

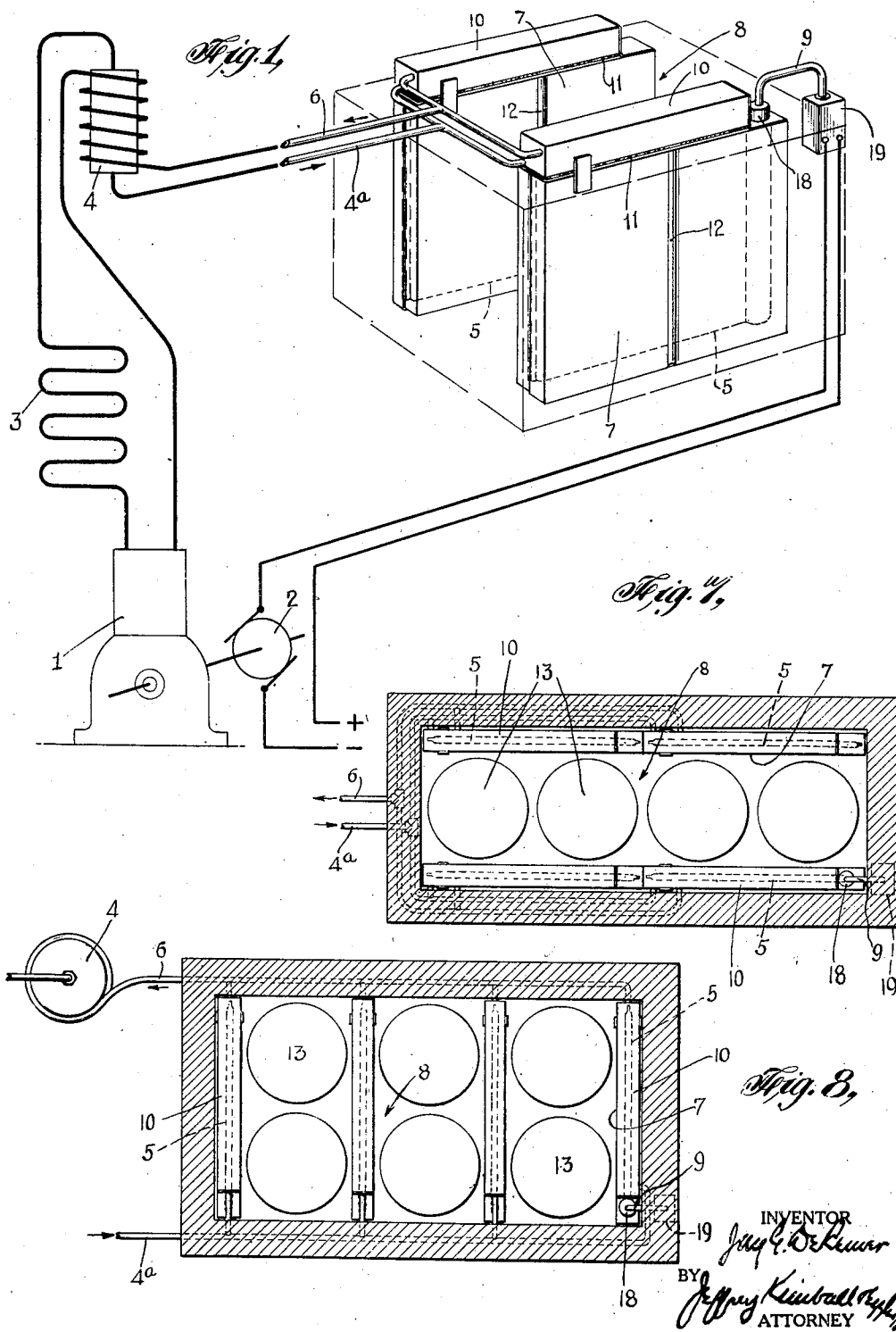
June 7, 1932.

J. G. DE REMER

1,861,957

ARTIFICIAL REFRIGERATION

Original Filed Dec. 22, 1925 2 Sheets-Sheet 1



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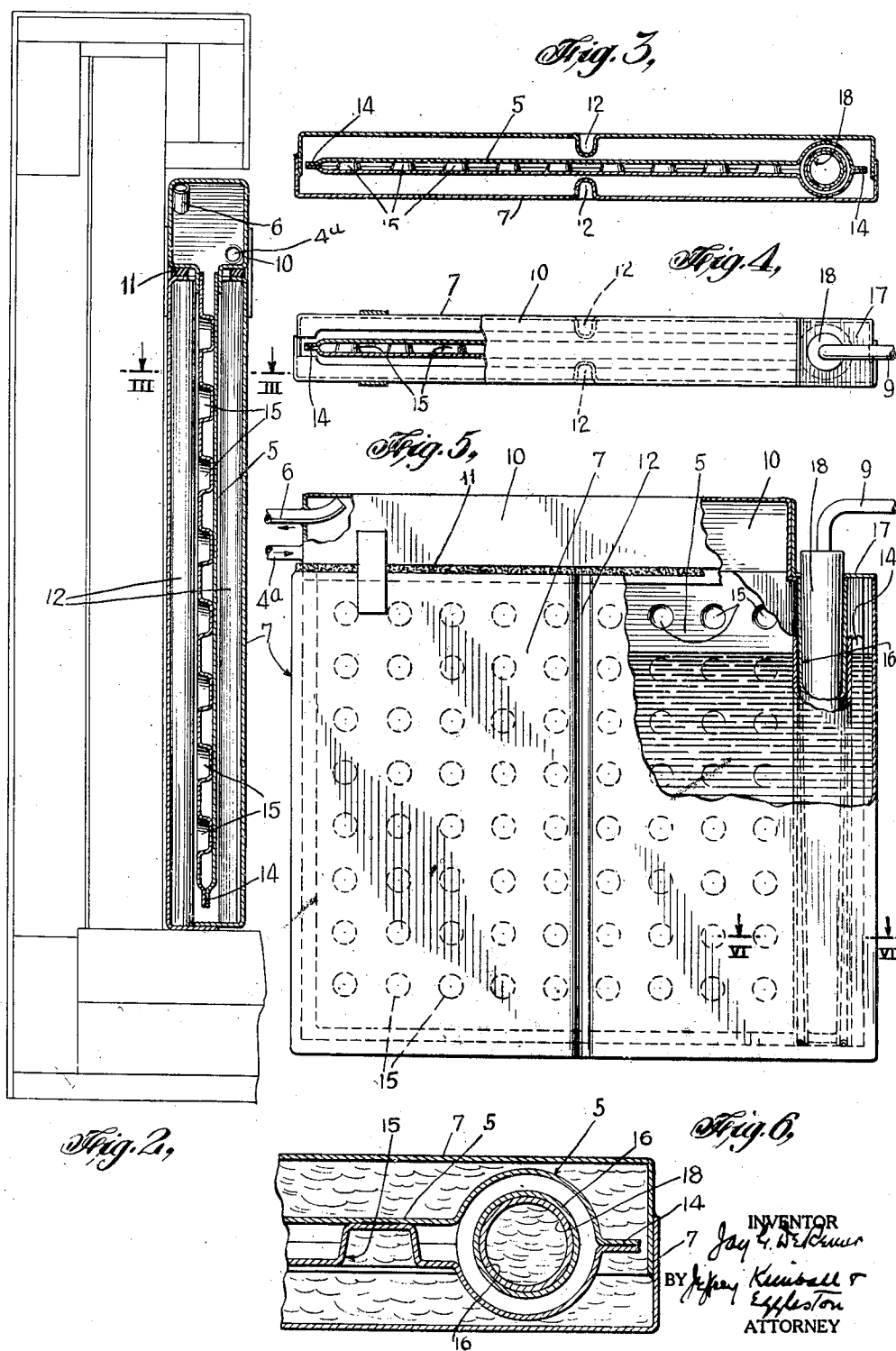
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ARTIFICIAL REFRIGERATION

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The object of this invention is to maintain substantially constant temperatures by mechanical refrigeration, particularly temperatures lower than 32° F., such as required for preserving ice-cream and other goods, and the invention consists in the method and means herein disclosed for that purpose.

The accompanying drawings illustrate, more or less diagrammatically, a suitable arrangement of apparatus by means of which the invention can be carried out;

Fig. 1 representing the general organization in diagram.

Fig. 2 (Sheet 2) is a vertical section of a refrigerator unit.

Fig. 3 a section on line III—III.

Fig. 4 a top plan with the header broken away.

Fig. 5, a broken out side elevation.

Fig. 6 a larger scale section on VI—VI of Fig. 5; and

Figs. 7 and 8 show the application of the units.

Referring to the diagram, the refrigerant circuit includes a compressor 1 of any suitable design, driven by a motor 2 and connected through a condenser 3 and expansion valve 4, and inlet pipe 4^a, to an evaporator 5, from which the return pipe 6 leads back to the compressor; for economy of heat the return pipe is coiled about the expansion valve to cool the liquid refrigerant therein. The expansion valve is merely a chamber containing a float which controls the outlet, at the bottom, to the evaporator. The evaporator 5 consists of one or more plate-form chambers of extended area placed inside of one or more receptacles 7, which latter contain a medium adapted to be frozen and when frozen, to keep the food or storage compartment 8 at the low temperature desired during intervals between the operation of the compressor.

The receptacles 7 may serve as the lining of the box or storage space 8 and the latter is of course adequately insulated from the surrounding temperature, as indicated by the dotted lines in Fig. 1, but the particular disposition of said receptacle and the freezing medium in it will presently be seen to be susceptible of application to refrigerator ap-

paratus in many different ways. The system above referred to, and constructed in accordance with the present invention, may be controlled by hand or automatically, and is preferably automatic, and for this purpose a thermostat such as represented by 9-18 can be associated with the receptacle 7 so as to be subject to the temperature thereof, or a like temperature, and controls, through appropriate electrical connections, the power circuit of the motor, so that the compressor is set in action whenever the temperature of the medium in the receptacle 7 rises above some pre-determined point, and vice versa. The detail of this thermostat forms the subject of a copending application.

The freezing medium in the receptacle 7 is compounded with reference to the constant temperature which it is desired to maintain in the storage compartment. It may consist of an aqueous salt solution, the eutectic freezing point of which approximates that temperature. As is well known, the solution of a salt in water freezes at a lower temperature than the water alone and, within limits, the more salt that is added, the lower in general becomes the temperature of freezing. If a salt solution, of less than saturation strength, be subjected to a decreasing temperature, the effect is first to freeze out some of the water in the form of pure ice crystals, and correspondingly concentrate the remaining liquid until it becomes a saturated solution at a particular temperature. If this particular temperature is not low enough to freeze such a saturated solution, further depression of the temperature will cause a precipitation of some of the salt until a temperature is reached at which the solution, still saturated, freezes, producing a conglomerate mass of mixed crystals closely interwoven. The temperature at which this occurs is termed the eutectic freezing point of the mixture of the salt and water, and is different for different salts. The solid or frozen product is termed the cryohydrate. In accordance with this invention, the salt employed for the freezing medium of receptacle 7 is selected with reference to its eutectic point, so that the latter shall approximate the constant temperature

which it is desired to maintain or two or more such salts are employed in the freezing medium to provide such temperature, as later explained. When the cryohydrate of such a mixture or solution is used for refrigerating purposes, as in the receptacles 7, the temperature thereof does not increase above the eutectic point until it is nearly all converted back to liquid form, this being recognized, of course, as the effect of the latent heat of fusion of the cryohydrate. It will be seen, therefore, that if the freezing medium in the receptacle 7 be frozen, it will maintain the storage space at a corresponding low temperature, which may be well under 32° F. for a long period of time, variable, of course, with the rate of leakage and the heat absorbed from such articles as may be on storage and even if the cryohydrate is completely melted, the cold solution will continue to have a refrigerating effect, superior to ordinary ice-boxes, until its temperature rises to 32° F. If the solution should be of sodium chlorid the eutectic temperature would be about -6° F.; if potassium chlorid, about 12½° F.; if sodium carbonate about 22° F. The eutectic points of other salts are known and they may be used according to this invention in so far as they are not injurious to the receptacle and are sufficiently inexpensive to be commercially available.

In order that the receptacle may be well filled with the cryohydrate of the particular solution employed, the solution is made of such strength that it will be saturated at 32° F. This avoids the preliminary production of the ice crystals above referred to during the cooling period and enables the space which they would occupy to be occupied by the more effective cryohydrate. It is satisfactory to prepare the solution saturated at normal or room temperature; it will then be saturated at 32° F.

In the practical use of such a solution wherein it is repeatedly converted from solid to liquid state, the amount of cryohydrate produced on each successive operation tends to become smaller and smaller and the duration of the low temperature period maintained thereby tends to become correspondingly shorter and the efficiency of the system as a whole correspondingly impaired. I have ascertained the cause of this tendency to arise from the fact that during the lowering of the temperature of a saturated solution to its freezing point, some of the salt is cooled out of it, following the law that the strength of saturation is inverse to the temperature of the solution. The eliminated salt tends to precipitate and collect in the bottom of the receptacle and on any subsequent rise of the temperature of the solution is not in a position to go back into solution automatically, except perhaps locally or near the bottom of the receptacle. The solution, being

thus robbed of some of its salt, is thus no longer saturated on a rising temperature but as it may still be below 32° F. the excess water at once freezes, forming ice crystals just to the extent necessary to restore saturation strength at the particular temperature. Such ice crystals are produced in increasing quantity as the temperature rises back to 32° F. and, unless preventive measures are taken, the repeated warming and cooling of the receptacle 7 produces larger and larger quantities of clear ice therein, and more and more precipitated salt, eventually destroying the efficiency of the system for maintaining constant low temperature in the storage compartment.

The appropriate remedy for this condition consists either in preventing the isolation of the salt eliminated on cooling or in the provision of means for redissolving it in the solution as the temperature rises, so as to keep the solution saturated at all times. A slight agitation of the solution will suffice for restoring it to solution and can be accomplished by the use of any common type of agitating means, such as a small impeller or the like, or even by so forming the receptacle as to produce slow currents therein by difference of temperature between different parts of the receptacle, all of which measures are to be understood as included in this invention. I prefer, however, to accomplish the same ultimate result by preventing the precipitation or elimination of the salt in the first instance, as by providing a suitable support for it, so that, on the next warming, it will be well distributed throughout the mass of the solution and thus be retained in position where it can be automatically taken up by the solution to restore it to saturation progressively as the temperature increases. Certain sponge-like materials or fillers are available for this purpose, for example sawdust, which can be filled into the receptacle 7 so as to fill it more or less completely, thus providing an infinite number of surfaces on which the eliminated salt may rest until again taken up for restoring the saturation strength. Also if the solution be thickened so as to be buoyant to such eliminated salt, the same effect will obviously be produced. The addition of starch to the solution so as to give it a somewhat jelly-like consistency has produced excellent results without apparent effect on the refrigerating function. Other colloids will produce like results, enabling the freezing medium to be frozen and thawed for an indefinite number of times without diminution of the amount of cryohydrate thereafter formed, or otherwise impairing the function of the system in maintaining constant low temperatures over long periods of time.

For certain commercial purposes it is desired to maintain the temperature at a particular point without substantial variation;

for instance, in ice-cream storage cabinets a temperature of about 5° is commonly required, but I have been unable to find any solution of a single salt available within commercial limits; and otherwise satisfactory,

5 which has a eutectic freezing point corresponding to this temperature. However, I have ascertained that such temperature, or any desired temperature, may be maintained
10 by employing a solution of two or more salts having different eutectic points. By a proper selection of such salts and of their relative amounts it is possible to produce a mixture of which the eutectic point is as
15 desired, and different from that of either salt in single solution. For example, I have found that normal sodium carbonate in saturated solution has a freezing temperature of about 28° F. and in melting will hold the
20 temperature in general below 29. By introducing enough sodium carbonate to a saturated potassium chlorid solution, which freezes at about 12½° F., I have obtained a constant freezing temperature of about 8°
25 with a melting temperature of between 8 and 10° F. By adding a proper portion of sodium bicarbonate to this double solution a constant freezing temperature of 5° F. is obtained. The preferred freezing medium is produced,
30 in accordance with this principle, by dissolving in 160 pounds of water, 50 pounds of potassium chlorid, 22 pounds of sodium carbonate and 13 pounds of sodium bicarbonate. This is a solution which is saturated
35 at 32° F. The colloid added to this solution for the purpose of suspending or preventing precipitation of the eliminated salt is added in the form of starch, about two pounds, such
40 starch having first been brought to the boiling point in a separated portion of the solution and then mixed with the remainder.

This mixture is filled into the receptacle or receptacles 7 leaving enough air space at the top to accommodate the expansion.
45 When the compressor motor is started the solution temperature is reduced to its eutectic temperature and freezes solid. The thermostat then shuts off the motor and the storage space 8 will thereafter be maintained at a
50 low temperature corresponding to the eutectic of that particular solution. This temperature continues substantially constant until the cryohydrate is mostly melted, at which time the thermostat calls the motor
55 again into action and the solution is refrozen and so on. The intervals between motor operation may be several days, in practice, depending on the temperature of the stored material and indefinite repetitions of the
60 cycle have no effect on the efficiency or the length of the interval between motor operations. Thermostatic control is not necessary, except as a labor-saving convenience because the motor operations are normally so infrequent
65 that they can be personally attended

to whenever an inspection of the solution in the receptacle, as by tapping the side wall thereof, indicates that to be necessary.

The long interval between motor operations is the result of the saturated condition
70 of the freezing medium at normal temperature or at least at 32° F. and of keeping it up to its proper strength during any rise of temperature, thus preventing objectionable accumulation of ice crystals and always
75 insuring the maximum amount of cryohydrate for a given size of refrigerator compartment, this last consideration being of particular importance in household refrigerators and ice-cream cabinets where space
80 limitations are exacting.

As indicated in Figs. 2 to 6 the receptacle 7 which contains the freezing medium is thin in proportion to its height and length,
85 being about 2¼ inches thick, and is made of sheet metal folded and flange-jointed as indicated in Fig. 3; its joints are sufficiently strong if united by solder. The evaporator 5 is also made of sheet metal. It consists of a horizontal gas header 10 with a hollow, plate-
90 form extension depending from its under side and constituting the evaporator body. When assembled in the receptacle 7, the plate-form evaporator occupies the central
95 plane thereof so that the freezing is from that plane outwards, and the header 10, which is wider than the body, forms the top closure for the receptacle 7 being united
100 thereto in any suitable way, with a gasket 11 intervening, to prevent escape of the eutectic mixture if the device should be tipped over. The inlet and outlet pipes are connected to the header 10, at the end or side as
105 preferred. To keep the thin evaporator body steady in the receptacle, the side walls of the latter are provided with opposed inward projections 12, these being preferably formed by indenting each sheet metal side wall with a vertical rib or bead as shown; obviously the
110 same support could be provided in other ways. As thus constructed the combined evaporator 5 and the container 7 constitute a unit which can be adapted to refrigerators or ice-cream cabinets in various ways being
115 treated in all respects as though it were merely a section of lining for the storage compartment, and in the case of existing apparatus, built for the use of a packing of ice and salt, as customary, these units can take
120 the place of such packing and occupy the same space. Thus for an ice-cream cabinet intended for a single row of ice-cream cans as shown at 13 in Fig. 7, the units are placed
125 along the side walls, each being connected in the refrigerant circuit in multiple relation as indicated, and for cabinets accommodating double rows of ice-cream cans they are placed crosswise as indicated in Fig. 8, and connected as before. In both cases, the units occupy the space originally designed for the

ice-salt packing, but when frozen maintain the proper temperature for a much longer time.

The constructional detail of the evaporator is of course subject to variation but this invention includes its formation out of two closely parallel metal walls spaced apart about $\frac{1}{4}$ inch and brought together at their edges and united by welding, forming a marginal seam as indicated at 14. These walls are kept parallel by forming one of them with a series of indentations 15 and spot welding the bottoms of the latter to the opposite wall, thus tying the two walls together over the whole side of the evaporator body and thereby adapting the device to be made of much lighter gauge stock and hence thinner, than would otherwise be practical.

As shown by Fig. 4, the header 10 is not required to be of the same length as the evaporator body and it is preferably somewhat shorter, which provides a space or shoulder on the unit for the introduction of the bulb-member 18 of the thermostat 9. For this purpose the walls of the evaporator body are spread apart at one end, and within the solution receptacle, (Fig. 6) to accommodate a tapered tube 16 which is welded at its top and bottom or otherwise fastened to the evaporator walls, so that the refrigerant will surround it on all sides and so that the tapered bulb member 18 of the thermostat can be inserted into it from one end. This enlarged part of the evaporator body is enclosed in the receptacle 7, the top closure plate 17 of the latter being apertured in registry with the top of the tapered tube to accommodate the insertion of the thermostat bulb, from the outside of the receptacle. For those units in which the thermostat is not required, the thermostat enlargement is omitted and the evaporator body may be of uniform thickness from end to end as indicated in dotted lines in Fig. 7. The thermostat bulb 18 contains the same eutectic solution as the receptacle 7 and thus freezes and thaws with it. Its expansion on freezing develops pressure which is transmitted by a tube 9 to the motor switch mechanism 19 which opens the motor circuit when freezing has taken place and opens it before the cryohydrate has completely or substantially disappeared. Constancy of temperature requires in practice that the motor be started when the cryohydrate is at least 90% melted but for safety's sake it is customary to set the thermostat for even earlier operation, and thus maintain a steady temperature indefinitely.

The following is claimed:

1. The process of refrigeration which includes repeatedly freezing a saturated salt solution while maintaining precipitated salt in a suspended condition in the liquid.
2. In a refrigerating system, the combina-

tion with a refrigerant circuit including an evaporator, a receptacle containing a solution, saturated at 32° F. adapted to be frozen by said evaporator, means for maintaining said solution in a saturated condition at varying solution temperatures less than 32° F. and thermostatic means for controlling the operation of said refrigerant circuit.

3. In a refrigerating system, a unit-type freezing receptacle having a height and length both several times the thickness or width of the receptacle whereby said receptacle is adapted for introduction into an ice cream cabinet in the place intended for the ice and salt mixture, a thin plate-like evaporator mounted within said receptacle, substantially co-extensive with the height and length thereof and located midway between the side walls thereof, said evaporator having a header disposed along the outer edge of the receptacle and the evaporator and substantially equal in width to the width of said receptacle, and a freezing mixture occupying the space in said receptacle on opposite sides of said thin evaporator.

4. In a refrigerating system, the combination of a refrigerant means, a container holding a salt solution, saturated at 32° F., and adapted to be frozen by said means and also holding means to maintain precipitated salt in distributed condition in the liquid.

5. The process of refrigerating a chamber which comprises associating with said chamber a body of salt solution saturated when in operation, periodically depressing the temperature of said solution to or below its eutectic freezing point, allowing it to refrigerate said chamber in the intervals between the depressions and coincidently maintaining precipitated salt particles in distributed relation throughout the solution.

6. The process of refrigerating a chamber which comprises periodically depressing the temperature of a saturated salt solution containing a colloid to or below its eutectic freezing point, and causing the frozen mass to refrigerate the chamber during the intervals between the depressions, said colloid being present in amount sufficient to prevent settlement of precipitated salt.

7. The process of refrigerating a chamber which comprises periodically depressing the temperature of a saturated salt solution containing starch to or below its eutectic freezing point and utilizing the frozen mass to refrigerate said chamber, in the intervals between depressions, said starch being adapted to maintain precipitated salt in suspended condition in the solution.

8. The combination of a chamber to be refrigerated, a refrigerant system adapted for periodic operation, a body of saturated salt solution adapted to be repeatedly frozen by said system and serving to refrigerate said chamber in the intervals between operations

of said refrigerant system said solution having a eutectic freezing point corresponding to the temperature at which it is desired to keep said chamber and having means to maintain precipitated salt particles in distributed relation in said solution.

9. The combination of a chamber to be refrigerated, a refrigerant system, thermally controlled means for periodically operating said system, a body of saturated salt solution repeatedly frozen to or below its eutectic freezing point by said system and associated with said chamber to refrigerate the same in the intervals between the operations of said system, and means for suspending precipitated salt particles in the solution, thereby maintaining the strength of the solution after repeated thawings.

In testimony whereof, I have signed this specification.

JAY G. DE REMER.