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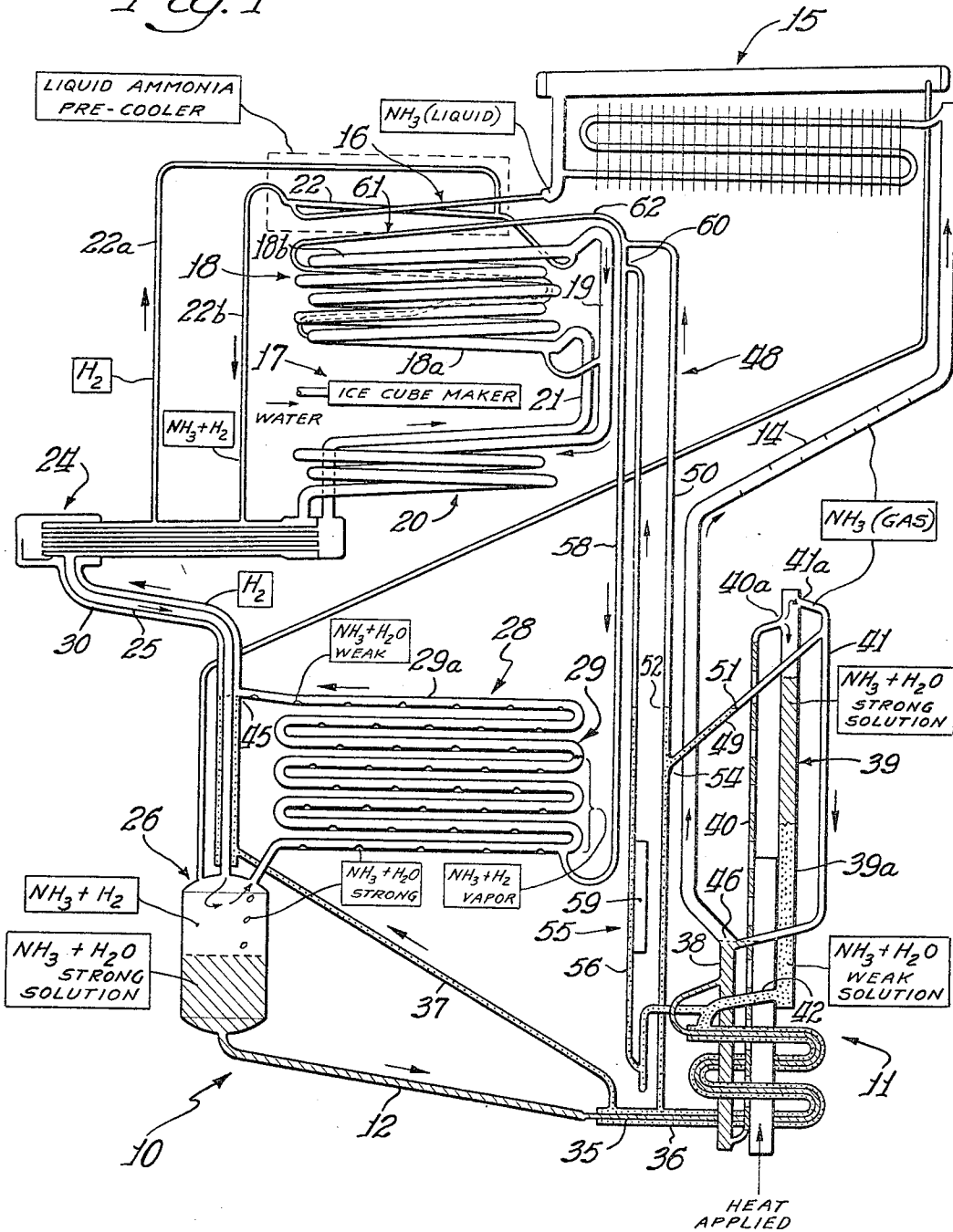
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DEFROST SYSTEM FOR GAS ABSORPTION TYPE REFRIGERATORS

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2 Sheets-Sheet 1

Fig. 1



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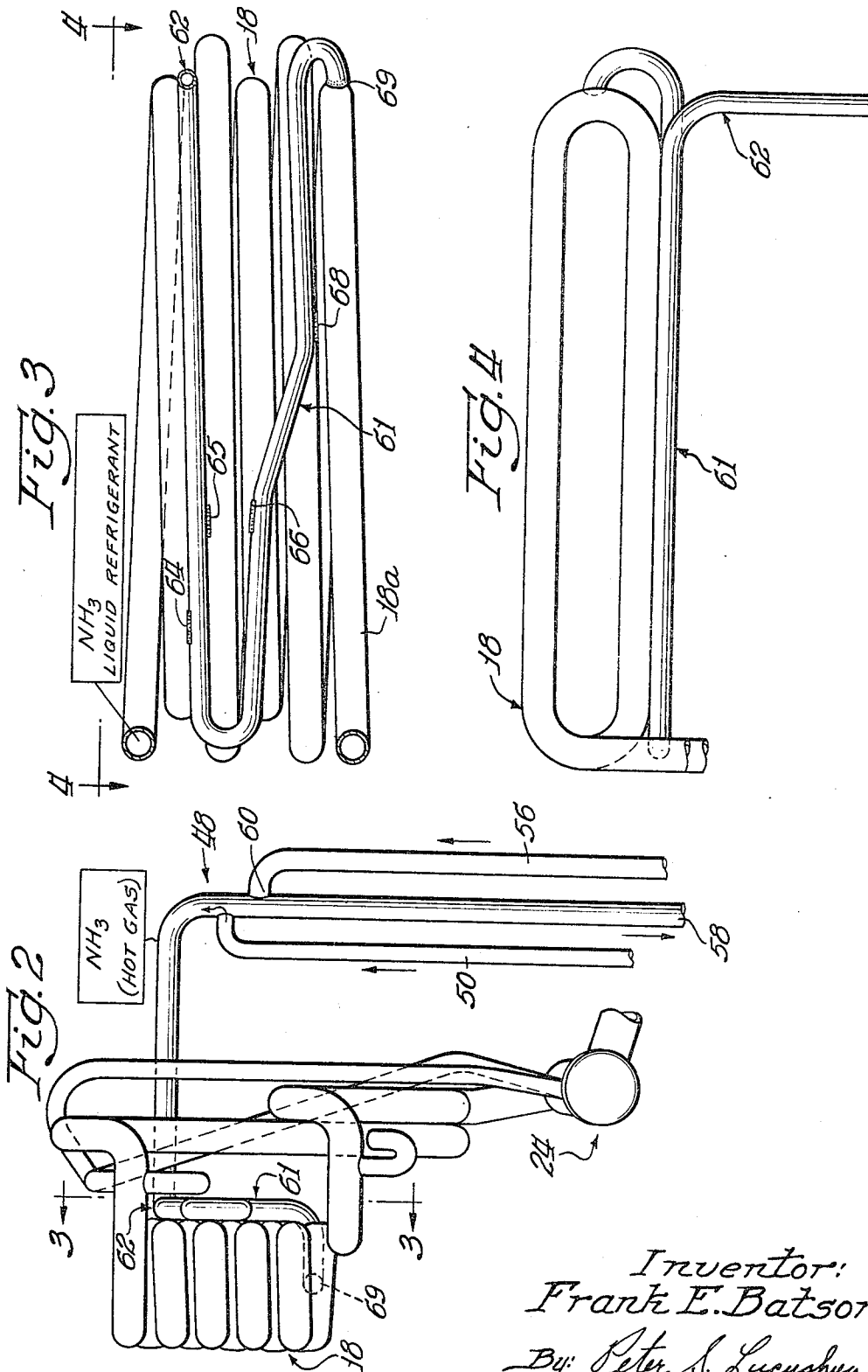
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DEFROST SYSTEM FOR GAS ABSORPTION TYPE REFRIGERATORS

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The present invention relates to gas absorption type refrigerators and more particularly to an improved defrost system for such refrigerators.

Gas absorption type refrigerators, using hot gas refrigerant as the working fluid to effect defrosting, generally do not defrost as quickly as comparable compressor type units also using hot gas refrigerant as a source of heat. This is because the compressor can be used in the latter type refrigerator to increase flow of working fluid through the evaporator area, while the gas absorption system relies simply upon the generation of hot gas to move or push the gas through. As a result, the gas absorption defrost systems must efficiently use the heat that is made available at the evaporator for defrosting.

In the past, the gas absorption defrost systems have used direct feeding of hot gases into the evaporator coils. The result has been non-uniform defrosting. The top of the evaporator has been heated to a relatively high temperature quickly, while the bottom of the evaporator remained below freezing after a substantial period of defrosting. Also used, as shown by the prior art, is bottom feeding of hot gases into a separate defrost coil supported adjacent the evaporator coils. However, much of the heat possessed by the defrost working fluid was lost as hot gas condensed in the evaporator area and flowed downwardly to the source of the hot gas.

The problem becomes particularly acute in modern refrigerators which have larger food freezing and refrigerating compartments than the units of a few years ago. These new refrigerators require larger capacity refrigerating systems with larger evaporators, resulting in increased loads on their defrost systems.

Accordingly, it is an object of the present invention to provide an improved defrost system for a gas absorption type refrigerating unit and the like which effects defrosting faster than systems of the prior art. Along this line, it is an object of the present invention to provide a defrost system which efficiently utilizes the heat in the defrost work fluid to melt collected ice and frost.

It is a more detailed object of the present invention to provide an improved heat transfer structure for the portion of the defrost sub-system associated with the evaporator of a gas absorption type refrigerating system which, in transferring heat from the defrost work fluid to the evaporator, distributes the same to assure effective removal of frost and ice from all parts of the evaporator.

It is an overall object of the present invention to provide an economically manufacturable defrost system for a gas absorption type refrigerator which is adaptable for installation in standard refrigerators.

Other objects and advantages will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIGURE 1 is a schematic of a gas absorption refrigerator system embodying the present invention;

FIGURE 2 is an enlarged side elevation of an evaporator shown in the refrigerator of FIGURE 1 utilizing the present inventive defrosting system;

FIGURE 3 is a sectional side elevation taken along 3-3 in FIGURE 2; and

FIGURE 4 is a top plan view of the evaporator of FIGURE 2 taken along 4-4 of FIGURE 3.

Turning to the drawings, there is shown in FIGURE 1

a schematic of a gas absorption refrigerating system 10 embodying the present invention. Presenting a summary of the operation of such a system, a gas generator 11 receives a "strong" solution from conduit 12, in the present instance, water heavily laden with ammonia, and heats the same to release the ammonia as a gas phase refrigerant. The "hot" ammonia gas travels upwardly through a conduit 14 to a condenser 15. The latter converts the gas phase ammonia into liquid phase ammonia and discharges the latter through conduits, generally designated 16, into the top of a set of low temperature evaporator coils 18. All of the liquid phase refrigerant is fed to the stack of evaporator coils 18 with a portion spilling over through conduit 19 into a second set of evaporator coils 20 which operate at a higher temperature than the first set of evaporator coils 18. The exemplary refrigerating system is for a two-zone refrigerator. In practice, coils 18 maintain a food freezing temperature of about 0° F. to -5° F. (air temperature), while coils 20 maintain a food refrigerating or cooling temperature of about 35° F.

To lower the respective temperatures in the environments of the evaporator coils 18, 20, refrigerant is converted from gas phase to liquid phase and hydrogen, H₂, is flowed countercurrent thereto, thereby sweeping away the NH₃ vapors. Change of the refrigerant to gas phase to consequently lower the evaporator temperature occurs because the (NH₃) pressure maintained on the refrigerant at the evaporator is reduced in comparison to the pressure maintained on the refrigerant at the condenser. Hydrogen is added as an inert gas to equalize the total pressure at the evaporator with the total pressure at the condenser, while permitting application of a partial pressure on the ammonia refrigerant at the evaporator. This is understood by those skilled in the art as a partial pressure phenomenon. Explaining, in an exemplary gas absorption refrigerating system, the pressure, for example, at the condenser may be 380 p.s.i.g. applied to the refrigerant resulting in condensation and production of liquid phase refrigerant at condenser temperatures below 140° F. The total pressure of hydrogen and ammonia at the evaporator, the sum of which must be 380 p.s.i.g., includes a charge of 374 p.s.i.g. of hydrogen gas leaving 6 p.s.i.g. ammonia vapor pressure on the liquid ammonia refrigerant. At this partial pressure, the ammonia refrigerant vaporizes at approximately -15° F., to cool the food freezer down to about 0° F. to -5° F., depending upon the ambient temperature. The exemplary five-coil unit was charged, in practice, with hydrogen to a pressure of 380 p.s.i.g. when operating in 110° F. At any ambient lower than 110°, the pressure is less than 380 p.s.i.g. The evaporator coils 18, operating at the lowest temperature, are most likely to collect frost or ice. As shown in the preferred embodiment, an ice cube maker 17, an accessory which is often added to modern refrigerators, is mounted near the evaporator coils 18. This increases the humidity in the evaporator environment so as to increase the amount of frost and ice collected on the coils. As is explained subsequently, the present invention is particularly adapted to effectively remove such ice and frost from even the large capacity evaporators.

The hydrogen flows upwardly through the evaporator coils from a heat exchanger 24. A conduit 21 receives dry (substantially void of ammonia) hydrogen gas and carries it to the bottom coil 18a of the low temperature evaporator. The greatest diffusion of ammonia vapors into the hydrogen gas takes place at the bottom coil, thus, the latter is the coolest during refrigerator operation and collects the most frost. The hydrogen gas continues to pick up ammonia vapors as it travels upwardly through

the evaporator coils and becomes heavier. At the top of the lower temperature freezer coils 18, the depending conduit 19 receives the heavy mixture and carries the same down to the high temperature evaporator 20 and on through the heat exchanger 24, and an inner conduit 25 to an absorber storage vessel 26. The column of hydrogen gas and ammonia vapor leaving the evaporator is heavier than the column of hydrogen flowing from the absorber back to the evaporator. The difference provides the driving power for circulating the hydrogen.

An evaporator subsystem is provided for precooling the liquid ammonia leaving the condenser 15 and entering conduit 16 on the way to the evaporators 18, 20. As herein illustrated, the conduit 16 discharges liquid ammonia into one end of an inclined conduit 22 (see FIGURE 1) which slopes downwardly to connect with a top coil 18b of the evaporator 18. A conduit 22a carries hydrogen upwardly from heat exchanger 24 and passes it over the downwardly flowing ammonia liquid to carry away ammonia vapors and lower the temperature of the ammonia liquid. The heavier hydrogen gas with ammonia vapors diffused therethrough returns by way of a depending conduit 22b to the heat exchanger 24. Again, the column of heavier hydrogen gas and ammonia vapor mixture provides the driving force for the operation of the precooler evaporation cycle.

The storage vessel 26 is connected to the bottom of an absorber 28 to both feed the mixture of hydrogen and ammonia gas thereto, and also to receive a strong solution of water and ammonia discharged therefrom. Explaining, in the present instance, the absorber 28 includes a plurality of coils 29 arranged in stacked relationship. A weak solution of ammonia and water is received from the generator 11, and is fed into a top coil 29a of the absorber 28 so as to trickle downwardly through the coils 29 countercurrent to the hydrogen laden with ammonia gas which is flowing upwardly from the absorber vessel 26. Because the ammonia gas is quite soluble in water, the weak solution of ammonia and water absorbs ammonia from the countercurrent flowing mixture of gases thereby adding ammonia to the solution. By the time the solution reaches the storage vessel 26 located at the bottom of the stack of absorber coils 29, it is strong in ammonia and is ready to be charged to the generator 11. Thus, the cycle is started over. The hydrogen gas is freed, as the ammonia is absorbed, and travels upwardly to the gas heat exchanger 24 through a flow line defined by an outer conduit 36 and the inner hydrogen and ammonia gas carrying conduit 25. The exchanger 24 transfers heat from the hydrogen flowing upwardly on its way to the evaporator coils 18, 20, to the hydrogen laden with ammonia gas flowing downwardly to the absorber storage vessel.

Explaining the operation of the generator 11, the latter receives a strong solution of ammonia, applies heat thereto to release the ammonia gas which is conveyed to the condenser and discharges the resulting solution weak in ammonia into the absorber to pick up ammonia which has been used to cool the evaporator coils. A pair of coaxial conduits 35, 36 serve as the solution input and output lines respectively. The inner conduit 35 is connected to receive strong or rich solution from the absorber flowing in line 12, and the outer conduit 36 is connected to discharge a weak solution from the generator 11 into an absorber return conduit 37. The inner conduit 35 conveys the strong solution of ammonia and water to the upper portion of an analyzer storage pipe 38.

For pumping strong solution from the storage pipe 38 to the top of a generator reservoir pipe 39, the bottom of the analyzer storage pipe 38 is connected to the bottom of a thermal-siphon pipe 40, which percolates the solution upward and discharges it at point 40a into the top of the generator reservoir pipe 39. The top of the reservoir pipe 39 has a depending conduit 41 connected at point 41a, above the connection point 40a at which

strong solution is discharged into the reservoir pipe, to receive ammonia gas as it is released. Heat, from a suitable heat source, for example, a gas flame or the like, is applied to the bottom portion of the reservoir pipe to release the ammonia gas out of solution.

As hot refrigerant vapors are released from the strong solution, a bottom portion 39a of the gas generator reservoir pipe becomes filled with a solution weak in ammonia. The weak solution flows from the bottom of the generator reservoir pipe 39 through a conduit 42, connected to the flow line defined by the space between inner and outer conduits 35, 36, to be returned to the absorber by way of the conduit 37. As is clear from FIGURE 1, the level of the solutions in the absorber and generator must be maintained high enough so that the weak solution will flow into the top coil 29a of the absorber 28, i.e., to a level 45.

Noting the flow paths open to the ammonia refrigerant gas expelled from the generator reservoir pipe 39, a first path is downward through conduit 41 to a point 46 at the top of the analyzer storage pipe 38. At point 46 there is a Y-connection between the bottoms of generally vertical conduits 14 and 41 and the top of the analyzer storage pipe 38. In normal operation, the refrigerant gas flows through the Y-connection point upwardly through conduit 14 to the condenser 15.

In the illustrative embodiment, for feeding hot refrigerant gas to a defrost system 48, a second path is provided for the hot gas refrigerant. The second path is defined by a diagonally depending conduit 49 having one end connected near the top of the depending refrigerant gas carrying conduit 41 and extending downwardly to make a connection at a point 54 with a vertical conduit 50 serving as a hot gas input line for the defrost system 48. As is clear from FIGURE 1, the hot gas input line 50 is connected at the bottom end to outer conduit 36 carrying weak solution away from the generator 11.

In normal operation, the level of weak solution is maintained at level 45 in the absorber 26, and the weak solution seeks a level in both conduits 49, 50. As illustrated, such a level in these conduits corresponds to points 51, 52 respectively. With the weak solution level at point 51 in conduit 49, the refrigerant gas is blocked from travelling therethrough into input line 50. Thus, the hot gas flows downwardly through depending conduit 41 into line 14 on the way to condenser 15. However, if the weak solution is lowered, below level 51, indeed, below the point 54 at which the conduit 49 makes connection with conduit 50, then refrigerant gas will bypass the line 14 to feed hot refrigerant gas into defrost system input line 50.

To effect lowering of the weak solution level and permit hot gas to flow into the defrost system input 50, a defrost control 55 is provided. In the present instance, the defrost control includes a pair of vertically positioned conduits 56, 58 and a heater element 59. The conduit 56 is connected into the weak solution supply at the generator 11 in the present instance into conduit 42 and has mounted thereon in heat transfer relationship, the heating element 59. The conduit 56 and heating element 59 operate as a thermal-siphon pump to percolate weak solution upward to a point 60 where the conduit 56 connects with conduit 58 and discharges the weak solution to be carried by the latter flow defining means to the bottom of the absorber 28. The conduit 58 is connected to the bottom end of the absorber for this purpose. The result is that the level of weak solution is lowered in the generator 11, indeed sufficiently to bring the weak solution level in conduit 49 below point 54. At this time, hot refrigerant gas will be fed into line 50 to operate the defrost system 48.

In accordance with the present invention, the defrost system 48 effects efficient and quick defrosting of the evaporator coils using a separate defrost working fluid

flow line 61 disposed adjacent the evaporator coils in predetermined heat exchange relationship and receiving hot gas at an upper end 62. As herein illustrated, the flow line 61 is a defrost coil wound in a generally serpentine configuration to both distribute the heat of the hot gas as the latter is carried by the coil and also to retard the flow to effect efficient use of the heat in the gas phase refrigerant. The defrost coil 61 is thermally connected to transfer heat to the evaporator coils at predetermined selected points to effect optimum heat transfer to the individual ones of the set of evaporator coils. In the present instance, the defrost coil 61 and the evaporator coils 18 being of metal, the thermal connection points include welds at 64, 65, 66 and 68. The defrost coil discharges the defrost working fluid into a bottom coil of the evaporator at point 69.

Because of the novel structure of the present defrost system, hot gas is fed into the top of the defrost coil 61 without losing any of its heat to condensed refrigerant returning from the evaporator environment. Such occurs, for example, in bottom feed for the defrost coil where condensed hot gas having converted to liquid, flows back and absorbs heat from the upwardly flowing hot gas. Furthermore, the condensed gas travelling in the defrost coil 61 is not lost to the defrosting system. The liquid continues to flow downwardly through the defrost coil and the remaining heat possessed by the liquid contributes to the defrosting operation, the latter liquid thus being a part of the defrost working fluid.

In practice, it has been found that the separate flow system for the defrost working fluid, permitting adjustment of heat transfer to different areas of the evaporator, is particularly adapted for defrosting large capacity, multi-coil evaporators. As has been explained, the bottom coil 18a ordinarily has the greatest amount of frost. Thus, the adjustment of thermal conductivity between the defrost coil and the evaporator coil taught by the present invention permits uniform defrosting of even non-uniform frost collection.

In one practical example, a five-coil evaporator operating to maintain a freezer temperature of about -10° F. in an ambient of 80° F. was defrosted in 27 minutes. This same evaporator, using a bottom feed for the defrost flow line and maintaining approximately the same freezer temperature in the same ambient, required 34 to 36 minutes to defrost. During use, it is desirable to maintain the defrost time at a minimum in order to provide rapid recovery of proper temperatures. By maintaining the temperature change to a minimum, food stores better. Accordingly, any time saved in the heating of the evaporator area will aid in operating the refrigerator.

In addition, the present inventive defrost system permits substantially uniform heating of the defrost coils. In practice, it was found that by using $\frac{1}{2}$ inch welds at points 64, 65, 66 and 68 at positions as shown in FIGURE 3, the top coil was heated to a temperature of approximately 70° F., while the bottom evaporator coil was raised to a temperature of $45-50^{\circ}$ F. These temperatures provide complete defrosting, even of the usually ice-covered bottom coil, without permitting refrigerator temperatures to become excessively high.

Though a specific system for controlling input of hot gas to the defrost system is here shown, it is, of course, within the knowledge of those skilled in the art to use other systems for bypassing the condenser and feeding the generator produced hot gas into the defrost system, for example, a simple solenoid valve having selectable outputs. Also, though an ammonia gas refrigerant system is exemplarily illustrated, gas absorption type systems using other refrigerants may also be used.

What is claimed is:

1. In an absorption type refrigerating system having a generator, a condenser, a set of evaporator coils arranged in a generally stacked orientation and subject to collect-

ing frost during normal operation, and an absorber, a defrost system using vaporized refrigerant from the generator as a source of heat characterized by having a defrost coil disposed adjacent said stacked evaporator coils and orientated to define a generally top to bottom flow path, an input means at said defrost coil top adapted to receive hot gas from the generator, an output means at said defrost coil bottom connected to a lower one of said stack of evaporator coils, said defrost coil formed to define a circuitous path for retarding flow of defrost working fluid therethrough so as to assist in transfer of heat to said defrost coil and therethrough to said evaporator coils and means thermally connecting said defrost coil to said evaporator coils to transfer a predetermined portion of the heat from said defrost coil to individual ones of said set of evaporator coils as to uniformly defrost said evaporator coils.

2. In an absorption type refrigerating system having a generator, a condenser, a set of metal evaporator coils arranged in a generally stacked orientation and subject to collecting frost during normal operation and an absorber, a defrost system using vaporized refrigerant from the generator as a source of heat characterized by having a metal defrost coil disposed adjacent said stacked evaporator coils and oriented to define a generally top to bottom flow path, an input means at said defrost coil top adapted to be connected to a line conducting hot gas from the generator, an output means at said defrost coil bottom connected to a lower one of said stack of evaporator coils, said defrost coil formed to define a circuitous path for retarding flow of defrost working fluid refrigerant therein so as to assist in transfer of heat to said defrost coil and therethrough to said evaporator coils, and a metal connection between said defrost coil and said respective evaporator coils to effect a transfer of heat at a predetermined rate from said defrost coil to individual ones of said set of evaporator coils to efficiently defrost the latter.

3. In an absorption type refrigerating system having a generator, a condenser, a set of evaporator coils arranged in a stacked orientation and subject to the collection of frost thereon during normal operation, and an absorber, a defrost system using vaporized refrigerant from the generator to provide heat for defrosting the evaporator coils characterized by defrosting conduit means disposed adjacent said evaporator coils in heat exchange relationship thereto for receiving and conducting said vaporized refrigerant, means connecting said conduit means to said evaporator coils for effecting transfer of a predetermined portion of the heat from said conduit means to said set of evaporator coils to effect sufficient heating of the latter to remove frost therefrom, an input for said conduit means coupled for receiving gas phase refrigerant from said generator, and a conduit output coupled to a lower portion of said evaporator for discharging refrigerant after the latter has been utilized to heat said evaporator coils, said refrigerant upon travelling through said conduit means, being converted partially to the liquid phase, said liquid phase refrigerant thereafter flowing by gravity through the remainder of said conduit means to said lower portion of said evaporator and thereby increasing the efficiency of the heat exchange between the hot refrigerant carried by the conduit means and said evaporator coils.

References Cited by the Examiner

UNITED STATES PATENTS

2,285,884	6/1942	Ashby	62-81
2,286,205	6/1942	Grubb	62-81
2,402,413	6/1946	Kogel	62-81
2,457,334	12/1948	Widell	62-81
2,631,443	3/1953	Backstrom	62-277
2,960,841	11/1960	Kogel	62-278
3,163,997	1/1965	Stierlin	62-81