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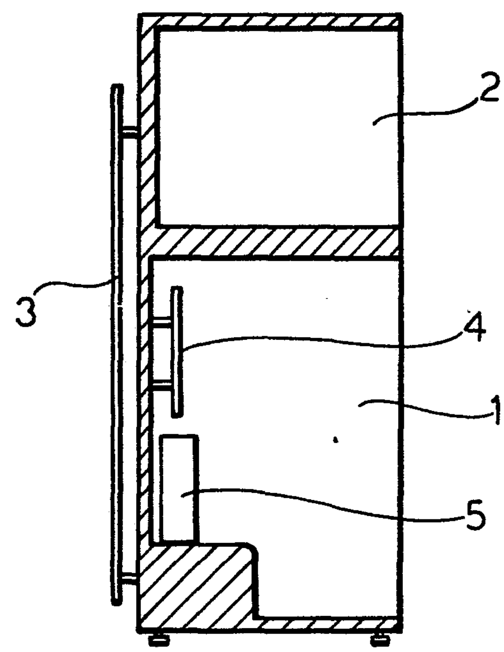
(54) Perfected refrigerator.

(57) The invention relates to a perfected refrigerator with two compartments, one for frozen food and one for cold food, capable of withstanding working loads of considerable intensity in the freezer compartment without however, harming the foods or drinks in the cold food compartment.

This result is achieved by inserting into the cold food compartment one or more elements which are capable of storing heat or cold in predetermined period of operation and of yielding them up in other periods of operation.

In particular it deals with the provision of a heat storage element in the cold food compartment of the refrigerator which may be constituted for example by a tank of pure water (or of a solution with a freezing point slightly above 0° C, which is placed in the coldest zone in this compartment (just below the evaporator).

Thus, during normal operation, the water in the tank remains in the liquid state while under conditions of operation with the compressor continuously activated, as occurs during rapid freezing, if the temperature within the cold food compartment tends to fall below zero (such as would harm some foods contained therein) the mass of water contained in the said tank introduces an obstacle to this lowering of the temperature. Indeed before the temperature in the compartment can fall below zero, the refrigerator must take all the latent heat of freezing from the water in the tank which is necessary to transform it into ice and hence



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this mass of water, if of suitable size, prevents the temperature in the compartment from falling below zero before the freezing operation of the food just introduced is ended.

Perfected Refrigerator

The present invention relates to a refrigerator provided with a refrigerating system comprising at least one compressor device for refrigerant fluid, a condenser device for the refrigerant fluid leaving the compressor, at least one evaporator device for the refrigerant fluid coming from the condenser having first and second parts arranged in series and at least a first and a second freezing compartment associated with the two parts of the evaporator.

The invention applies principally to refrigerators provided with two refrigerated compartments, one for frozen foods and one for cold foods.

In present refrigerators with two compartments, a single compressor and two evaporators, the operation of the two evaporators is not completely independent but rather the operation of one also influences the operation of the other.

For example when fresh foods to be frozen are introduced into the freezer compartment, it is necessary for the freezing to occur in a few hours since there are standards which set down that a specific quantity of food must be frozen within 24 hours.

This necessitates the almost continuous operation of the evaporator of the freezer compartment at full load and hence, in addition, the almost continuous operation of the evaporator of the cold food compartment, with the attendant danger that the temperature in this compartment will fall below 9^{o}C which would harm several types of foods contained therein.

Until now this problem has been solved by energising a suitable resistance, during the said freezing stage, which, by heating the fresh food compartment, avoids this falling below 0^{o}C.

But deliberated to introduce heat into apparatus which has the function of producing cold is really absurd and results in a considerable wastage of energy.

It is known,as shown for example by U.S. Patent No. 2,741,100, to provide means in the cold food compartment which have a thermal inertia, for example containers full of water in which the evaporator of this compartment is immersed.

However such means are not able to allow the absorption of the excess frigories produced in the cold food compartment during the freezing of large quantities of food in the freezer compartment.

Indeed, in cited U.S. Patent No. 2,741,100 itself, it is taught that when there is danger of overcooling in the cold food compartment, the evaporator thereof must be bypassed, rendering it inoperative; while no mention is made of the possibility of using the latent heat of freezing presented by the water in the container.

Solutions of the type explained in U.S. Patent No. 2,741,100 therefore, have the disadvantage of requiring expensive inhibiting means, which increase the energy consumption and may create problems in the reliability of the apparatus, being subject to possible breakdown.

The object of the present invention is to demonstate the use of suitable means capable of increasing the thermal inertia of the system, in particular the use of eutectic plates which, placed in the cold food compartment near the evaporator during normal operation of the refrigerator, accumulate heat and then yield it up to the cold food compartment during "peak working loads" due to the needs of the freezer compartment, thus preventing the temperature in the cold food compartment from falling below a certain minimum value.

In order to achieve these objects, the present invention provides a refrigerator having a cooling system comprising at least one compressor device for the refrigerant fluid, a condenser device for the refrigerant fluid leaving the compressor, at least one evaporator device for the refrigerant fluid coming from the condenser, having first and second parts placed in series and at least a first and a second cooling compartment associated with the two parts of the evaporator, characterised in that there is inserted in the said second compartment at least one first element capable of storing heat during a first period of operation of the refrigerator and of yielding it up during a second period of operation, in which the heat storage capacity of said first element is such that, during the periods of working of the refrigerator in the said second period, the said first element is able to provide the said second compartment with heat in order to prevent the temperature within it from falling below a predetermined value.

Further objects and advantages of the present invention will become clear from the description and from the appended drawings, in which Figure 1 shows a possible embodiment of the prefected refrigerator according to the present invention.

In this, the cold food compartment is shown as 1 and the frozen food compartment as 2. The refrigerant fluid condenser is shown as 3 and the evaporator for the said fluid,which is associated with the cold food compartment, is shown as 4.

By 5 is shown a heat storage element in the form of a rectangular reservoir tank arranged under the evaporator 4. This tank may be fixed or may be removable according to the manner of operation of the refrigerator itself, as will be explained in detail below.

The tank 5 is filled with a liquid which has a freezing point close to 0^{o}, for example water.

This tank has dimensions such that, with regard to its depth, it does not project much beyond the front of the evaporator 4, its height being such as to allow it to be housed beneath the evaporator and its width being such as to allow it to be inserted in the space constituted by the compartment 1.

It is noted that the larger the surface of this tank the greater is its capacity to transmit heat with consequent increase in the efficiency of the device.

The operation of this device is as follows.

As stated above, there are well defined and strict standards relating to the capacity of a freezer compartment for freezing hot foods from the external environment. In particular it is necessary for the device to be able to bring a specific quantity of hot food to a temperature of -18^{o} in a predetermined time. To achieve this if one does not wish to be forced to provide the whole system with a considerable cooling capacity, a capacity which would be wasted under normal operating conditions, the refrigeration system must be made to operate at its maximum, if necessary also inhibiting the normal stoppages for allowing automatic defrosting. This is the typical "fast freezer" operation.

This solution, although on the one hand it can solve the problem of overcoming these peak working loads, on the other hand creates another problem. Indeed, since in normal two door refrigerators the first cooling circuit passes through the evaporator associated with the frozen food compartment and then through that associated with the cold food compartment, the boosting to peak operation of the evaporator of the frozen food compartment is the same as a boosting to peak operation of the evaporator of the cold food compartment, with the consequent possibility of making the temperature within the cold food compartment fall below zero degrees.

This cannot be accepted in that foods are kept in this compartment which cannot tolerate being brought below zero: green vegetables, cheeses, butter, and particularly water in bottles which on freezing increases in volume causing breakage.

According to the present invention the liquid contained in the tank 5 has the purpose of yielding up all the latent heat of freezing of which it is capable, bringing it to the solid state, thus interposing an obstacle to the descent of the temperature in the compartment below zero degrees.

In fact, if the capacity of the tank 5 is well dimensioned compared to the actual refrigerating capacity of the "freezer" compartment and to the capacity which this compartment must have to surpass the said standards, the delay in the lowering of the temperature in the cold food compartment introduced by the tank 5 is sufficient to allow the freezing operation within the freezer compartment to be completed without the temperature in the cold food compartment falling below zero and without having been forced to make it excessively large compared to that which the refrigeration system requires for normal operation.

It is noted that in order to improve the functioning ability of the device, the tank 5 has been arranged in the coldest part of the cold food compartment under the evaporator where it receives air falling from the evaporator, which may be several degrees below zero; thus the water in the tank 5 may freeze since it is surrounded by the current of cold air, and hence fulfills its function, without the temperature in the remaining part of the cold food compartment falling below zero (in particular in the space formed in the portion of the refrigerator where bottles containing water are usually kept).

Moreover it is suitable for the tank 5 not to have its back against the rear wall of the refrigerator but for there to be an air space which improves the heat exchange between the air falling from the evaporator and the liquid in the tank 5 which therefore must be made from a material which is a good heat conductor.

According to this embodiment of the invention the tank 5 behaves in a dual manner compared with the known art. Indeed in normal operation, the plates of the known art absorbed frigories from the cooling system and yielded them up at times of greater working load of the system;

the tank 5, on the contrary, in normal operation absorbs calories which are then, at the moment of greater working load, given up to the compartment.

The tank 5 may, as stated above, also be formed so as to be removable. This produces the advantage that when no need is foreseen for the freezing of fresh foods, the refrigerator has a greater storage capacity for foodstuff in the cold compartment. On the other hand when the need to freeze fresh foods arises, on introduction of these foods into the freezing compartment, the tank 5, which acts as a ballast is simultaneously also introduced into the cold food compartment; hence the higher its temperature the higher its functioning ability.

From this point of view, the removability of the tank 5 is an advantage.

If, instead, the case of the temporary interruption of the electrical power supply is considered, the fact that a thermal mass of considerable size is located in the cold food compartment may serve to keep a sufficiently low temperature for a longer period while waiting the re-connection of the electrical supply.

With regard to the quantification of the capacity of the tank 5, the following considerations may apply: for example, in the case of a two-compartment refrigerator with a 180 litre cold food compartment, there is a cooling power in the said compartment of about 30 Kcal/h, while in a refrigerator with a 220 litre cold food compartment, there is a cooling power of about 40 Kcal/h.

The operating time under "fast freezer" conditions for such apparatus is normally about 12 hours but for the first 6 hours there is no great danger of the cold food compartment falling below $0^{O}C$ since it must first be cooled from the existing temperature (about $5^{O}C$ to $0^{O}C$.

Even though, as stated above, it is not necessary.

for the tank 5 to have a capacity such as to enable it to cope with frigories introduced into the cold food compartment for 12 hours of operation as a fast freezer it is however material for the purpose of dimensioning the said tank 5 to analyse this case as well.

In the case of a 180 litre cold food compartment with a cooling power of 30 Kcal/h, 6 x 30 = 180 Kcal are taken from this compartment in 6 hours while in 12 hours 12 x 30 = 360 Kcal are taken.

In the case of a 220 litre cold food compartment with a cooling power of 40 Kcal/h, 6 x 40 = 240 Kcal are taken from this compartment in 6 hours while in 12 hours 12 x 40 = 480 Kcal are taken.

On the other hand we know that the latent heat of freezing of one litre of water is 79.6 Kcal.

Hence in the two preceding cases, for 6 and 12 hours of operation, the capacity of the tank 5 must be:

180 l compartment for 6h	180 : 79.6 = 2.26 l
180 l compartment for 12h	360 : 79.6 = 4.52 l
240 l compartment for 6h	240 : 79.6 = 3.01 l
240 l compartment for 12h	480 : 79.6 = 6.02 l

It may be interesting to determine the percentage ratio of the volume of the tank 5 to the volume of the cold food compartment in the various cases set out above.

180 l compartment for 6h	(0.26 : 180) x 100 = 1.25%
180 l compartment for 12h	(4.52 : 180) x 100 = 2.50%
220 l compartment for 6h	(3.01 : 220) x 100 = 1.37%
220 l compartment for 12h	(6.02 : 220) x 100 : 2.74%

It is seen that for the cases considered, the percentage volume occupied by the tank 5 varies from 1 to 3% of the total volume of the compartment.

Hitherto we have considered only the heat which the water yields to the compartment in changing from the liquid to the solid state at $0^{\circ}C$; that is, the case in which the tank 5 is formed so as to be fixed inside the cold food compartment (the less favourable case since the water in the said compartment is normally at about 5^{O}C).

Considering the case in which the tank 5 is formed so as to be removable and is inserted into the fresh food compartment before the freezing of food in the freezer compartment, the water contained therein is presumably at about 20^{O}C. In this case, in addition to the latent heat of freezing, the water also gives up to the compartment the heat needed to cool it from 20^{O}C to 0^{O}C, which will be 20 Kcal per litre.

In order to obtain the 180 Kcal in the case of the 180 litre compartment for 6 hours, consequently less than 2 litres of water will suffice, which would provide 2 x (20 = 79.6) = 199 Kcal.

In conclusion it is seen that in order to avoid the cold food compartment from falling below 0^{O}C when the freezer compartment works as a"fast freezer"a tank suffices with a quantity of water which is between 1% and 3% of the capacity of the cold food compartment, more specifically for refrigerators at present on the market this quantity of water will be between 1 and 6 litres.

From the above description the advantages of the present invention are clear.

Among these is that of not having to use the defrosting resistance during the food freezing stage with obvious saving of electrical energy and rendering the temperature in the cold food compartment more constant with time.

A further advantage lies in the facility of obtaining the desired results and in the economical nature of the means adopted.

Clearly numerous variations of the embodiment des--cribed are possible to the man skilled in the art without thereby departing from the scope of the inventive idea inherent in the present invention.

Among the many variations there may be mentioned in possibility of using the plate containing a mixture with a eutectic point at a temperature slightly higher than 0^{O}C.

In another variant, eutectic plates may be used in the frozen food compartment with freezing points slightly below the temperature in this compartment as is widely illustrated in the known art. Thus when food to be frozen is placed in the said freezer compartment part of the frigories necessary for freezing is given up by the said eutectic plates whereby the time for which the refrigerator operates as a fast freezer is reduced. The frigories yielded up during this operation by the second part of the evaporator to the cold food compartment is consequently also reduced and hence the tank 5 placed in the said compartment must provide fewer calories than is the case when the said eutectic plates are not placed in the freezer compartment whereby it may have a smaller heat capacity than in the previous case.

Finally it is clear that it is possible to change both the choice of the components forming part of the mixture and the percentages thereof by modifying the information given in the preceding description, just as it is also possible to choose different freezing temperatures and a different liquid to be inserted in the tank contained in the cold food compartment.

CLAIMS

1. Refrigerator provided with a cooling system comprising at least one compressor device for the refrigerant fluid, a condenser device for the refrigerant fluid leaving the compressor, at least one evaporator device for the refrigerant fluid coming from the condenser having first and second parts placed in series and at least a first and a second cooling compartment associated with the two parts of the evaporator, characterised in that in the said second compartment there is inserted at least a first element capable of storing heat during a first period of operation of the refrigerator and of yielding it up during a second period of operation, in which the heat storage capacity of the said first element is such that, during the periods of working of the refrigerator in the said second period, the said first element is able to provide heat to the said second compartment in order to prevent the temperature within it from falling below a predetermined value.

2. Refrigerator according to Claim 1, characterised in that the said second period of operation is related to the period which follows the introduction, into the said first compartment, of food to be frozen.

3. Refrigerator according to Claim 1, characterised in that the temperature within the said first compartment is normally less than that in the said second compartment.

4. Refrigerator according to Claim 2, characterised in that the said refrigerating system, during the said second period of operation, is made to work at its maximum cooling capacity.

5. Refrigerator according to Claim 4, characterised in that the said first element is formed so as to have such a large heat exchange capacity with the air present

in the said second compartment as to succeed in preventing the temperature in the said second compartment from falling below a predetermined danger limit, during the said second period of operation.

6. Refrigerator according to Claim 5, characterised in that the heat yielded up by the said first element to the said second compartment in the said second period of operation is passed to the said first element during the said first period of operation.

7. Refrigerator according to Claim 6, characterised in that the said first element is constituted by a tank which is filled with a liquid which has a temperature of transition from the liquid to the solid state similar to that which normally exists in the said second cell.

8. Refrigerator according to Claim 7, characterised in that the said temperature of transition from the liquid to the solid state is equal to or slightly higher than the minimum temperature allowable in the said second compartment.

9. Refrigerator according to Claim 8, characterised in that the said liquid is water.

10. Refrigerator according to Claim 8, characterised in that the said liquid is a solution with a freezing point slightly above $0^{o}C$.

11. Refrigerator according to Claim 9, characterised in that the quantity of the said water is between 1 and 6 litres.

12. Refrigerator according to Claim 9, characterised in that the ratio of the volume of the said water to the volume of the said second compartment varies between a minimum of 1% and a maximum of 3%.

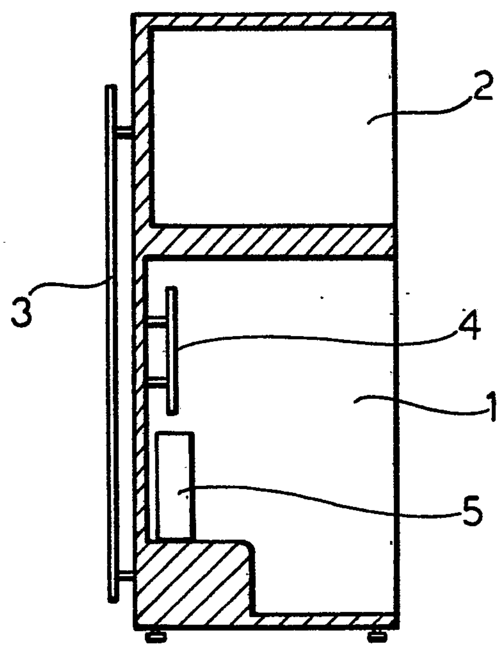
13. Refrigerator according to Claim 7, characterised in that the said first compartment is the compartment for keeping frozen foods (freezer) and the said second compartment is the compartment for keeping cold foods in a two compartment refrigerator.

14. Refrigerator according to Claim 7, characterised in that, the said tank is inserted within the second compartment, below the zone occupied by the said second part of the evaporator device so as to be surrounded by the air which falls from the said second part.

15. Refrigerator according to Claim 7, characterised in that the said tank is formed so as to allow it to be removed during the said period of operation of the refrigerator and can store heat from a suitable heat source.

16. Refrigerator according to claim 5, characterised in that, in the said first compartment there is inserted a second element, capable of storing heat during the said second period of operation which follows the introduction into the said compartment of food at a somewhat higher temperature, and in that the said first element is inserted into the said second compartment and is capable of yielding up heat during the said second period of operation which follows the introduction into the said compartment of food at the said higher temperature.

17. Perfected refrigerator as in the present description and in the appended drawings.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