

May 26, 1970

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REVAPORIZING REFRIGERATION SYSTEM

Filed May 16, 1968

3 Sheets-Sheet 1

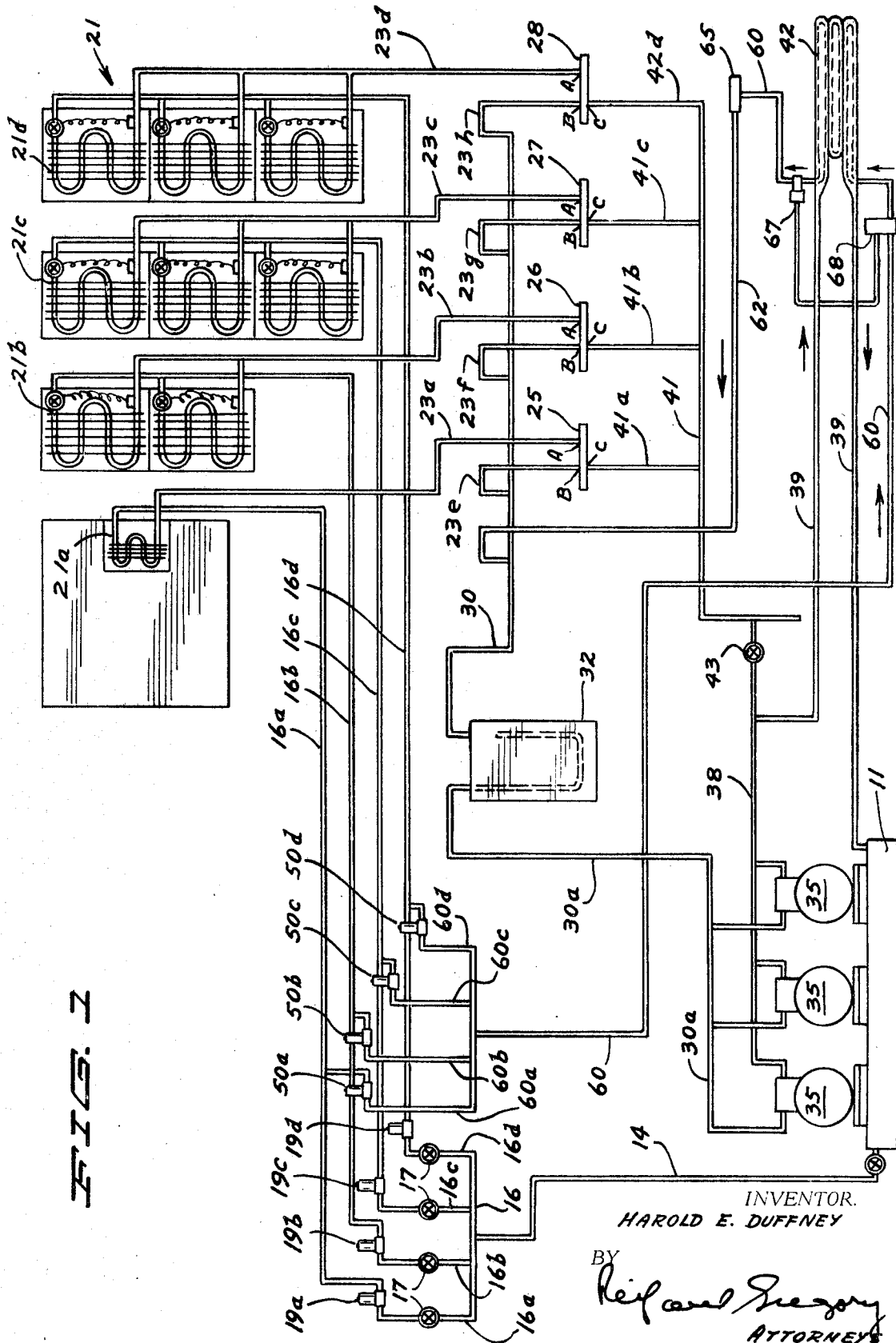


FIG. 1

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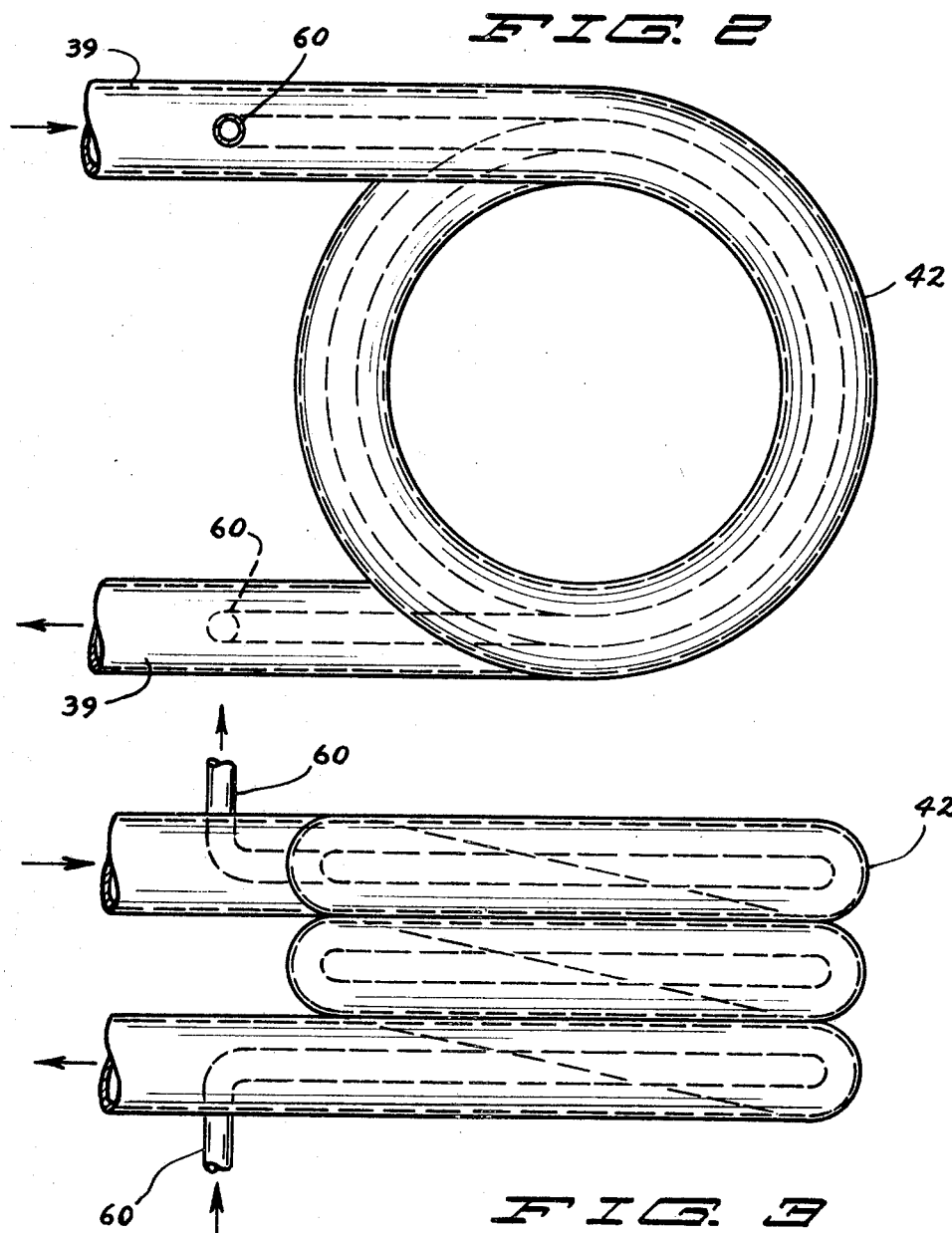
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FIG. 4

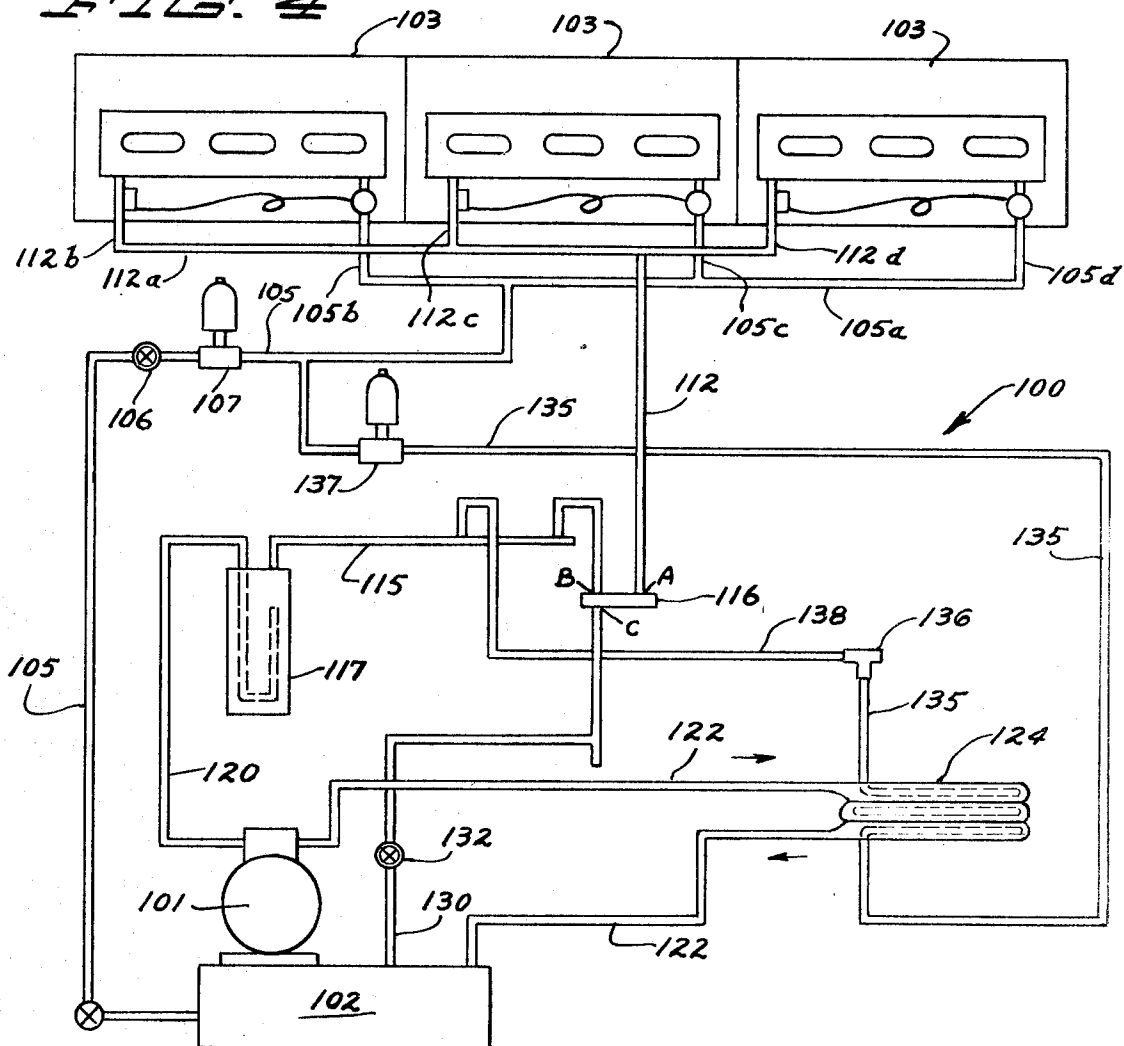
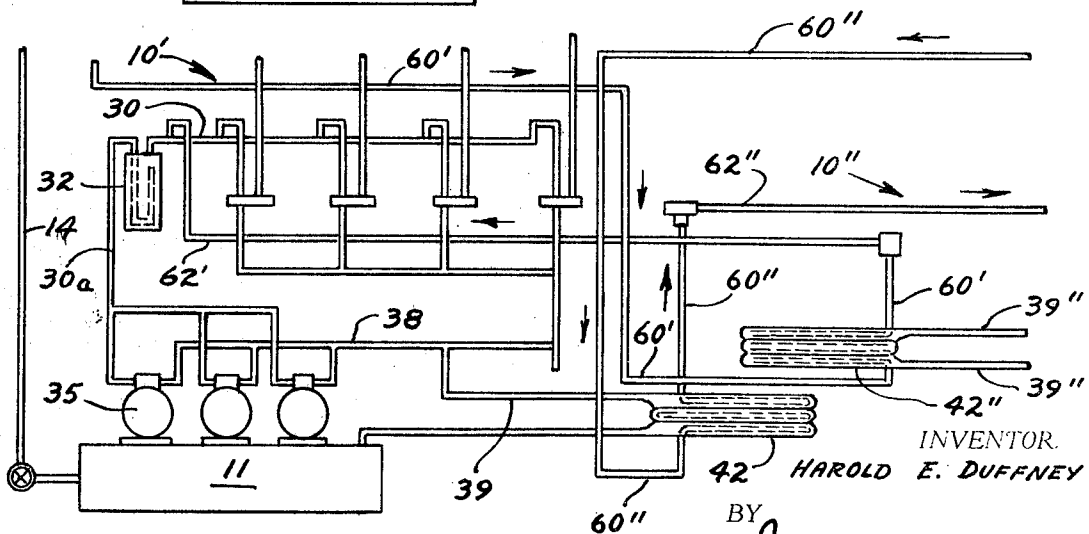


FIG. 5

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REVAPOORIZING REFRIGERATION SYSTEM

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1 Claim

ABSTRACT OF THE DISCLOSURE

A refrigeration system comprising a multiple of evaporators including a coil which comprises a counter-flow heat exchanger and which is formed as a portion of the hot gas refrigerant line running from the compressor to the condenser and a return line running through said coil carrying the return liquid refrigerant in a defrosting cycle, said liquid refrigerant, before its return to the compressor, first being revaporized by counter-flowing the hot gas refrigerant passing through said coil. The refrigeration cycles with respect to the evaporators not being defrosted continue their normal operation and selectively said refrigeration cycles convert to defrosting cycles.

Background and summary of the invention

This invention relates to an automatic low temperature or commercial type refrigeration system embodying the use of a multiple of evaporators in parallel relationship.

Periodically it is necessary to defrost evaporators. One method used for defrosting is conventionally known as the hot gas method.

The hot gas from the discharge side of the compressor is used frequently by having a bypass line running directly to the evaporators. Problems arise in revaporizing the liquid refrigerant returning from a defrosting cycle. Methods used to revaporize said liquid refrigerant generally require auxiliary equipment and a separate or additional heat source and generally the efficiency of the refrigeration cycle is affected.

The area of improvement in the invention herein lies in utilizing the hot gas from the discharge side of the compressor through a counter-flow heat exchanger formed in the hot gas line running from the compressor to the condenser whereby hot gas is flowing normally through said heat exchanger in passing to the condenser and thence through it through a normal refrigeration cycle to the evaporators. The heat exchanger is referred to as a revaporizer. The counter-flow fluid through said revaporizer is the fluid returning from a defrosting cycle and this is reduced from a liquid to a vapor state in passing through said revaporizer to the suction line returning to the suction side of the compressor. Thus the return liquid from a defrosting cycle is vaporized for safe return to the compressor by the normal flow of hot gas from the discharge side of the compressor to the condenser without interrupting the normal refrigeration cycle of the system. There is sufficient heat present in the hot gas coming from the discharge side of the compressor to revaporize the return liquid refrigerant from a defrost cycle without reducing or impairing the efficiency of the refrigeration cycle. Thus the system is self contained in utilizing efficiently its own heat source for revaporizing refrigerant returning from a defrosting cycle.

Representative of the closest known art is the following reference material.

U.S. Letters Patent 3,012,414 to La Porte shows a refrigeration apparatus in which during a defrost cycle hot gas goes directly from the compressor to the evaporator bypassing the condenser but involves the disrupting of the normal refrigeration cycle.

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In U.S. Letters Patent 3,012,415 to La Porte, a heat storage unit is shown having an auxiliary heating element and having an auxiliary line running some hot gas from the compressor to heat a liquid medium and is gravity fed for return to the condenser. There is no positive circulation of hot gas to counter-flow liquid refrigerant for its revaporization.

U.S. Letters Patents 3,150,498 and 3,184,926 to Blake provide for defrosting by passing a hot gas through the evaporator under the influence of a pressure differential and embody the use of valves controlling the pressure in the hot gas supply line and in the liquid refrigerant supply line and having valves for selectively connecting an evaporator for refrigeration or for defrosting. During defrosting the liquefied refrigerant is injected into the liquid refrigerant supply line by reason of said pressure differential. No continuous supply of hot gas is provided to vaporize the liquid return from the defrosting cycle. Here it is preferable that at least two evaporator units be in refrigeration cycles for each evaporator in a defrosting cycle to provide an adequate supply of vaporized refrigerant to the compressor.

The U.S. Letters Patent 2,729,950 to Toothman shows the flow of hot gas during a defrosting cycle being diverted through a branch line to provide heat for chambers in a vessel for reheating and revaporizing the liquefied refrigerant for return to the compressor. Here both the diverted hot gas and revaporized refrigerant return to the suction side of the compressor and thus throwing an excessive load onto the compressor.

The invention herein comprises a coil forming a counter-flow heat exchanger and referred to as a revaporizer through which hot gases normally and continuously pass from a compressor to a condenser during the entire operation of the system, and a liquid line runs from the condenser to a multiple of evaporators with a return line from said evaporators running to the compressor in a refrigeration cycle, and a bypass line provides a controlled diversion of a sufficient portion of said hot gas to an evaporator for a defrosting cycle, and a line carries the return liquefied refrigerant in a defrost cycle through said revaporizer to revaporize the same for return to the compressor.

It is an object of this invention therefore to provide a refrigeration system embodying the use of a hot gas defrost system wherein the refrigerant liquefied during the defrosting cycle is revaporized by the use of heat from the hot gas normally flowing from the compressor to the condenser without interference with or impairing the efficiency of the normal refrigeration cycles.

It is another object of this invention to provide an improved refrigeration system wherein a multiple of evaporators may be selectively defrosted and the return liquefied refrigerant in a defrosting cycle will be returned in a revaporized state to the suction side of a compressor after first passing through a counter-flow revaporizer to counter-flow the normal flow therethrough of hot gas refrigerant passing from the compressor to the condenser of the system.

It is another object of this invention to utilize the normal flow of hot gas from a compressor to a condenser by running it through an intermediate counter-flow heat exchanger or revaporizer of one refrigeration system to provide a fully adequate heat source to revaporize liquid refrigerant returning in a defrosting cycle for return to the compressor of an adjacent refrigeration system.

These and other objects and advantages of the invention will be set forth in the following description made in connection with the accompanying drawings in which like reference characters refer to similar parts throughout the several views and in which—

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FIG. 1 is for the most part a schematic plan view of the refrigeration system herein;

FIGS. 2 and 3 are broken views showing a detail of construction on an enlarged scale;

FIG. 4 is a schematic plan view showing a modified refrigeration system; and

FIG. 5 is a broken schematic plan view showing another modification.

Description of a preferred embodiment

Referring to FIGS. 1-3 of the drawings, a low temperature or commercial type of multiple evaporator refrigeration system 10 is shown for the most part schematically in plan. Said system comprises a condenser receiver 11 hereinafter referred to as a condenser. A main liquid refrigerant supply line 14 runs from said condenser to a liquid line header 16 from which extend individual liquid refrigerant lines 16a, 16b, 16c and 16d. Said lines respectively have in connection therewith manual shut off valves 17. Said valves are installed for shut down purposes. Said lines 16a-16d continue through connecting means comprising solenoid valves 19a, 19b, 19c and 19d and from thence respectively to the evaporators 21 designated as groups or units 21a, 21b, 21c and 21d. The evaporators are of conventional design and operation in parallel relationship. As is shown, some of the designated evaporators are in multiples in parallel relationship but as designated are referred to in the singular.

The refrigerant goes out from the condenser in a liquid state to the evaporators and picks up heat in passing through and refrigerating the evaporators and thus changes to a vapor state. The refrigerant in vapor form takes a return path from the evaporators through individual suction lines 23a, 23b, 23c and 23d. Said lines respectively extend to connecting means comprising conventional 3-way reversing valves 25, 26, 27 and 28 to have passage therethrough and respectively through lines 23e, 23b, 23g and 23h to a common return suction line 30, which runs to an accumulator 32 of conventional design. Said 3-way valves respectively have ports A, B, and C. Said individual suction lines 23a-23d run directly to the respective ports A, and extensions 23e-23f of said individual suction lines run from the respective ports B to said common return suction line 30. During refrigeration, ports A and B are normally in open communication with one another and are closed off from port C. From said accumulator a suction line 30a runs to the suction side of a multiple of compressors 35 which are in parallel relationship and are hereinafter referred to as compressor.

From the discharge or outlet side of the compressor, the refrigerant in a hot gas or vapor state passes through discharge lines 38 and 39 and through a heat exchange means comprising a counter-flow or heat exchanger type of coil 42 forming a revaporizer which will be further described, and from thence said refrigerant runs through a continuation of said line 39 to the condenser. The above describes a refrigeration cycle. Said coil 42 may be variously formed but is shown here as an enlarged intermediate portion of said line 39.

The evaporators require periodic defrosting and they will be selectively defrosted by a defrosting timing mechanism which is conventional and not here shown and which operates or energizes control means comprising solenoid valves 50a-50d which will be described, it operates to deenergize appropriate of the solenoid valves 19a-19d and operates said 3-way valves as will be described. A hot gas line 41 which is a takeoff line from said line 38 has individual lines 41a-41d respectively running therefrom to said 3-way valves 25-28 to connect and communicate directly with the ports C of said valves. At the connection of said lines 38 and 41 is a shutoff valve 43.

There is a reverse cycling or flow of refrigerant with respect to the particular evaporator being defrosted. In commencing a defrosting cycle, the timing mechanism will energize the appropriate solenoid valves 50a-50d to open

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the same, deenergize the corresponding solenoid valves 19a-19d to close the same and actuate the corresponding 3-way valve 25-28 to open the ports C and A for passage therethrough and close off the port B. During the refrigeration cycle there is passage only between ports A and B with port C being closed off. Thus hot gas will flow from the selected of the lines 41a-41d to and through the corresponding lines 23a-23d and on through the corresponding evaporator.

The hot gas refrigerant is reduced to a liquid refrigerant in defrosting an evaporator and thus the defrosting gas is in liquid form on its return passage which is a reverse flow through the particular of the liquid lines 16a-16d corresponding to the evaporator being defrosted and through the solenoid valves 50a-50d corresponding with said lines. The corresponding solenoids 19a-19d are closed as indicated.

Running from the lines 16a-16d respectively are lines 60a-60d and these lines respectively carry said solenoid valves 50a-50d. Said lines 60a-60d all run into the common defrost return line 60 which runs into and through said revaporizer 42 and extends from the discharge side thereof and at the discharge side of said revaporizer has installed therein a conventional crankcase pressure regulating valve 65. This valve controls the pressure or flow of vaporized refrigerant returning from a defrosting cycle and running to the suction side of the compressor. The liquid refrigerant returning through the line 60 counterflows the hot gas passing from the compressor through the lines 38-39 and said revaporizer to the condenser.

Shown in line 60 adjacent its outflow side of said revaporizer is a conventional heat sensitive control element 67 having a fluid coupling with a thermally operated modulating valve 68 installed in the line 60 adjacent its inflow point with respect to said revaporizer 42. If the refrigerant passing through the line 60 is not picking up sufficient heat for revaporization from the hot gas passing through the line 39, then said element 67 at a predetermined minimum temperature of the refrigerant in line 60 will actuate the valve 68 to restrict the flow of refrigerant therethrough sufficiently to enable said refrigerant to pick up sufficient heat in the coil to reach a desired temperature range. Thus the element 67 and said valve 68 represent temperature and flow control means with respect to the refrigerant passing through the revaporizer in a defrost cycle. Thus refrigerant in liquid state is prevented from returning to the compressor.

Extending from valve 65 as an extension of the line 60 is line 62 running to the common suction line 30.

With reference to said coil 42 as shown in FIGS. 2 and 3, this is here shown formed as an enlarged portion of the line 39. Line 60 extends therethrough in a conventional manner, appropriate fittings not shown may be used. The refrigerant passing through the line 60 counterflows the hot gas refrigerant passing through said coil or revaporizer 42.

The electrical circuitry is not shown. It is conventional and known in the art.

A defrost cycle with respect to the evaporator will be described briefly for purpose of illustration. The defrost timing mechanism at a given time will energize the solenoid 50d to open the same and deenergize the solenoid 19d to close the same. At the same time said timing mechanism actuates the 3-way valve 28 to open the ports C and A for passage from one through the other and shuts off the port B.

Thus with free passage from line 41d through line 23d by way of ports C and A of the 3-way valve 28, hot gas passes directly from the discharge side of the compressor 35 to and through the evaporator 21d. Said hot gas is reduced to liquid in defrosting the evaporator and returns through line 16d which in a refrigeration cycle supplies liquid refrigerant. With the solenoid valve 19d closed, said return liquid refrigerant passes through the open solenoid valve 50d, through the individual return

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line 60d and through the common return line 60 into and through the revaporizer 42 and from thence through the line 62 to the common suction line 30.

The liquid refrigerant in passing through the revaporizer is vaporized into a condition acceptable into the suction side of the compressor. The hot gas counter-flowing the liquid refrigerant running through said revaporizer, has a temperature on the order of 180° F., and gives up from 80°-90° F. of this temperature in revaporizing the liquid refrigerant returning from a defrost cycle. This revaporization results from the normal and ordinary operation of the refrigeration system with respect to its refrigeration cycles. Not only is the hot gas from the compressor utilized for revaporizing the liquid refrigerant returning from a defrost cycle but in so doing the temperature of the hot gas is lowered which may be regarded as a precondensing step and thus the load on the condenser is lessened. The operation of the system herein has shown by test that the otherwise required defrosting time is reduced by one-half with many consequent benefits resulting from this in food preservation.

There is a substantial dual benefit for the refrigeration system and a mutual benefit as between the refrigeration and defrosting cycles of the refrigeration system. The possible return of liquid and slugs to the compressor is avoided. The presence of oil in the refrigerant is satisfactorily deposited in the accumulator. The embodiment of the revaporizer into the refrigeration system is a relatively simple addition thereto requiring a minimum of additional piping. Thus the above described refrigeration system is a complete self-contained operating unit.

Modification

A modification of the refrigeration system above described is shown in FIG. 4 being generally indicated by the reference numeral 100 and comprises a compressor 101, a condenser 102 and a multiple of evaporators 103.

Running from said condenser is a liquid refrigerant supply line 105 having a shutoff valve 106 and a solenoid valve 107 installed therein. Said line runs to a header line 105a which has individual takeoff lines 105b, 105c and 105d connecting the evaporators shown in parallel. In connection with said evaporators is a return or suction line 112 which includes a header line 112a having individual takeoff lines 112b, 112c and 112d running to the respective evaporators.

Said line 112 extends to a line connecting means 116 comprising a conventional 3-way valve having ports A, B and C. Said line 112 runs to the port A. Running from port B of said valve is line 115 which in effect forms a continuation of the line 112 and runs to a conventional accumulator 117 from which a line 120 runs to the suction side of said compressor 101.

A hot gas line 122 runs from said compressor to said condenser having an intermediate portion thereof forming a coil 124 of like structure as the coil 42 above described comprising a revaporizer in like manner.

The hot gas refrigerant from line 122 enters into said condenser. A line 130 having a shutoff valve 132 therein carries hot gas refrigerant from said condenser to port C of said 3-way valve and with communication between ports C and A said line communicates with the suction line 112 running to evaporators for defrosting the same. The liquid refrigerant return from said evaporators during the defrosting cycle is through the liquid refrigerant supply line 105 to the return liquid refrigerant line 135 to said revaporizer 124. Said line 135 runs through said revaporizer in a manner as described in connection with the revaporizer 42 and extends therefrom to a crankcase pressure regulating valve 136 from which valve a line 138 runs to the suction line 115. Said line 135 has a control or connecting means therein comprising a solenoid valve 137, which valve is opened during a defrosting cycle.

An electrical timing mechanism of conventional de-

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sign and not here shown will be used in a conventional manner to operate the defrost cycles.

In the start of a defrost cycle, the solenoid valve 107 will be deenergized and closed. The solenoid valve 137 will be energized and opened for passage therethrough. The 3-way valve 116 will be energized to have ports C and A in communication with one another for passage through the valve. The port B will be shut off.

Hot gas refrigerant flows continuously from the compressor through the revaporizer to the condenser throughout the entire operation of the refrigeration system whether in refrigeration or defrosting cycles. Said hot gas refrigerant passing from the condenser through the line 130 passes in vapor form through the evaporators returning in liquid form for passage through the line 135 through said revaporizer to be revaporized for return to the suction side of the compressor.

As described above, the maintenance of the revaporizer by the continuous flow of hot gas refrigerant therethrough for revaporizing the return liquid refrigerant counter-flowing therethrough and the resulting highly efficient revaporization of said return liquid refrigerant is an essential element in substantially reducing the time required for a defrosting cycle, and the use of said revaporizer avoids the passage of liquid or slugs into the compressor.

The modification of the refrigeration system hereinabove described is well adapted for a refrigeration system having a single unit or group of evaporators embodied therein.

Modification

With reference to FIG. 5, another modification is shown of the structure described in FIGS. 1-3 showing the use of a revaporizer from one refrigeration system for an adjacent refrigeration system. Only so much of structure is here shown as is necessary to disclose and describe the modification.

The refrigeration system indicated generally by the reference numeral 10' is like the refrigeration system 10 above described except as hereinafter modified. Like parts thereof are indicated by like numerals and modified portions are indicated by like numerals with a prime added.

Adjacent said refrigeration system 10' is a like refrigeration system 10'' with only a small portion thereof being shown for purpose of disclosure herein. The compressor and condenser thereof are not shown and are the same as compressor 35 and condenser 11.

The modification herein has reference only to the liquid refrigerant return line used during a defrost cycle.

With reference to the refrigeration system 10', the liquid refrigerant return line 60' thereof has a portion thereof running through the revaporizer 42' of the adjacent refrigeration system 10'' and said line through the line 62' returns the refrigerant revaporized to the suction line 30 of said refrigeration system 10'.

In like manner the return liquid refrigerant line 60'' of the refrigeration system 10'' has a portion thereof running through the revaporizer 42 of said refrigeration system 10' and said line through the line 62'' returns said refrigerant revaporized to the suction line of the refrigeration system 10''.

Thus for revaporizing return liquid refrigerant in a defrost cycle, the revaporizer of one refrigeration system serves the adjacent refrigeration system.

Thus it is seen that there has been provided a simple and efficient means for revaporizing the return liquid refrigerant of a defrosting cycle without interference with the normal operation of the refrigeration cycles.

What is claimed is:

1. A refrigeration system 10' including a compressor 35 and a condenser 11 having in combination, a hot gas supply line 38, 39 running from said compressor to said condenser passing hot gas refrigerant continuously, said line having an intermediate portion thereof formed into a coil 42,

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a liquid refrigerant common supply line 14 running from said condenser,
 a common suction line 30, 30a running to said compressor,
 a multiple of evaporator units 21a-21d connected in parallel by respective individual liquid refrigerant supply lines 16a-16d and suction lines 23a-23d between said common liquid refrigerant supply line 14 and said common suction line 30,
 a second hot gas line 41 running from said first mentioned hot gas line 38, means selectively connecting said second hot gas line 41 to an individual suction line 23a, 23b, 23c or 23d of one of said evaporator units 21a-21d for reverse flow of hot gas refrigerant through said last mentioned individual suction line to said one of said corresponding evaporator units,
 means disconnecting said last mentioned individual suction line of said corresponding evaporator unit from said common suction line 30, 30a,
 means disconnecting the individual liquid refrigerant supply line of said last mentioned evaporator from said common liquid refrigerant supply line 14,
 a second compressor and a second condenser having a hot gas line 39'' running therebetween with said last mentioned hot gas line having an intermediate portion thereof formed into a coil 42'',

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a return line 60' running from said last mentioned individual liquid refrigerant supply line 14 through said coiled portion 42'' of said last mentioned hot gas line 39'' and to said common suction line 30, 30a, and
 means connecting said individual liquid refrigerant supply line and said return line 60', said individual liquid refrigerant line and said return line 60' carrying the return of hot gas from said second hot gas line 41, the hot gas in said second hot gas line 41 having been reduced to a liquefied state in defrosting said one of said evaporators and becoming revaporized in passing through said coiled portion of said last mentioned hot gas line 39''.

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MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

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