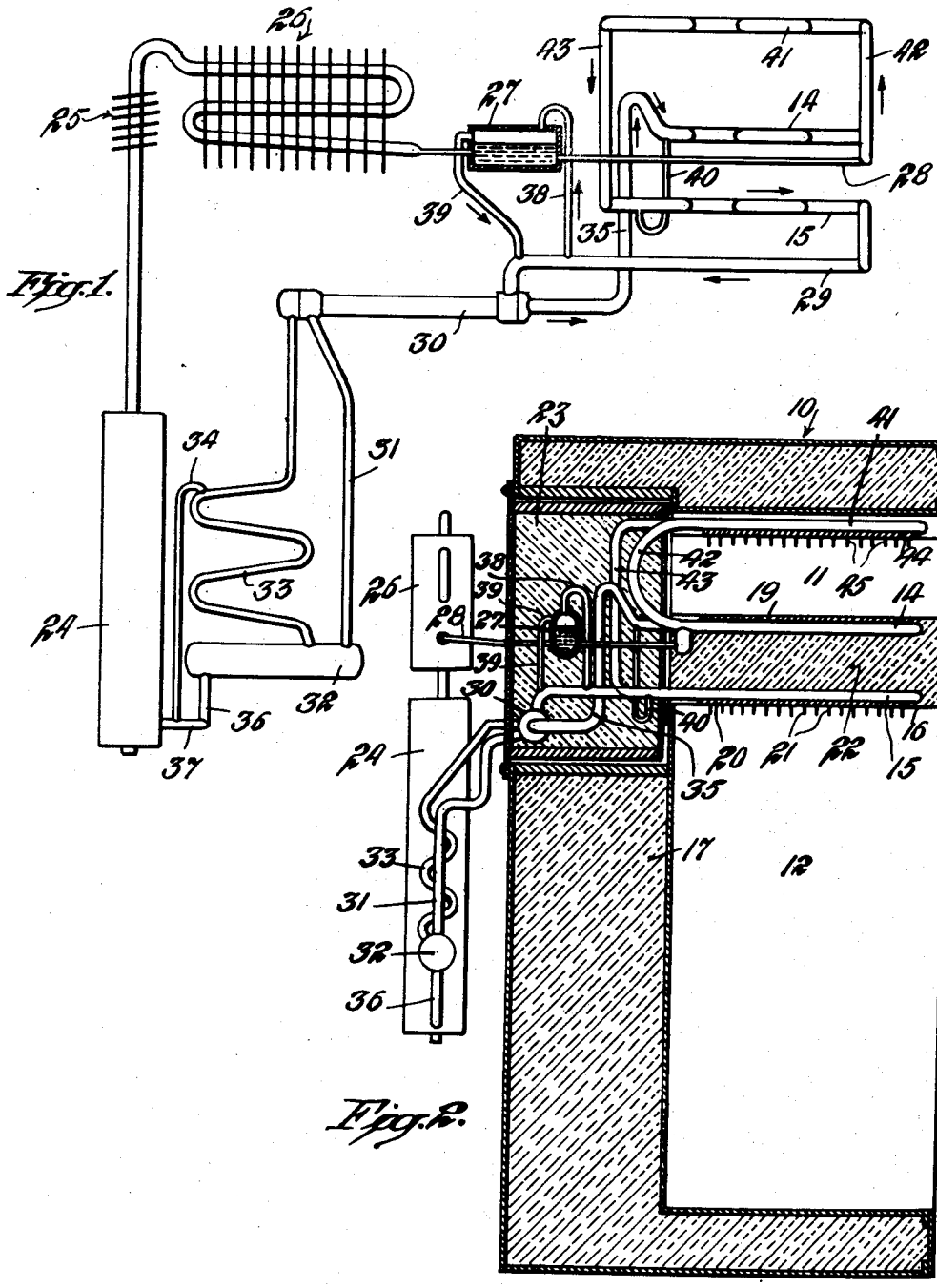
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ABSORPTION REFRIGERATION SYSTEM OF THE INERT GAS TYPE

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ABSORPTION REFRIGERATION SYSTEM OF THE INERT GAS TYPE

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My invention relates to refrigeration, and more particularly to absorption refrigeration systems of the type employing an inert gas or pressure equalizing agent.

It is an object of my invention to effect improvements in systems of this type, particularly to transmit cooling effect more effectively to different parts of a space or compartment of a household refrigerator. More particularly, it is an object to provide an improvement for transmitting cooling effect to matter stored in the upper part of a freezing compartment of the kind in which the cooling element of a refrigeration system usually is associated only with the bottom of such a compartment.

I accomplish this by providing a first cooling element in which evaporation of liquid refrigerant takes place in the presence of inert gas to produce a cooling effect which is transmitted to the bottom or lower part of a space or storage compartment of a refrigerator, and by transmitting cooling effect to the upper part or top of such space or storage compartment from a higher located element to which inert gas flows from the first cooling element, the higher located element being arranged and connected in the refrigeration system in such manner that previously cooled inert gas passes therethrough out of physical contact with liquid refrigerant.

In the preferred embodiment of the invention the higher located element is so positioned with respect to the first cooling element that it not only is above the highest point of the path of flow for liquid refrigerant but also constitutes the highest point of the refrigeration system. By positioning and locating the higher located element above the condenser or place of liquefaction of refrigerant fluid, a compact refrigerator construction is provided in which the overall height of the refrigerator is at a minimum although the freezing compartment may be located at the uppermost part of the thermally insulated interior of the refrigerator.

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 drawing forming a part of this specification, and of which:

Fig. 1 more or less diagrammatically illustrates an absorption refrigeration system embodying the invention; and

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Fig. 2 illustrates the refrigeration system of Fig. 1 and a fragmentary side vertical sectional view of a refrigerator associated therewith.

Referring to Fig. 2, I have shown my invention in connection with a household refrigerator 10 having a thermally insulated space which is subdivided into a plurality of compartments 11 and 12 one above the other and arranged to be cooled by a plurality of cooling elements 14 and 15 operable at different temperatures. The cooling elements 14 and 15 are embodied in a horizontal partition 16, the upper compartment 11 being cooled primarily by the cooling element 14 so as to freeze water and other matter as well as store frozen food packages therein.

The partition 16 is of such size that it extends substantially over the entire width of the storage space and from the rear wall 17 to a region 18 at the open front which is relatively close to the rear face of a door (not shown) adapted to be hinged at the front of the refrigerator. With such arrangement circulation of air between the upper and lower compartments 11 and 12 is substantially prevented.

The cooling element 14, which is in the form of a horizontally disposed looped coil, is thermally connected to the underside of the top surface 19 of the partition. The cooling element 15 is thermally connected to the upper side of the bottom surface 20 of the partition and is primarily effective to abstract heat from the lower compartment 12. To provide a relatively extensive heat transfer surface at the bottom surface of the partition, a plurality of heat transfer members 21 may be fixed thereto, as by welding for example.

If desired, the partition 16 may be filled with a suitable insulating material 22 for thermally shielding the cooling elements 14 and 15 from one another. Even when no insulating material is employed, the stagnant body of air in the partition effectively shields the cooling elements 14 and 15 thermally from one another.

The cooling elements 14 and 15 constitute the cooling unit or evaporator structure of an absorption refrigeration system of the inert gas type and are connected by conduits to other parts of the system for circulation of inert gas as well as supply liquid refrigerant to the evaporators. When such an absorption refrigeration system is employed in the cabinet of a household refrigerator, as shown in Fig. 2, the cooling elements 14 and 15 and connections thereto are usually inserted into the thermally insulated storage space through an opening in the rear wall 17 which is

adapted to be closed by an insulated closure member 23.

An absorption refrigeration system of the inert gas type to which the invention is applied is more or less diagrammatically shown in Figs. 1 and 2. In order to simplify Fig. 1, the cooling elements 14 and 15 have been illustrated apart from a household refrigerator having subdivided compartments one above the other. The absorption refrigeration system shown in Figs. 1 and 2 is of a uniform pressure type in which an inert gas or auxiliary pressure equalizing fluid is employed.

In a system of this type, refrigerant expelled from solution in a generator 24 by heating passes upwardly through an air cooled rectifier 25 into an air cooled condenser 26 in which the expelled refrigerant is condensed and liquefied. Liquid refrigerant flows from condenser 26 into a vessel 27 in which precooling of refrigerant is effected, as will be described presently, and refrigerant flows therefrom through a conduit 28 into the cooling elements or evaporator sections 14 and 15.

In evaporator sections 14 and 15 the refrigerant evaporates and diffuses into an inert gas, such as hydrogen, for example, to produce a refrigerating effect and abstract heat from the surroundings. The resulting gas mixture of refrigerant and inert gas flows from evaporator section 15 through a conduit 29, gas heat exchanger 30 and conduit 31 into an absorber comprising a vessel 32 and a looped coil 33. In the absorber vessel 32 and coil 33 refrigerant vapor is absorbed into a liquid absorbent, such as water, for example, which enters through a conduit 34. The hydrogen or inert gas, which is practically insoluble and weak in refrigerant, is returned to evaporator sections 14 and 15 through gas heat exchanger 30 and a conduit 35. Absorption liquid enriched in the absorber flows from vessel 32 through a conduit 36 and liquid heat exchanger 37 to generator 24 where it is heated and refrigerant vapor is again expelled out of solution. The weakened absorption liquid from which refrigerant has been expelled flows from generator 24 through the liquid heat exchanger 37 and conduit 34 to coil 33 to absorb refrigerant vapor again.

In order to precool liquid refrigerant in vessel 27 prior to entering evaporator section 14, the opposite ends of the vessel are connected by conduits 38 and 39 to the conduit 29 through which inert gas rich in refrigerant flows from evaporator section 15 to the absorber. In this way natural circulation of a part of the rich gas takes place through a local circuit including conduits 38 and 39 and vessel 27. Liquid refrigerant in vessel 27 evaporates and diffuses into rich gas above the liquid surface level thereof, thereby taking up heat from liquid refrigerant.

In Fig. 1 the evaporator sections 14 and 15 are diagrammatically shown as horizontally disposed coils which are located at different levels. Inert gas from conduit 35 flows through evaporator section 14 in the presence of and counterflow to liquid refrigerant which is introduced through conduit 28. Unevaporated liquid refrigerant is conducted from evaporator section 14 through a vertically connecting conduit 40 for flow through the lower evaporator section 17. Such liquid refrigerant flows in the presence of and in parallel flow with inert gas which passes into evaporator section 15 from evaporator section 14.

Since inert gas weak in refrigerant first flows through evaporator section 14 and thereafter flows through evaporator section 15, the gas in the upper evaporator section 14 contains a lesser amount of refrigerant vapor than the gas in the lower evaporator section 15. The partial vapor pressure of the refrigerant is a gradient, so that the temperature in the evaporator coils is also a gradient, the evaporating temperature of liquid refrigerant being lower in the upper evaporator section 14 which constitutes the freezing portion of the evaporator structure.

The refrigerating effect produced by the upper evaporator section 14, which is adapted to be operated at temperatures below freezing, is utilized to effect cooling of the upper compartment 11 which is defined by the partition 16 and thermally insulated walls of the refrigerator 10. Accordingly, the upper compartment 11 serves as a freezing space which is adapted to receive ice trays, frozen food packages and other matter to be frozen. The refrigerating effect produced by the lower evaporator section 15, which is adapted to be operated at a higher temperature than that of evaporator section 14 and desirably above freezing, is utilized to cool air in the lower compartment 12.

In accordance with my invention, in order to abstract heat more effectively from the upper compartment 11, I provide a looped coil 41 at a higher level than the upper evaporator section 14 and into which inert gas passes from evaporator section 14 through a conduit 42 and from which inert gas passes through a conduit 43 into the lower evaporator section 15. The looped coil 41, which includes spaced apart straight portions and connecting bends, is disposed essentially in a single horizontal plane adjacent to the top wall or ceiling of the upper compartment 11. In order to provide a relatively extensive heat transfer surface, a plate 44 may be secured to the underside or face of the looped coil 41, such plate having a plurality of heat transfer members 45 fixed thereto, if desired.

When the upper compartment 11 is loaded with ice trays, frozen food packages or other matter to be frozen, cooling effect is effectively transmitted to the matter resting on the top surface of the partition 16. Since the looped coil 41 is located in the upper part of the freezing compartment 11, cooling effect is also effectively transmitted to matter housed in the upper part of the compartment 11. This is so because the inert gas flowing in the upper evaporator section 14 is cooled to a low temperature in the range of −10° to −20° C., and such cool inert gas then passes directly into the looped coil 41 before entering the higher temperature evaporator section 15.

By employing cool inert gas from the evaporator section 14 to promote cooling of the upper part of the freezing compartment 11, important advantages are realized in that cooling effect can be transmitted directly from a part of the inert gas circuit to the uppermost region of the thermally insulated space of the refrigerator 10 without needlessly increasing the overall height of the refrigerator. This is so because the cooling effect transmitted to the upper part of compartment 11 is effected entirely by the gas introduced into the looped coil 41 and without introducing liquid refrigerant thereto. Hence, as shown in Fig. 2, the condenser 26 may be positioned at the rear of the insulated wall 17 at an elevation which is below the looped coil 41 and yet sufficiently high to permit liquid to flow therefrom by gravity to the upper evaporator section 14. For a refrigeration system of a given capacity, therefore, the refrigerator can be of minimum overall height and its height does not

need to be increased to provide adequate space at the rear thereof to take care of the condenser when the latter is to be positioned to drain liquid refrigerant therefrom by gravity flow into a coil like the coil 41, for example, which is arranged closely adjacent to the uppermost wall or ceiling of the thermally insulated interior of the refrigerator.

In view of the foregoing, it will now be understood that I have provided an improved arrangement for transmitting cooling effect to any region of a storage space of a refrigerator although, as explained above, it is especially suitable in those constructions in which difficulty is encountered in supplying liquid refrigerant to such a region. In the preferred embodiment of the invention shown and described above, for example, the cooling effect produced by circulation of inert gas through the looped coil 41 is effected at a region which not only is above the highest point of the path of flow for liquid refrigerant but which also constitutes the highest point of the refrigeration system. Such cooling effect is transmitted to matter external to the refrigeration system and is effected by flow of inert gas through the looped coil 41 while out of physical contact with liquid refrigerant.

The cooling effect produced at the looped coil 41 is transmitted to the upper part of compartment 11 while the cooling effect produced by evaporator section 14 is transmitted to the lower part or bottom of the same compartment. Hence, the storage space in effect is located between the horizontally disposed regions at which the cooling effects are produced. The inert gas passing from the evaporator section 14 is cooled in the latter to a temperature below the freezing temperature of water, so that it is effectively utilized in the upper looped coil 41 to promote preservation of food and other matter in the compartment 11 at temperatures below freezing.

As seen in Fig. 1, the conduit 35 through which inert gas weak in refrigerant flows from the upper gas outlet end of absorber coil 33 is connected at its upper end to one end of evaporator section 14 which may be referred to as a first cooling element. Inert gas partially enriched in refrigerant vapor flows from evaporator section 14 to the looped coil 41 which may be referred to as a second cooling element. From looped coil 41 inert gas flows through conduit 43 to evaporator section 15 which may be referred to as a third cooling element. Hence, inert gas is only introduced into looped coil 41 from evaporator section 14 and inert gas is only introduced into evaporator section 15 from the looped coil 41.

All of the liquid refrigerant formed in the condenser or refrigerant liquefier 26 flows through vessel 27 and conduit 28 into the first cooling element or evaporator section 14 for gravity flow in the latter. It will be seen that the vessel 27 and conduit 28 provide a connection in which the first cooling element or evaporator section 14 is the initial cooling element to which is conducted all refrigerant that condenses and liquefies in the condenser 26. Liquid refrigerant flows by gravity from the evaporator section 14 through conduit 40 to the third cooling element or evaporator section 15, the conduit 40 providing a path of flow for liquid refrigerant which by-passes the second cooling element or looped coil 41.

As shown in Fig. 2, all of the connections leading to the evaporator sections 14 and 15 and looped coil 41, as well as the connections therebetween, may be located outside the thermally insulated compartments 11 and 12. If desired, many of such connections, including the precooler vessel 27 and gas heat exchanger 30, may be located in the thermally insulated closure member 23, if desired. Further, the looped coil 41 in certain instances advantageously may be thermally connected to the inner metal liner defining the uppermost region of the upper compartment 11.

Since absorption refrigeration systems of the inert gas type are well known in the art, the refrigeration system has only been diagrammatically shown in order to simplify the drawing. Moreover, it will be understood that a force is developed or produced within the refrigeration system for causing circulation of inert gas in the manner described above, such circulation being due to the difference in specific weight of the columns of gas rich and weak, respectively, in refrigerant vapor.

While a particular embodiment of the invention has been shown and described, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the spirit and scope of the invention, as pointed out in the following claims.

What is claimed is:

1. In a refrigerator of a household type, a cabinet comprising thermally insulated walls defining an insulated interior having a plurality of compartments, the insulated walls including a horizontal wall which extends across the top of the cabinet, said compartments including a freezing compartment which is of less height than the overall height of the insulated interior and whose uppermost region is essentially at the underside of the top insulated wall, an absorption refrigeration system of the inert gas type comprising a vapor expulsion unit for expelling refrigerant vapor from solution, refrigerant liquefying means in which liquefaction of expelled vapor is effected, and a gas circuit including an absorber having an inlet for inert gas enriched in refrigerant vapor and an outlet for inert gas weak in refrigerant vapor and a plurality of cooling elements each having an inlet and outlet for inert gas, said cooling elements including a first cooling element arranged to abstract heat at the bottom of the freezing compartment and a second cooling element arranged to abstract heat from the upper region of the freezing compartment, conduit means connecting the outlet of said absorber and the inlet of said first cooling element, means connecting the outlet of said first cooling element and the inlet of said second cooling element, said last-mentioned connecting means constituting the only connection for introducing inert gas to said second cooling element, conduit means connecting the outlet of said second cooling element and the inlet of said absorber, conduit means for conducting liquid refrigerant from said liquefying means to said first cooling element for gravity flow in the latter, said last-mentioned conduit means providing a connection in which said first cooling element is the initial cooling element to which is conducted substantially all liquid refrigerant formed in said liquefying means in the normal operation of the refrigeration system, and means for flowing liquid refrigerant by gravity from said first cooling element in a path of flow which by-passes said second cooling element.

2. A refrigerator as set forth in claim 1 including a first horizontal member at the bottom

of said freezing compartment and a second horizontal member removed therefrom which is essentially at the underside of the top insulated wall, said first cooling element comprising piping in thermal relation with the underside of said first horizontal member and said second cooling element comprises piping in thermal relation with the upper side of said second horizontal member.

3. In a refrigerator of a household type, a cabinet comprising thermally insulated walls defining an insulated interior having a plurality of compartments including a freezing compartment and a higher temperature compartment, the insulated walls including a horizontal wall which extends across the top of the cabinet, said freezing compartment being of less height than the overall height of the insulated interior and having the uppermost region thereof essentially at the underside of the top insulated wall, an absorption refrigeration system of the inert gas type comprising a vapor expulsion unit for expelling refrigerant vapor from solution, refrigerant liquefying means in which liquefaction of expelled vapor is effected, and a gas circuit including an absorber having an inlet for inert gas enriched in refrigerant vapor and an outlet for inert gas weak in refrigerant vapor and a plurality of cooling elements each having an inlet and outlet for inert gas, said cooling elements including a first cooling element arranged to abstract heat at the bottom of the freezing compartment, a second cooling element arranged to abstract heat from the upper region of the freezing compartment and a third cooling element for abstracting heat primarily from said higher temperature compartment, conduit means connecting the outlet of said absorber and the inlet of said first cooling element, means connecting the outlet of said first cooling element and the inlet of said second cooling element and connecting the outlet of said second cooling element and the inlet of said third cooling element, said last-mentioned connecting means constituting the only provisions for introducing inert gas to said second and third cooling elements, respectively, conduit means connecting the outlet of said third cooling element and the inlet of said absorber, conduit means for conducting liquid refrigerant from said liquefying means to said first cooling element for gravity flow in the latter, said last-mentioned conduit means providing a connection in which said first cooling element is the initial cooling element to which is conducted substantially all liquid refrigerant formed in said liquefying means in the normal operation of the refrigeration system, and conduit means for flowing liquid refrigerant by gravity from said first cooling element to said third cooling element for gravity flow therethrough, said last-mentioned conduit means providing a path of flow for liquid refrigerant which by-passes said second cooling element.

4. In a refrigerator of a household type, a cabinet comprising thermally insulated walls defining an insulated interior having a plurality of compartments including a freezing compartment and a higher temperature compartment, said freezing compartment being of less height than the overall height of the insulated interior,

an absorption refrigeration system of the inert gas type comprising a vapor expulsion unit for expelling refrigerant vapor from solution, condensing means in which condensation of expelled vapor is effected, and a gas circuit including an absorber having an inlet for inert gas enriched in refrigerant vapor and an outlet for inert gas weak in refrigerant vapor and a plurality of cooling elements each having an inlet and outlet for inert gas, said cooling elements including a first cooling element arranged to abstract heat at the bottom of the freezing compartment, a second cooling element arranged to abstract heat from the upper region of the freezing compartment and a third cooling element for abstracting heat primarily from said higher temperature compartment, conduit means connecting the outlet of said absorber and the inlet of said first cooling element, means connecting the outlet of said first cooling element and the inlet of said second cooling element and connecting the outlet of said second cooling element and the inlet of said third cooling element, said last-mentioned connecting means constituting the only provisions for introducing inert gas to said second and third cooling elements, respectively, conduit means connecting the outlet of said third cooling element and the inlet of said absorber, conduit means for conducting liquid refrigerant from said condensing means to said first cooling element for gravity flow in the latter, said last-mentioned conduit means providing a connection in which said first cooling element is the initial cooling element to which is conducted substantially all liquid refrigerant formed in said condensing means in the normal operation of the refrigeration system, and conduit means for flowing liquid refrigerant by gravity from said first cooling element to said third cooling element for gravity flow therethrough, said last-mentioned conduit means providing a path of flow for liquid refrigerant which by-passes said second cooling element, the aforesaid conduit means and connecting means enabling inert gas at a low temperature to pass from said first cooling element to said second cooling element out of the presence of liquid refrigerant before again coming in physical contact with such liquid in said third cooling element in order to reduce the vertical temperature gradient in said freezing compartment and allow said condenser to be positioned at a level which is lower than that at which it would be positioned providing said second cooling element were connected to receive liquid refrigerant therefrom by gravity.

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