

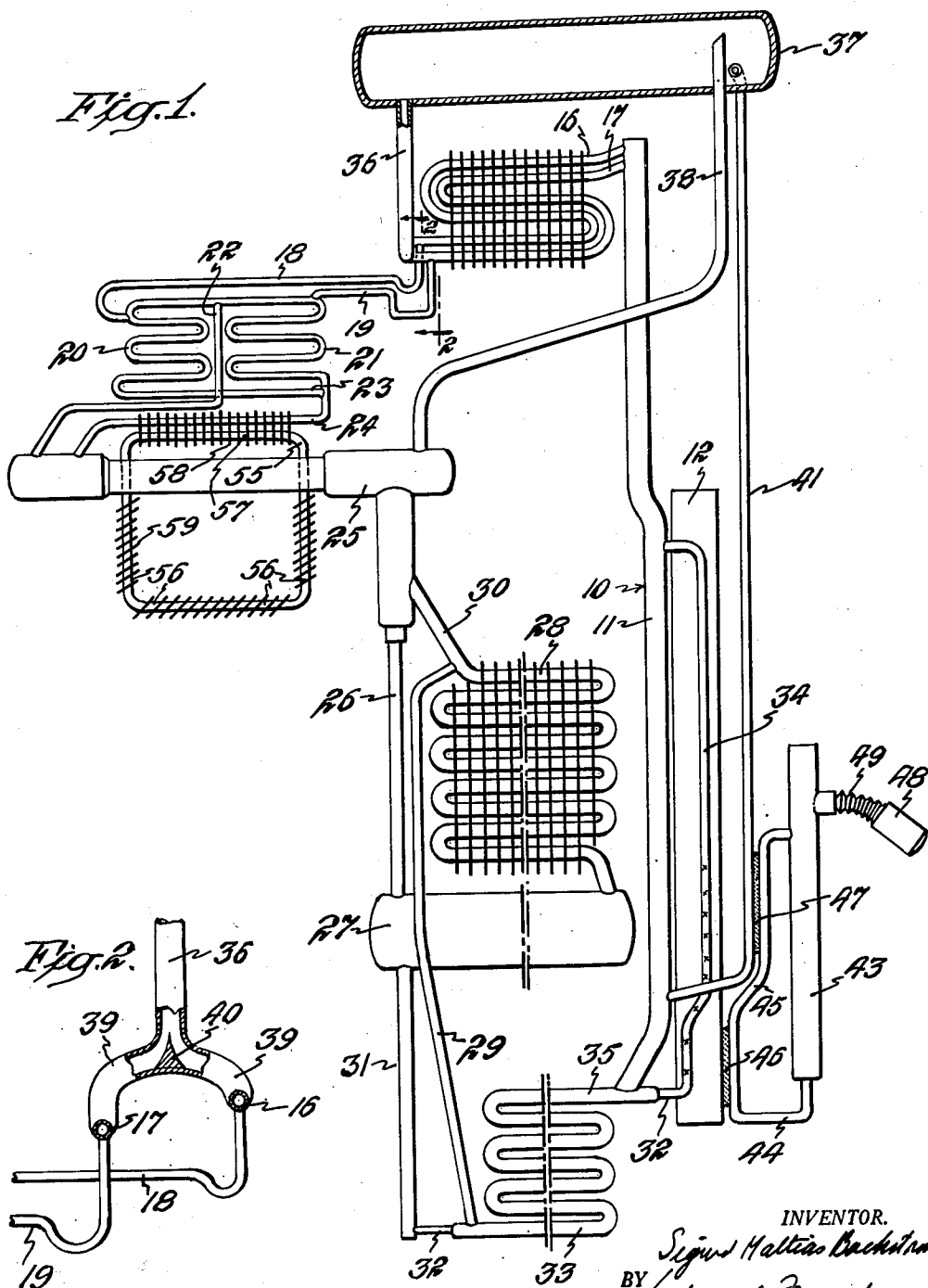
March 17, 1953

S. M. BACKSTROM
ABSORPTION REFRIGERATION

2,631,443

Filed Feb. 26, 1949

2 SHEETS—SHEET 1



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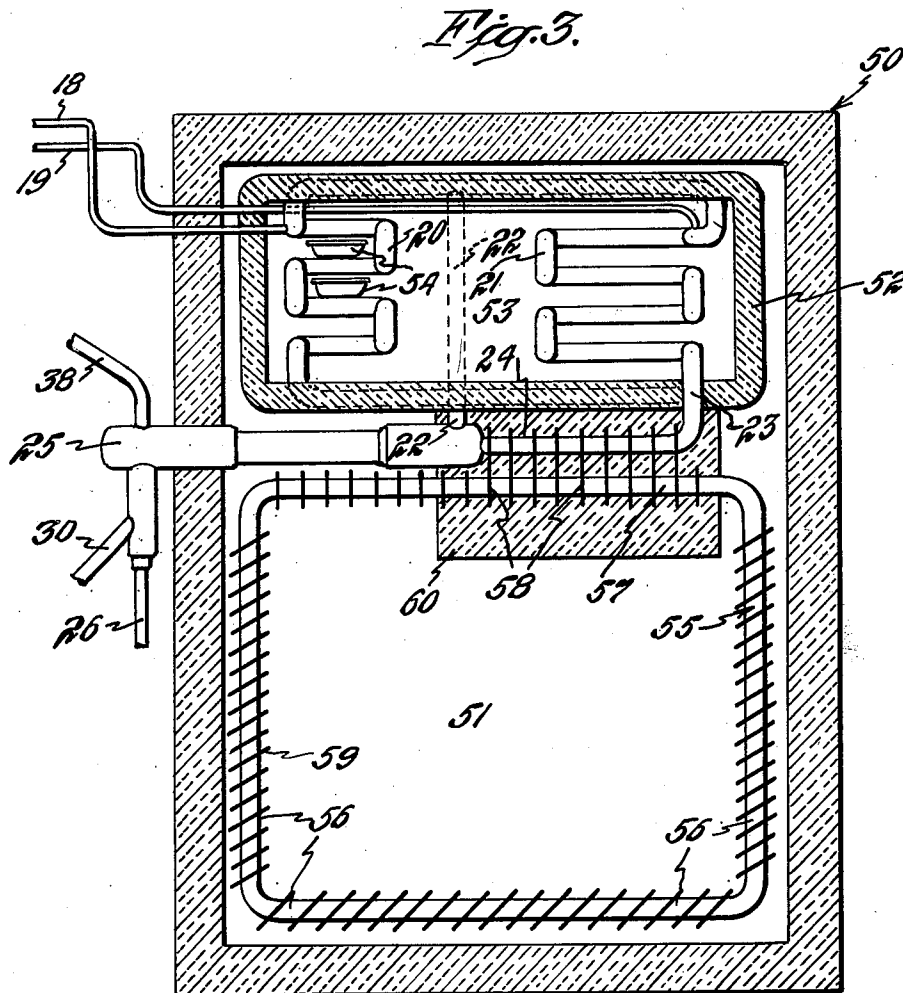
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2 SHEETS—SHEET 2



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UNITED STATES PATENT OFFICE

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ABSORPTION REFRIGERATION

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My invention relates to refrigeration, and more particularly concerns producing refrigeration at a plurality of temperatures in several thermally separated storage compartments of a refrigerator.

It is an object of my invention to provide an improvement for cooling several thermally segregated compartments of a refrigerator whereby food products may be maintained at a safe refrigerating temperature in one compartment while heat is being supplied to a low temperature cooling element arranged to cool another compartment to melt frost which tends to form and accumulate on such low temperature cooling element.

Another object of my invention is to provide an improved refrigerator in which an absorption refrigeration system having one or more cooling elements is employed for maintaining a freezing section at a desired low temperature, and utilizing such refrigeration system to effect cooling of a thermally segregated space with the aid of a secondary heat transfer system in such manner that, when heat is supplied to the cooling element or elements of the freezing section to melt frost which may form thereon, substantially no heat is supplied to the evaporation portion of the secondary heat transfer system arranged to abstract heat from such other space.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the claims. The invention, both as to organization and method, together with the above and other objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawings forming a part of this specification, and of which Fig. 1 more or less diagrammatically illustrates an absorption refrigeration system embodying the invention; Fig. 2 is an enlarged fragmentary sectional view taken at line 2—2 of Fig. 1; and Fig. 3 is a vertical sectional view of a refrigerator cabinet schematically illustrating one manner in which parts of the refrigeration system of Fig. 1 may be incorporated therein in accord with the invention.

In Fig. 1 I have shown my invention in connection with an absorption refrigeration system of a uniform pressure type which is well known in the art and in which an inert pressure equalizing gas is employed. Such a refrigeration system comprises a generator or vapor expulsion unit 10 including a boiler or pipe 11 containing a refrigerant, such as ammonia, in a body of

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absorption liquid, such as water. Heat is supplied to the boiler 11 from a heating tube or flue 12 thermally connected therewith, as by welding, for example. The heating tube 12 may be heated in any suitable manner, as by an electrical heating element disposed within the lower part of the tube 12 or by a liquid or gaseous fuel burner which is adapted to project its flame into the lower heat input end of the tube.

The heat supplied to the boiler 11 and its contents expels refrigerant vapor out of solution and such vapor passes upwardly from the vapor expulsion unit 10 into air cooled condensers 16 and 17 in which it is condensed and liquefied. Liquid refrigerant flows from condensers 16 and 17 through conduits 18 and 19 into cooling elements or evaporators 20 and 21, respectively, in which it evaporates and diffuses into an inert pressure equalizing gas, such as hydrogen, which enters through a conduit 22. Due to evaporation of refrigerant fluid into inert gas, a refrigerating effect is produced by cooling elements 20 and 21 with consequent absorption of heat from the surroundings.

The rich gas mixture of refrigerant vapor and inert gas formed in cooling elements 20 and 21 merge or come together at 23 and flows through a conduit 24, one passage of a gas heat exchanger 25, conduit 26 and absorber vessel 27 into the lower end of an absorber coil 28. In absorber coil 28 the rich gas mixture flows counter-current to downwardly flowing absorption liquid which enters through a conduit 29. The absorption liquid absorbs refrigerant vapor from inert gas, and inert gas weak in refrigerant flows from absorber coil 28 in a path of flow including conduit 30, another passage of gas heat exchanger 25 and conduit 22 into the upper parts of the cooling elements 20 and 21.

Absorption solution enriched in refrigerant flows from the absorber vessel 27 through a conduit 31 and an inner passage 32 of a liquid heat exchanger 33 into the lower end of a lift tube or pump pipe 34. The pump pipe 34 is in thermal exchange relation with the heating tube 12, as by welding, for example, and liquid is raised therethrough by vapor-liquid lift action to the upper part of the boiler 11. The vapor expelled out of solution in boiler 11, together with vapor entering the latter from the pump pipe 34, flows upwardly from the vapor expulsion unit 10 to the condensers 16 and 17, as previously explained. The absorption liquid from which refrigerant has been expelled flows from the boiler 11 through the outer passage 35 of the liquid heat

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exchanger 33 and conduit 29 into the upper part of the absorber coil 28.

The outlet ends of the condensers 16 and 17 are connected by a conduit 36, vessel 37 and conduit 38 to a part of the gas circuit, as at one end of gas heat exchanger 25, for example, so that any inert gas which may pass through the condensers 16 and 17 can flow into the gas circuit. Refrigerant vapor not liquefied in the condensers flows through conduit 36 to displace inert gas in vessel 37 and force such gas through conduit 38 into the gas circuit. The effect of forcing gas into the gas circuit in this manner is to raise the total pressure in the entire system whereby an adequate condensing pressure is obtained to insure condensation of refrigerant vapor in condensers 16 and 17.

The vessel 37 in effect serves as an extension of the air cooled condensers 16 and 17. Refrigerant condensed in the vessel 37 flows therefrom through conduit 36 at the lower end of which a liquid divider may be provided in any suitable manner. As shown in Fig. 2, the lower end of conduit 36 may be formed with branches or arms 39 at the upper ends of which a baffle or divider 40 is disposed to divide any liquid flowing downwardly in conduit 36 into two streams, one of which is conducted through conduit 18 to cooling element 20 and the other through conduit 19 to the cooling element 21.

In order to increase the temperature of cooling elements 20 and 21 when it is desired to melt frost which may accumulate thereon, provision is made for raising warm absorption solution from the boiler 11 through a riser conduit 41 into the vessel 37. The raised warm absorption solution flows from vessel 37 through conduit 36, such solution being divided into two streams at the lower end of conduit 36 and passing into the cooling elements 20 and 21. In this manner rapid defrosting is effected due to the relatively high temperature to which the solution is heated in the vapor expulsion unit 10. The absorption solution passes from the cooling elements through conduit 24 and gas heat exchanger 25 to the absorber vessel 27.

The riser conduit 41 constitutes a vapor lift tube or pump pipe through which absorption solution is raised when desired by heat derived from the heating flue 12 with the aid of a controllable secondary heat transfer system. As shown in Fig. 1, such a system may include a vertical conduit 43 and a U-tube 44 having one arm connected to the lower end of conduit 43 and the other longer arm 45 in thermal relation with the heating tube 12 at 46. The upper part of the arm 45 is also in thermal relation with the riser conduit 41 at 47, and the extreme upper end thereof is connected to the upper part of conduit 43. A bulb 48 is flexibly connected at 49 to the upper end of the conduit 43.

The heat transfer system is hermetically sealed and is charged with a volatile fluid substantially all of which is held in the bulb 48 when the latter is in the position shown in Fig. 1. When it is desired to effect defrosting of the cooling elements 20 and 21, the bulb 48 is raised from the position shown, so that fluid will flow therefrom by gravity to the U-tube 44. The longer arm 45 of the U-tube 44 constitutes the vaporization portion of the heat transfer system in which fluid is vaporized by heat taken up from the heating tube 12. The vapor formed in this manner is partly condensed in the arm 45 and gives up heat to the conduit 41 and its contents to raise absorption

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solution by vapor lift action from the boiler 11 to the vessel 37. Such lifting of absorption solution continues until all of the vapor is condensed in the bulb 48 which previously has been returned to its lower position shown in Fig. 1. In this way substantially all of the volatile fluid is held back from the lower vaporization portion of arm 45, and heat transfer to the conduit 41 is reduced to terminate raising of solution therein.

In Fig. 3 is shown a refrigerator comprising a cabinet 50 having thermally insulated walls defining a storage space 51. In the upper part of space 51 is provided a freezing section comprising a shell 52 having thermally insulated walls defining a chamber 53 within which the cooling elements 20 and 21 of the refrigeration system of Fig. 1 are disposed. Although not shown, it is to be understood that closure members or doors are provided to close an access opening of the space 51 and a similar access opening of the chamber 53.

One of the cooling elements 20 may be employed for ice freezing and provided with suitable supporting surfaces upon which ice trays 54 can be positioned. The other cooling element may be employed primarily to cool the freezing chamber 53 in which frozen foods, meat and other matter may be stored. Hence, it is desirable to insulate the chamber 53 effectively from the storage space 51.

The parts of the refrigeration system shown in Fig. 2 are similar to those illustrated in Fig. 1, like parts being indicated by the same reference numerals. In the operation of the refrigerator of Fig. 2, liquid refrigerant is conducted to the upper parts of cooling elements 20 and 21 through conduits 18 and 19, respectively, as previously explained in describing the refrigeration system of Fig. 1. Inert gas weak in refrigerant flows from the absorber through conduit 30, one passage of gas heat exchanger 25 and conduit 22 whose upper end communicates with the upper ends of cooling elements 20 and 21. Refrigerant evaporates and diffuses into inert gas in the cooling elements 20 and 21, and such gas mixture from the cooling elements 20 and 21 merge at 23. All of the gas mixture then flows through the conduit 24, one passage of the gas heat exchanger 25 and conduit 26 to the absorber. Any unevaporated refrigerant also flows from the cooling elements 20 and 21 and meet at 23 from which region all of the refrigerant flows through conduit 24 and gas heat exchanger 25 and eventually finds its way to the absorber vessel.

In accordance with my invention the absorption refrigeration system having the cooling elements 20 and 21 is advantageously employed to effect cooling of storage space 51 with the aid of a secondary heat transfer system 55 which is so arranged that, when heat is supplied to the cooling elements 20 and 21 to melt frost accumulated thereon, substantially no heat is supplied to the evaporation portion of the secondary heat transfer system which is arranged to abstract heat from the storage space 51.

The secondary heat transfer system 55 includes an evaporation or vaporization portion 56 in the form of piping which desirably is distributed throughout the storage space 51 so that it will effectively take up heat from air in such space. The vaporization portion 56 is connected to a condensation portion 57 which is arranged in thermal exchange relation with the conduit 24, as by a plurality of heat transfer plates or fins 58, for example. The heat transfer system 55 is her-

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metically sealed and is partly filled with a suitable volatile fluid or heat transfer agent having a relatively low boiling temperature. In certain instances the heat transfer system 55 may also be charged with a suitable quantity of inert gas in addition to the volatile heat transfer fluid.

During operation of the refrigerator the volatile fluid evaporates in the lower part of the vaporization portion 56 and also partly in the vertically extending parts thereof, thereby taking up heat from air in the storage space 51. To promote such taking up of heat from the storage space 51, the vaporization portion 56 desirably is provided with heat absorbing members 59 to provide a relatively extensive heat transfer surface. The vapor flows from the vaporization portion 56 to the condensation portion 57 in which the vapor is condensed and liquefied, such condensate then returning by gravity to the vaporization portion 56.

The heat of condensation resulting from condensation of vapor in the condensation portion is given up to fluid flowing through the conduit 24. Since the gas mixture formed in the cooling elements 20 and 21 and passing through the conduit 24 is relatively cold, such gas mixture can be effectively utilized to take up the heat of condensation resulting from condensation of vapor in the condensation portion 57 of the secondary heat transfer system. When unevaporated refrigerant from the cooling elements 20 and 21 flows through the conduit 24, the latter in effect acts as an auxiliary cooling element in which refrigerant evaporates and diffuses into inert gas, thereby effectively taking up heat of condensation liberated by the secondary heat transfer system.

It will now be understood that the refrigeration system of which the cooling elements 20 and 21 form a part is employed to cool storage space 51 with the aid of the secondary heat transfer system 55. With such arrangement the storage space 51 is maintained at a useful refrigerating temperature which, however, is higher than that at which the freezing chamber 53 is maintained by the cooling elements 20 and 21.

The conduit 24, condensation portion 57 of the secondary heat transfer system 55 and heat transfer plates 58 thermally connecting these parts essentially constitute a heat exchanger. In order to obtain efficient operation of such heat exchanger and take full advantage of conduit 24 and the fluids flowing therethrough to take up heat of condensation, the conduit 24, condensation portion 57 and plates 58 desirably are embedded in a body of suitable insulating material, as indicated at 60 in Fig. 3.

During defrosting periods warm absorption solution is supplied to cooling elements 20 and 21 to melt frost thereon, as previously explained. Such absorption solution passes from cooling elements 20 and 21 through conduit 24 and gas heat exchanger 25 and eventually finds its way to the absorber vessel. Under such conditions the temperature of conduit 24 rises sufficiently so that condensation of vapor can no longer take place in the condensation portion of the secondary heat transfer system. When this occurs the natural circulation of volatile fluid in the heat transfer system 55 stops, and heat temporarily is not abstracted from the storage space 51. Under these conditions the body of insulation disposed about the conduit 24 thermally shields the latter from the storage space 51, so that the increase in temperature in the space 51 due to flow of absorption solution through the conduit 24 is negligible and

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only dependent upon the extent of heat leakage through the insulation 60. Although not shown, it is also advantageous for the reasons just given to embed the gas heat exchanger 25 in suitable insulation when the latter is located in the storage space 51, as illustrated in Fig. 3.

In view of the foregoing, it will now be understood that when heat is supplied to cooling elements 20 and 21 to effect defrosting, no heat to any appreciable extent is supplied to the vaporization portion 56 employed to effect cooling of the higher temperature storage space 51. Since frost only forms and accumulates on the low temperature cooling elements employed for freezing purposes, and substantially no frost forms in a higher temperature cooling space like the space 51 in Fig. 3 by reason of the relatively extensive heat transfer surface provided to abstract heat therefrom, it is of distinct advantage to supply defrosting heat only to the cooling element or elements upon which frost tends to form and accumulate, thereby making it possible to continue to store food and other matter at a safe refrigerating temperature in the higher temperature storage space in which frost normally does not form and accumulate.

Modifications of the embodiment of my invention which I have described will occur to those skilled in the art, so that I desire my invention not to be limited to the particular arrangement set forth. For example, provision may be made to supply a heating fluid other than warm absorption solution to the cooling element or elements upon which frost tends to form. Thus, refrigerant vapor flowing from the generator unit may be arranged to pass directly into one or more cooling elements in a heated state to effect defrosting. Also, the inner liner defining the space with which the secondary heat transfer system is associated may be double-walled to provide a space therebetween which can be employed as the vaporization portion of the secondary heat transfer system, thereby avoiding the necessity of providing a vaporization portion formed of tubing or piping. Therefore, I intend in the claims to cover all those modifications which do not depart from the spirit and scope of my invention.

What is claimed is:

1. In a refrigerator comprising a cabinet having segregated compartments, an absorption refrigeration system including an absorption solution circuit and a gas circuit comprising an absorber and one or more cooling elements in which refrigerant fluid evaporates in the presence of an inert gas and conduit means for conducting inert gas enriched in refrigerant from the latter to said absorber, at least one of said cooling elements being arranged to abstract heat from one of said compartments which is employed for freezing purposes and may cause formation of frost due to the refrigerating effect produced thereby, a system for heat transfer fluid having a vaporization portion arranged to abstract heat from another of said compartments and a heat rejecting portion in heat conductive relation with said conduit means, said refrigeration system including means for supplying warm absorption solution to said one cooling element which is operable to cause melting of any frost which may be formed, said conduit means serving to conduct such absorption solution from said one cooling element to said absorption solution circuit, and said conduit means at the region said heat rejecting portion is in heat conductive relation therewith being thermally segregated from

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said other compartment, said heat conductive relation being so constructed and formed that any increase in temperature of said other compartment resulting from flow of absorption solution through said conduit means is substantially negligible.

2. A refrigerator as set forth in claim 1 in which said heat rejecting portion is in heat conductive relation with a portion of said conduit means disposed in said other compartment.

3. A method of refrigeration which includes evaporating a first refrigerant fluid in the presence of an inert gas in one or more places of vaporization thermally segregated from the surroundings to produce refrigeration which may cause the formation of frost, flowing relatively cool inert gas enriched in refrigerant from the first-mentioned place or places of vaporization in a path of flow to a region removed therefrom which is at a lower level and serves as an auxiliary place of vaporization, flowing excess unevaporated refrigerant by gravity in such path of flow to said auxiliary place of vaporization from the first-mentioned place or places of vaporization, flowing inert gas enriched in refrigerant from the auxiliary place of vaporization to a place of absorption, evaporating a second refrigerant fluid in a place of vaporization thermally segregated from the surroundings and also segregated from said first-mentioned place or places of vaporization to produce refrigeration substantially free of frost formation, condensing the second vaporized fluid at a place of condensation in thermal relation with said region and returning condensate therefrom to said place of vaporization for second refrigerant fluid, intermittently effecting rapid heating of said place or places of vaporization for first refrigerant fluid by a medium at a temperature level above the ambient temperature of the surroundings to cause melting of any frost which may have been formed, the temperature of said place of vaporization for second refrigerant fluid being substantially unaffected by heated fluid received by said region or auxiliary place of vaporization from said place or places of vaporization for first refrigerant fluid when heating of the latter is effected, and thermally segregating said place of condensation and region in thermal relation therewith from the surroundings and from said place of vaporization for second refrigerant fluid.

4. A method of refrigeration which includes evaporating a first refrigerant fluid in the presence of an inert gas in one or more places of vaporization thermally segregated from the surroundings to produce refrigeration which may cause the formation of frost, flowing relatively cool inert gas enriched in refrigerant from the first-mentioned place or places of vaporization in a path of flow to a region removed therefrom which is at a lower level and serves as an auxiliary place of vaporization, flowing excess unevaporated refrigerant by gravity in such path of flow to said auxiliary place of vaporization from the first-mentioned place or places of vaporization, flowing inert gas enriched in refrigerant from the auxiliary place of vaporization to a place of absorption, evaporating a second refrigerant fluid in a place of vaporization thermally segregated from the surroundings and also segregated from said first-mentioned place or places of vaporization to produce refrigeration substantially free of frost formation, condensing the second vaporized fluid at a place of condensation in thermal relation with said region and returning

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condensate therefrom to said place of vaporization for second refrigerant fluid, intermittently supplying a heated fluid to said place or places of vaporization for first refrigerant fluid to effect rapid heating of the latter and cause melting of any frost which may have been formed, the temperature of said place of vaporization for second refrigerant fluid being substantially unaffected by any heated fluid received by said region or auxiliary place of vaporization from said place or places of vaporization for first refrigerant fluid when heating of the latter is effected, and thermally segregating said place of condensation and region in thermal relation therewith from the surroundings and from said place of vaporization for second refrigerant fluid.

5. In a refrigerator comprising a cabinet having segregated compartments, an absorption refrigeration system comprising a circuit for inert gas including one or more cooling elements in which refrigerant fluid evaporates in the presence of an inert gas and an absorber, at least one of said cooling elements being arranged to abstract heat from one of said compartments which serves as a freezer and may cause formation of frost due to the refrigerating effect produced thereby, conduit means for conducting inert gas enriched in refrigerant from said one or more cooling elements to said absorber, said conduit means including a conduit section intermediate said absorber and freezer into which enriched inert gas flows after leaving said one or more cooling elements, said conduit section being below said freezer and into which unevaporated refrigerant passes by gravity from said one or more cooling elements, heating means operable to provide at said one cooling element, at a region removed from said conduit section, a medium which is at a temperature level above the ambient temperature of the surroundings for rapidly heating said one cooling element to cause melting of any frost which may be formed, and a system for heat transfer fluid having a vaporization portion at one level arranged to abstract heat from another of said compartments and a heat rejecting portion at a higher level in heat conductive relation with said conduit section, and means for thermally insulating said condensation portion and at least the part of said conduit section in heat conductive relation therewith.

6. In a refrigerator comprising a cabinet having segregated compartments, an absorption refrigeration system including a gas circuit comprising an absorber and one or more cooling elements in which refrigerant fluid evaporates in the presence of an inert gas, at least one of said cooling elements being arranged to abstract heat from one of said compartments which is employed for freezing purposes and may cause formation of frost due to the refrigerating effect produced thereby, conduit means for conducting inert gas enriched in refrigerant from said one or more cooling elements to said absorber and into which unevaporated refrigerant passes by gravity from said cooling element or elements, and a system for heat transfer fluid having a vaporization portion arranged at one level to abstract heat from another of said compartments and a heat rejecting portion at a higher level in heat conductive relation with said conduit means, said refrigeration system including a connection for conducting a heated fluid to said one cooling element which is operable to cause melting of any frost which may be formed, means for controlling flow of such heated fluid through

such connection, and means including insulation enveloping said condensation portion and at least the part of said conduit means in heat conductive relation therewith.

7. In a refrigerator comprising a cabinet having segregated compartments, an absorption refrigeration system including a gas circuit comprising an absorber and one or more cooling elements in which refrigerant fluid evaporates in the presence of an inert gas and conduit means for conducting inert gas enriched in refrigerant from the latter to said absorber, at least one of said cooling elements being arranged to abstract heat from one of said compartments which is employed for freezing purposes and may cause formation of frost due to the refrigerating effect produced thereby, a system for heat transfer fluid having a vaporization portion arranged at one level to abstract heat from another of said compartments and a heat rejecting portion at a higher level in heat conductive relation with said conduit means, said refrigeration system including a connection for conducting warm absorption solution to said one cooling element which is operable to cause melting of any frost which may be formed, means for controlling flow of such absorption solution through such connection, said conduit means serving as a path of flow for absorption solution from said one or more cooling elements to said absorber, and means including insulation enveloping said condensation portion and at least the part of said conduit means in heat conductive relation therewith.

8. In a refrigerator comprising a cabinet having segregated compartments, an absorption refrigeration system including a circuit for inert gas having one or more cooling elements in which refrigerant fluid evaporates in the presence of an inert gas and conduit means for conducting therefrom inert gas enriched in refrigerant and

through which unevaporated refrigerant passes by gravity from said cooling element or elements, at least one of said cooling elements being arranged to abstract heat from one of said compartments which serves as a freezer and may cause formation of frost due to the refrigerating effect produced thereby, a system for heat transfer fluid having a vaporization portion arranged to abstract heat from another of said compartments and a heat rejecting portion in heat conductive relation with said conduit means, said refrigeration system including a connection for conducting to said one cooling element heated liquid having a higher boiling point than the refrigerant, such heated liquid being operable to cause melting of any frost which may be formed, means for controlling flow of such heated liquid through such connection, said conduit means also serving as a path of flow for such liquid which passes therethrough by gravity from said one cooling element, and means for thermally insulating said condensation portion and at least the part of said conduit means in heat conductive relation therewith.

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