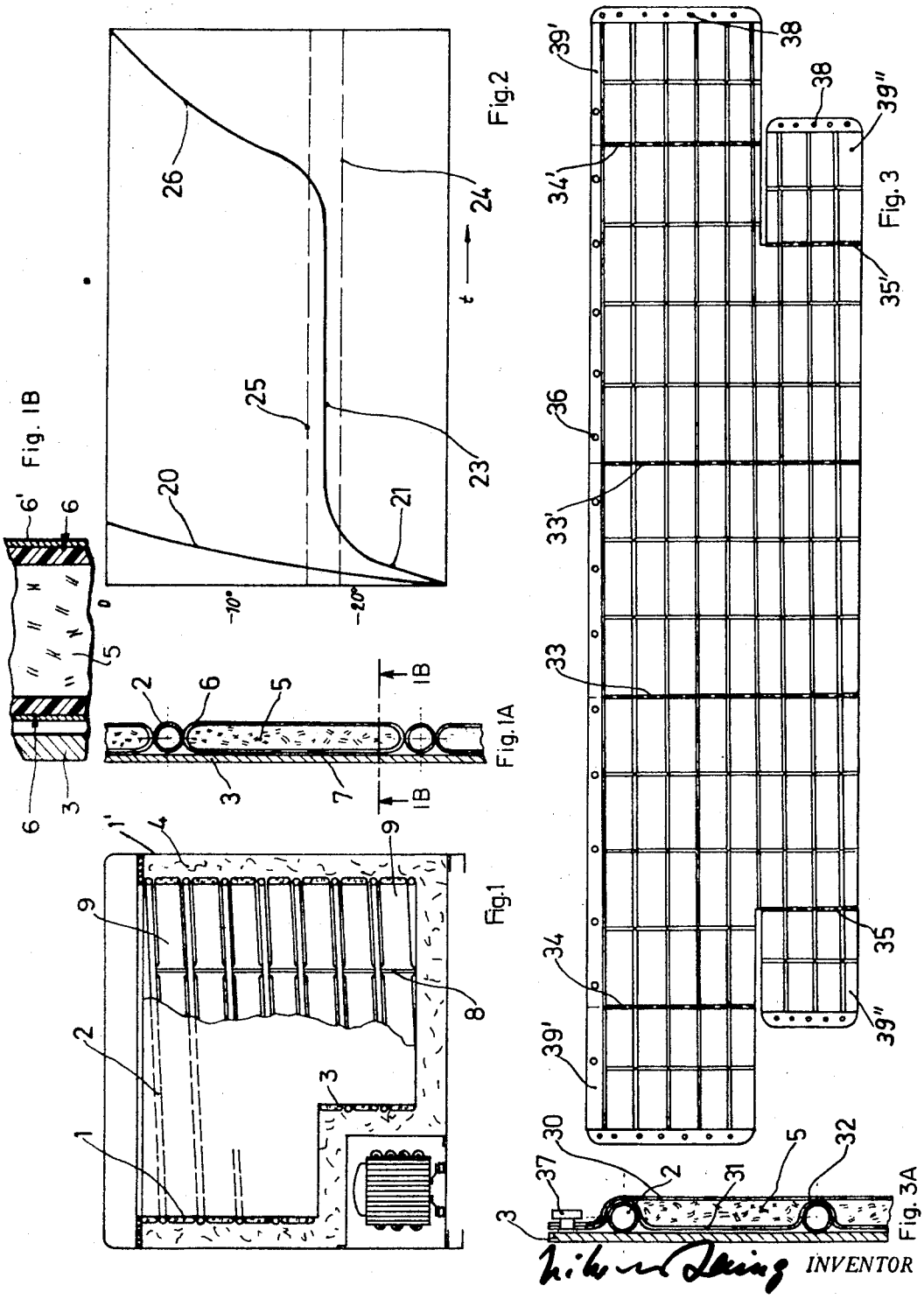


Fig. 1B
6'
6
5
6
3
Fig. 2
26
24
t
25
23
20
21
0
-10°
-20°
Fig. 1A
2
6
5
IB
IB
3
7
Fig. 1
1'
4
9
9
8
2
3
1
Fig. 3
39'
38
38
39''
34'
35''
36
33'
33
34
35
39''
39'
Fig. 3A
30
37
2
31
5
32
3
INVENTOR

NEW FREEZING CHAMBER WITH REFRIGERATION STORAGE

THE PRIOR ART

It is known to provide storage bodies in freezing chests, from which heat of crystallization is withdrawn during operation, so that for example in the event of electric power failure an adequately low temperature is maintained for prolonged periods without the operation of the refrigeration plant. Eutectic cryohydrates which are liquid at normal temperature while crystallizing during compressor operation, are used as storage masses. These masses are accomodated in containers which are at the same time traversed by the heat exchanger tubes of the coolant evaporator.

The advantages to be expected are, however, counteracted by appreciable disadvantages, so that refrigeration storage apparatus has not caught on in this field, because it was found that all cryohydrates — these are eutectic systems consisting of ionogenic compounds and water — experience a large change of density as they crystallize, so that the walls of the containers are subjected to large alternating mechanical stresses. It has more ever been found that the substances which crystallize in the course of refrigeration operation frequently no longer work in the appropriate temperature ranges, even after only a few month of operation. The reason for this is that the seed crystals added for the purpose of preventing supercooling of the storage mass and also the ingredients of the eutectic of higher specific gravity collect on the floor of the vessel, so that either the supercooling which is prevented during normal operation by seed crystals uniformly distributed through the storage mass is no longer prevented, i.e., that the temperature of crystallization drops to lower values, or that the eutectic temperature is no longer reached by reason of a change in the weight ratio of the ingredients forming a eutectic, i.e., that the temperature of crystallization changes in the direction of higher values.

A further disadvantage of known solutions consists in that the evaporator tubes are surrounded by the storage mass. Thereby the heat transfer between the evaporator tubes and the wall of the container for the goods to be refrigerated is made considerably worse, so that newly introduced such goods require a substantially longer period for freezing.

SUMMARY OF THE INVENTION

The invention relates to storage bodies which are not subject to the aforesaid disadvantages. According to the invention the storage mass container consists of plastics sheets which are sufficiently deformable at least for compensating the variation in density, which form resilient hollow vessels by welding along predetermined seams and, if desired, also spots, in which the storage mass is enclosed. Preferably the double walled sheet is provided over the entire exterior surface of the container for the goods to be refrigerated, so that the mean required thickness of the layer of storage mass amounts to only a few millimeter. By means of this arrangement, the high grade heat contact between the evaporator tubes and container for the goods to be refrigerated is not adversely affected. The metallic wall of the container for the goods to be refrigerated serves not only the purpose of a heat conduit for heat from the said goods and from the insulation, but also for conducting the heat from the double walled vessel with the storage mass.

Homogeneous mixtures, e.g. methanol + water, are used as the storage mass. The storage may, however, also, in a manner known per se, consist of meltable eutectic mixtures. In accordance with the invention, this mass has then seed crystals, whose position is fixed by a substance providing a supporting structure, e.g., a gel-forming mixture additive, added to it in a uniform spatial distribution. In accordance with the invention, the storage body is arranged between the wall of the container for the goods to be refrigerated facing the said goods and the elastically deformable insulating layer consisting of foamed plastics. Thereby the metallic wall of the container for the goods to be refrigerated, which is in good heat conductive communication with the evaporator tubes, is utilized at the same time for heat distribution between the evaporator tubes of not directly adjacent regions of the cooling body and furthermore for fixing the storage bodies. The first sheet which is secured to the metallic wall of the container for the goods to be refrigerated by an adhesive maintains its position during crystallization which entails volumetric expansion. The change in density causes a displacement of the second wall, which bounds the elastic insulating layer. Since the mean thickness of the layer of storage mass amounts to only a few millimeters, when the entire surface of the container for the goods to be refrigerated is coated with the storage body described, the movement only has the order of magnitude of 1 millimeter. The storage body is preferably suspended by being secured by an adhesive to the wall of the container for the goods to be refrigerated, the regions between the evaporator tubes preferably being filled in. It is sufficient to provide temporary fixing or adhesion, since the storage bodies are held between the evaporator tubes after foaming of the insulating layer by the adaptation of its shape to the spaces between the evaporator tubes.

As a result of the melt being thickened by a substance providing a supporting structure, the invention avoids ageing of the storage mass and the latter becoming ineffective, since the seed crystals, salt and water remain in isotropic distribution and thus at an adequately small relative spacing. At the same time hydrostatic pressures in the lower regions of the container are prevented, since the thickened liquid behaves similarly to a solid body. By using plastics sheet for storage mass containers and the arrangement between the rigid wall of the chamber containing the goods to be refrigerated and the insulation, non-permissible deformation of the material is prevented. Since all the suitable storage masses have considerably lower heat conductivity in the liquid phase than in the crystalline phase, the storage mass which has been protected against heat transfer convection by the substance forming the supporting structure, acts as additional insulation when heated above the temperature of crystallization.

In order that damage to the refrigeration storage device as a result of damage to the thin walled sheets does not result in loss of storage capacity, the invention provides for the subdivision of the storage mass vessel into a large number of independent individual chambers, by welding seams on the sheets. Thereby, in the event of damage, a proportion of the total storage capacity amounting to only a few percent is lost.

It has been found that, by the use of suitable storage masses hereinafter described, extraordinarily small layer thicknesses of, for example, 5 – 8 mm result in storage capacities which permit a bridging period of many hours, for example, in the event of electric power failure.

The invention provides, as a special further instance of its application, the combination of the storage bodies with a refrigeration plant, whose rating is such that the refrigeration effect required in the course of a day can be produced basically during the off-peak night time period. This has the advantage that the "charging" takes place only during the cool hours of night, in which the Carnot efficiency is better than during the day, so that during normal operation less energy is consumed. At the same time the mechanical efficiency of the installation increases with an increase in the size of the refrigeration plant, which provides further saving. The invention preferably provides the uniform distribution of the storage mass over all vertical walls. Thereby a considerable reduction in energy with optimum heat transfer conditions is created, which permits rapid freezing even in the case of large quantities to be refrigerated, e.g. the sudden demand for refrigeration of large quantities of goods during fruit harvest or slaughtering.

Suitable storage masses comprise alcohol-water mixtures, e. g. methanol-H_2O as well as cryohydrates, whose thermodynamically active constituent consists of 37 % $NaNO_3$ or 40 % $(NH_4)_2SO_4$ or 23 % NaCl or 42 % NH_4NO_3, all the said percentages being by weight. Suitable thickening substances comprise aerosiles of high-polymer swellable hydrocarbons, particularly alginates.

The disadvantage of storage mass vessels of large area consists in the possibility of loss of the substance in view of the vapor permeability of the majority of plastics sheets, particularly for the sheet which is not secured by adhesive to the wall of the container for the goods to be refrigerated. The invention therefore provides a multi-layer sheet, in which one layer consists of a metal, e.g., aluminum.

The arrangement according to the invention is suitable not only for the containers for the goods to be refrigerated of freezing chest, but also for refrigerators and particularly freezing shelves of refrigerators.

The invention will be explained in greater detail with reference to the following description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section view of a refrigerated compartment constructed according to the invention;

FIG. 1A is an enlarged section of a portion of FIG. 1 illustrating the positioning of a heat storage element with respect to the inner wall of the compartment;

FIG. 2 is a graph illustrating change of temperature of a compartment constructed according to the invention with respect to time;

FIG. 3 is a side view of a further embodiment of a heat storage element constructed according to the invention; and

FIG. 3A is an enlarged sectional view of a portion of FIG. 3 illustrating the attachment of the heat storage element to an inner wall of a refrigerated compartment.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates diagrammatically in section a refrigerated compartment **1** having an outer wall member **1'** and an inner wall member **3**. Evaporator tubes **2** which are in good heat conductive communication with the inner wall member **3** extend spirally around the compartment. The tubes **2** contain a coolant which is adapted to be circulated therethrough in order to cool the interior of the compartment. Between wall **3** and insulation material **4**, heat storage elements **5** are arranged which are surrounded by a thin flexible tube **6**. The thin flexible tube is connected to the wall **3**, e.g., by means of an adhesive, along the seam **7** and is held in this position by shape adaptation after foaming of the insulation **4**. The thin flexible tube **6** is sqeezed together at regular intervals and welded up along the seam **8** to form individual containers **9**.

FIG. **2** shows the heating curve **20** for refrigerated compartments without a storage mass and **21** for freezing chests with a storage mass. The horizontal region **23** corresponds to the temperature of crystallization of the storage mass. This lies above the temperature of evaporation **24** of the coolant circulated in the evaporator tubes and below the temperature **25** which must not be exceeded from the point of view of maintenance of the storability of the goods to be refrigerated. Only after completion of the crystallization, does the temperature increase along the curve **26**.

FIG. **3** shows a further embodiment of the invention. The storage element here consists of a coherent sleeve, whose wall **30** facing the insulation extends outside the evaporator tubes **2** along an approximately level plane, while the wall **31** facing the wall **3** has bulges **32**, which enclose the evaporator tubes. The sleeve shown is intended for compartment **1** for goods to be refrigerated, as shown in FIG. **1**, and is laid around the vertical edges of the compartment along the fold lines **33/33'**, **34/34'**, **35/35'** and preferably secured to protrusions **37** by means of eyes **36** and the straps **39'** and **39''** are held together by means of eyes **38** and a cord.

Preferably, the heat storage material may comprise alcohol water mixtures, for example methanol-H_2O as well as cryohydrates the thermodynamically active constituent of which may comprise either 37% NA NO_3, 40% $(NH_4)_2SO_4$, 23% Na Cl, or 42% NH_4NO_3, all of said percentages being by weight. In addition, thickening substances may be added to the heat storage material to provide a supporting structure, as for example, aerosiles of high-polymer swellable hydrocarbons, particularly alginates, or long-fiber silicon dioxide-hydrate crystals.

I claim:

1. A refrigerated compartment having an outer wall member, an inner wall member spaced from said outer wall member, insulation material between said wall members, a plurality of evaporator tubes positioned between said members for cooling said compartment, and a coolant circulating in said tubes; the improvement comprising including a heat storage element between said wall members where said element has a plurality of individual flat containers joined end to end positioned between and contacting said insulation material and said inner wall, the heat storage material in said containers having a crystallizing temperature above the temperature of evaporation of said coolant and below the maximum permissible working temperature of said compartment, and said tubes being positioned along the side edges of said containers.

2. A refrigerated compartment according to claim 1 wherein said containers are formed from thin flexible tubes.

3. A refrigerated compartment according to claim 1 wherein the heat storage element comprising the containers joined end to end is spirally wound around the compartment and between said tubes.

4. A refrigerated compartment according to claim 1 wherein said containers are in addition joined side to side along their edges to form a container sheet.

5. A refrigerated compartment according to claim 4 wherein the sheet is positioned along the vertically extending inner walls of said compartment.

6. A refrigerated compartment according to claim 1 wherein said heat storage material comprises a water-methanol mixture.

7. A refrigerated compartment according to claim 1 wherein the heat storage material includes in addition a thickner substance to provide a supporting structure to said material.

8. A refrigerated compartment according to claim 7 wherein said thickner comprises long fiber silicone-dioxide hydrate crystals.

9. A refrigerated compartment according to claim 7 wherein the heat storage material comprises ionogenic compounds and water and having in addition seed crystals uniformly distributed in the storage material wherein said thickner substance prevents the crystals from segregating out of the storage material.

10. A refrigerated compartment according to claim 1 wherein the storage material comprises a cryohydrate of approximately 42 percent by weight of NH_4NO_3.

11. A refrigerated compartment according to claim 1 wherein said storage material comprises a cryohydrate of approximately 37 percent by weight of NA NO_3.

12. A refrigerated compartment according to claim 1 wherein the storage material comprises a cryohydrate of approximately 40 percent by weight of $(NH_4)_2\ SO_4$.

13. A refrigerated compartment according to claim 1 wherein the storage material comprises a cryohydrate of approximately 23 percent by weight of Na Cl.

14. A refrigerated compartment according to claim 1 wherein said heat storage element comprises a water vapor impermeable sheet of multi-layer construction with one of said layers comprising a metal.

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