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REFRIGERATING APPARATUS

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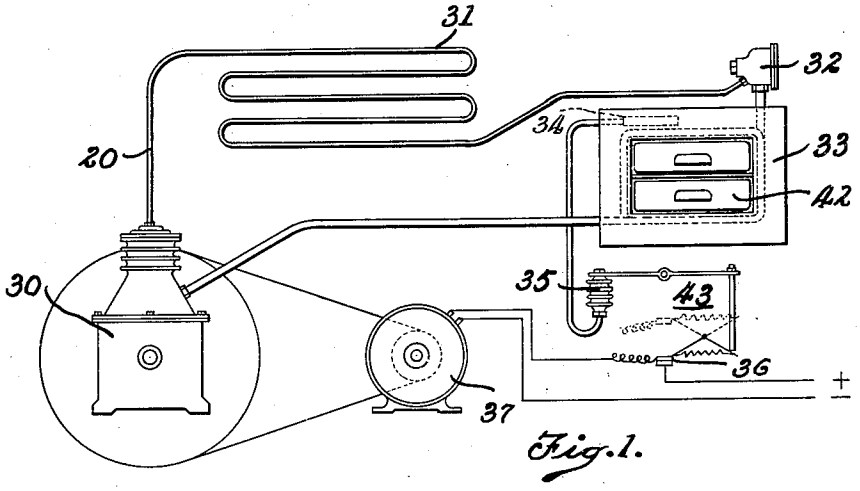


Fig. 1.

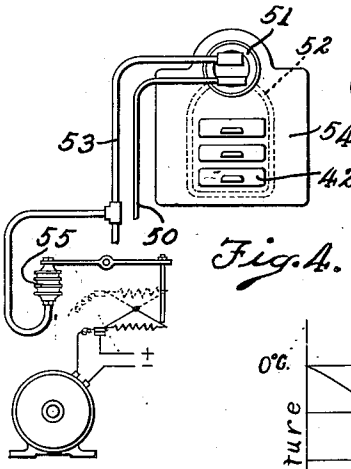


Fig. 4.

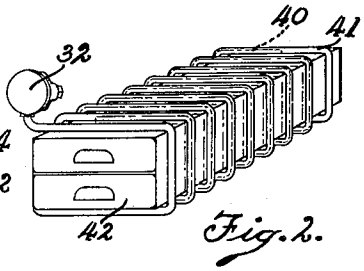


Fig. 2.

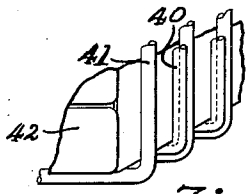
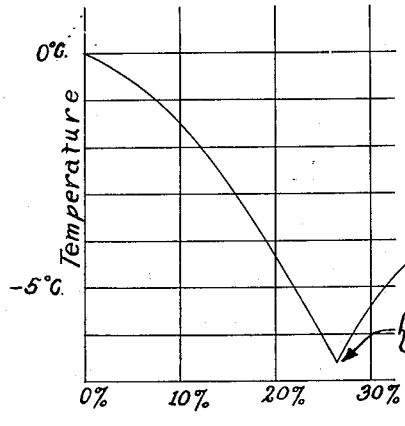


Fig. 3.



$ZnSO_4 \cdot 7H_2O$ Chart

Latent heat of fusion of this cryohydrate composition equals 50.9 kilogram calories per kilogram

Fig. 5.

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REFRIGERATING APPARATUS

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2 Claims. (Cl. 62—95)

Our invention relates to the use of holdovers in refrigerating apparatus. Holdovers may be used where there is a periodic operation of refrigerating mechanism and they furnish the refrigeration during the period of idleness of the refrigerating mechanism. They may also be used where there is continuous operation of refrigerating mechanism, to augment the mechanism during periods of excessive demand. In order that the invention may be more readily understood we prefer to describe first an apparatus embodying our invention and will thereafter more fully describe the principles involved in our invention.

In the drawing:

Fig. 1 is a form of apparatus embodying our invention;

Fig. 2 is a modified form of apparatus;

Fig. 3 is an enlarged detail view of part of Fig. 2;

Fig. 4 is another modified form of apparatus; and

Fig. 5 is a chart showing roughly certain properties of a solution of $ZnSO_4$.

In a domestic embodiment of our invention as shown in Fig. 1 the refrigerating circuit comprises refrigerant line 20 which starts at the compressor 30 and passes thru the condenser 31 to the expansion valve 32 and from thence passes thru a holdover box 33 and returns to the compressor 30. The holdover box 33 may be partially filled with a composition hereinafter described and the volume of this box need be only about 1/50 of the volume of a box containing ordinary brine and having the same holdover capacity. It is evident that the holdover box may be a means of augmenting the mechanical refrigeration during periods of excessive demand.

In another domestic embodiment of our invention shown in Fig. 2 the holdover may be provided by a spiral coil 40 shown in dotted lines in Fig. 2 instead of or in addition to the box 33 of Fig. 1 and in solid lines in Fig. 3 placed in between the coils 41 of a refrigerating circuit somewhat analogous to the one shown in Fig. 1. This modification may be provided with an expansion valve 32. Trays 42 for freezing water or other ices well known in the art may be provided in these installations. The refrigerating mechanism shown in Figs. 1 and 2 can be provided with a thermostatic or pressure switch 43 to cause the operation and stopping of the mechanism at the desired temperatures assumed in this case to be −5° C. and −10° C. The temperature control 43 may in this case be a thermostat having a bulb 34 placed in or under the influence of the holdover composition in box 33 or coil 40. This bulb 34 may be connected to an expansion bellows 35 operating snap switch 36 controlling the starting and stopping of motor 37, which drives the compressor 30. The temperature control 43 may be set to start the motor when the holdover composition is, in the instance to be described, at −5° C., and to stop the motor when the holdover composition is at −10° C. In the modification of the apparatus shown in Fig. 4, the line 50 connected to the usual compressor and condenser, not shown, delivers liquid refrigerant to a float chamber 51. The liquid refrigerant is held at a constant level in this float chamber, and fills the tubes 52 connected to the float chamber. The evaporated refrigerant returns thru line 53 to the compressor condenser. Surrounding the float chamber 51 and coils 52 may be placed a holdover tank 54 partially filled with a cryohydrate composition. The temperature control of the refrigerating apparatus in this case may be obtained by means of a pressure switch 55 connected to the return line 53 of the refrigerating circuit, the pressure in the return line being related to the temperature of the mechanism. This pressure switch 55 controls the starting and stopping of the refrigerator in accordance with the temperature. Trays 42 for freezing water or "ices" may be provided. The holdover capacity of the composition 54 at the critical temperature hereinafter described is about 50 times that of ordinary brine, and the pressure switch 55 is adjusted to start and stop the refrigerating mechanism at temperatures slightly above and below the critical temperature.

Our invention will be more readily understood by a description of the properties of the cryohydrate solution of $ZnSO_4$ which may be used in boxes 33 and 54, and coil 40, altho it is obvious that our invention is in no way limited to the use of this particular cryohydrate composition, which is described by way of example only, and it is obvious that the temperatures are also merely exemplary.

We have discovered that by the selective use of certain cryohydrate compositions a refrigerator may be provided with a holdover storage of exceptional capacity to operate at practically any desired refrigerating temperature, and within very close starting and stopping temperature limits.

In installations with ordinary brine, the holdover capacity of the refrigerator is ordinarily limited to the specific heat of the brine. No latent heat of fusion is used. When it is attempted to

use such latent heat by varying the concentration of brine so that freezing may occur at a given temperature, water is frozen out of the solution, and the concentration of the remaining solution is varied. This in turn varies the freezing temperature of the remaining solution. It is thus impossible to freeze substantially the entire holdover solution within small desired temperature limits of operation.

By selecting a suitable soluble substance and by dissolving this substance substantially to a critical degree of concentration to form what we prefer to call a cryohydrate composition, it is possible to obtain a composition which freezes and crystallizes completely at a desired fixed temperature.

Taking, by way of example $ZnSO_4$, the cryohydrate composition of this substance is obtained, according to Groeber, by dissolving 27.2% by weight of the anhydrous salt in 72.8% by weight of water. This composition freezes and crystallizes at the constant temperature of −6.55° C., and has a latent heat value of 50.9 kilogram calories per kilogram. A method of obtaining the cryohydrate composition may be by establishing a saturated solution at a higher temperature and thereafter cooling the solution until a constant freezing temperature is reached. The cryohydrate composition may be formed in the refrigerator by introducing into the holdover compartment water and an excess of $ZnSO_4$. The cooling of the solution to the critical temperature will automatically form the cryohydrate composition and the excess of $ZnSO_4$ will precipitate out of the solution, as will be more fully explained.

With this cryohydrate composition of $ZnSO_4$ it is possible to provide a refrigerator with temperature control set to snap on and off at holdover temperatures slightly on either side of −6.55° C. A holdover compartment can be provided in which the cryohydrate composition is placed. This composition by the operation of the refrigeration mechanism is frozen and gives up its latent heat of fusion to the mechanism. The refrigerating mechanism ceases to operate after the cryohydrate composition has been entirely frozen, after which the melting of the composition furnishes the desired refrigeration until the cycle is started again. It is evident therefore that when it is desired to operate a refrigerator within narrow temperature limits on either side of −6.55° C., the use of the cryohydrate composition of $ZnSO_4$ permits such operation with approximately 1/50 the amount of ordinary brine for the same holdover capacity.

In order to prevent the holdover compartment from bursting it is desirable to add to the cryohydrate composition some substance which prevents the composition from freezing in a solid mass. By way of example, some colloidal substance, such as gelatine, may be used. Another type of substance, which may be used is a soluble organic substance, such as glycerine, diethylene glycose and the like. When such a substance is added to the cryohydrate composition, the composition freezes into a mushy substance which does not burst the holdover compartment since a slight expansion space may be provided therein, and the freezing composition can flow into the expansion space.

While we have described somewhat fully the use of $ZnSO_4$ cryohydrate solution, our invention contemplates the selection of any proper cryohydrate which gives a constant desired freezing temperature. The cryohydrate composition of sodium sulphate, strontium nitrate, barium chloride and potassium chloride each gives a different constant freezing temperature within the range of ordinary domestic and commercial refrigeration. Under certain conditions the use of substances such as nickel sulphate, which would react with free hydrogen sulphide might be used in an exposed condition to keep the refrigerator more sweet.

The term cryohydrate, as herein used, may include compositions which have no water. It is possible that a solution in a substance other than water may be selected which will have a constant freezing temperature within the range of ordinary domestic and commercial refrigeration.

We are aware that the freezing of holdovers has been contemplated but in no case, with the exception of water, has it been thought desirable, for holdover purposes, to select a certain substance and to produce therefrom a solution of such critical strength that substantially the entire solution will freeze at a constant desired temperature. Our invention opens the entire domestic and commercial refrigerating temperature range to the use of a constant-temperature totally-freezing substance, thus making available a large volume of holdover capacity with a small volume of substance, in any particular case, within narrow temperature limits of operation.

By way of example, we give herein some of the many cryohydrate substances which may be chosen under certain conditions and which operate at various temperatures. The values given are by well recognized authorities.

Substance	Percent solution of the anhydrous salt forming the cryohydrate composition	Freezing point of the cryohydrate composition centigrade	Latent heat of fusion of cryohydrate composition
$Na_2SO_4.10H_2O$	3.8	−1.2	80.1
K_2SO_4	6.54	−1.55	
$Na_2CO_3.10H_2O$	5.93	−2.1	77.2
KNO_3	11.2	−3.0	80.7
$ZnSO_4.7H_2O$	27.2	−6.55	50.9
$Na_2S_2O_3.5H_2O$	30.0	−11	
NH_4Cl	18.7	−15.8	75.0
NH_4NO_3	43.3	−17.5	68.4
$NaNO_3$	37	−18.5	57.5
NaCl	23.1	−22.4	
$CaCl.6H_2O$	58.8	−54.9	

It will be seen that the freezing temperature of the cryohydrate composition of $CaCl_2-6H_2O$, the brine ordinarily used for holdover purposes, is −54.9° C. Such a temperature would ordinarily be too low for domestic or commercial refrigeration now in use. At no other temperature than −54.9 could the pure $CaCl-6H_2O$ brine be completely frozen and at no other temperature will that brine maintain a constant freezing temperature. Its use as a cryohydrate composition has not heretofore been contemplated.

Should one attempt to freeze the entire holdover solution of $CaCl_2.6H_2O$ to take the maximum advantage of the latent heat of fusion, and at the same time it should be desired to operate between the temperature ranges of −5° C. and −10° C., it would be impossible to fulfill these requirements. In order to obtain any freezing at all in the $CaCl_2$ holdover liquid, the brine would have to be in a dilute condition. When a slight amount of water in the holdover liquid should freeze, then the concentration and therefore the freezing temperature of the remaining

solution would change. When the minimum desired temperature of −10° C. should be reached a large per cent of the holdover brine would still not be frozen, and therefore advantage of the high latent heat of fusion from the entire solution could not be obtained. However, if instead of $CaCl_2.6H_2O$ the holdover spaces were filled with $ZnSO_4$ cryohydrate composition, the entire holdover composition would freeze at −6.55° C. (well within the required range of −5° to −10° C.) and then the maximum advantage of the latent heat of the composition would be obtained and the holdover space could be materially reduced to about 1/50 of that of $CaCl_2$ brine.

By the use of our invention it is possible to set thermostatic or pressure controls to start and stop the refrigerating mechanism within narrow temperature limits, and, because of the high heat storage capacity of the latent heat, the time between starting and stopping of the refrigerating mechanism will be greatly lengthened.

While we have disclosed binary cryohydrate compositions formed of a liquid and a salt, it is possible that we may use ternary and other cryohydrate compositions formed of one or more liquids combined with one or more salts, when such compositions have a constant freezing temperature within the range of ordinary domestic and commercial refrigeration. In order that the advantages of cryohydrate compositions may be more fully brought out, reference may be had to Fig. 5 in which the vertical scale is a temperature scale and the horizontal scale indicates the per cent by weight of the anhydrous salt. Since, in this case, the temperatures of 0° C. and −6.55° C. are the only ones of particular interest the intermediate curve is only roughly indicated and is not intended to be used for intermediate values. By reference to this chart, it will be seen that 0% solution, or pure water, freezes at 0° C. and that a 27.2% solution of anhydrous salt of $ZnSO_4$ freezes at −6.55°. A weaker solution, say 10%, would start freezing at some intermediate temperature and at first substantially pure H_2O would solidify and the remaining solution would therefore become more concentrated. This remaining concentrated solution, say 20% solution, would then have a freezing temperature lower than the 10% solution. When the degree of concentration reaches 27.2% however, the freezing temperature remains constant until the entire remaining substance is frozen. If on the other hand a solution of 30% should be chosen, then upon the lowering of the temperature some of the salt would crystallize first and the solution would be weakened as the temperature drops until the critical value of 27.2% is reached. It is therefore obvious that the critical concentration in this case is 27.2%. Since the lowering of the temperatures to a point near the critical temperature will reduce the solution to the proper concentration it would be possible to use initially a solution of slightly different concentration than the cryohydrate value, and the lowering of the temperature of the solution would bring part of the solution automatically to the proper cryohydrate value. When the temperature starting and stopping limits are not required to be extremely close, the initial solution need not be a true cryohydrate composition, as it would then be possible to rely on the automatic formation of cryohydrate composition during the operation of the refrigerating mechanism. Especially, it would be convenient to start out with a saturated solution of the substance at room temperatures. The reduction of the temperature would then automatically form the cryohydrate composition at the critical temperature. Since the heat of precipitation of the substance is very small as compared with the latent heat of freezing of water, the excess of the substance will be precipitated without the absorption of a large amount of heat, and therefore the temperature of the mixture during the freezing operation would remain essentially constant. A close temperature control can therefore be obtained with an excess of the substance in the liquid. The disadvantage in this case would be that the latent heat capacity of such a substance might not be as great as the perfect composition and that the temperature limits of operation would have to be farther apart. Such a use of a solution near the cryohydrate value is contemplated in our invention.

Under certain conditions, the refrigerating mechanism may be continuously operative, and the holdover cryohydrate composition may be used to augment the refrigerating capacity of the mechanism during periods of excessive demand, being frozen during periods of inferior demand.

This invention is of particular value when it is desired to furnish refrigeration of very accurate and close temperature limits and in ice cream cabinets where the temperature of the ice cream is a material factor of its quality.

While the form of embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A refrigerating apparatus comprising a sleeve, a removable receptacle in said sleeve adapted to contain substances to be refrigerated, means in thermal contact with at least opposite sides of said sleeve and containing a cryohydrate composition, said cryohydrate composition having a melting point below the freezing point of said substances, and an intermittently operating refrigerating system automatically controlled to maintain temperatures below the freezing point of said substances and to maintain said cryohydrate composition in a frozen condition at least during part of the operating time of said system and in an unfrozen condition at least during part of the idle time of said system.

2. A refrigerating apparatus comprising a receptacle removable from a freezing zone and adapted to contain substances to be refrigerated, means surrounding at least a portion of the periphery of said zone and containing a cryohydrate composition, said cryohydrate composition having a melting point below the freezing point of said substances, and an intermittently operating refrigerating system automatically controlled to maintain temperatures below the freezing point of said substances and to maintain said cryohydrate composition in a frozen condition at least during part of the operating time of said system and in an unfrozen condition at least during part of the idle time of said system.

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