July 16, 1968 O. J. NUSSBAUM 3,392,542

HOT GAS DEFROSTABLE REFRIGERATION SYSTEM

Filed Oct. 14, 1966 3 Sheets-Sheet 1

Fig-1

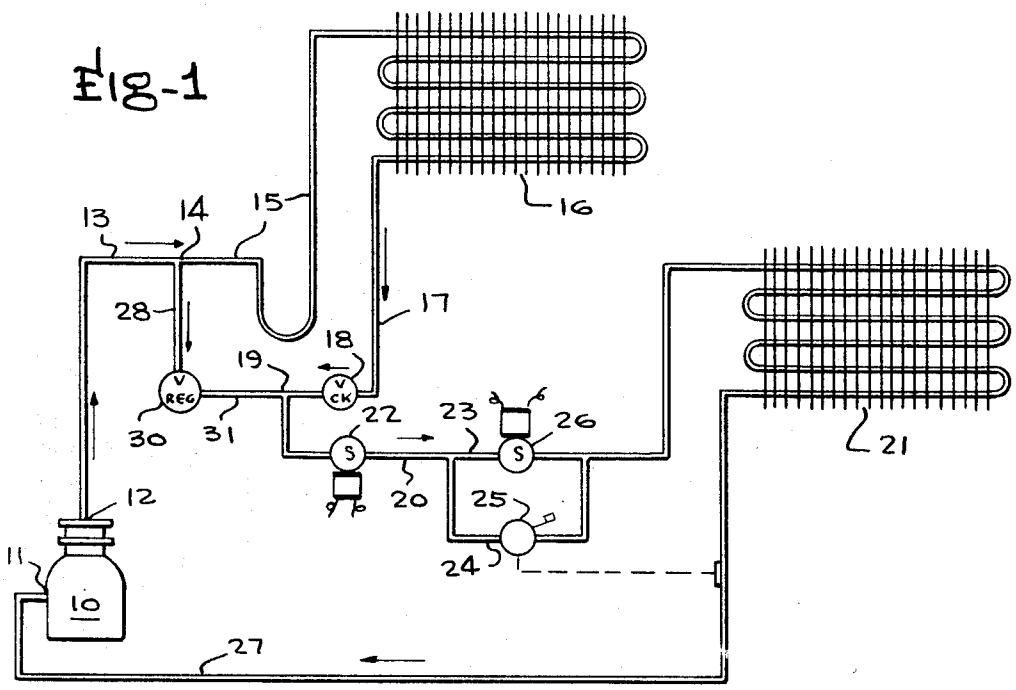
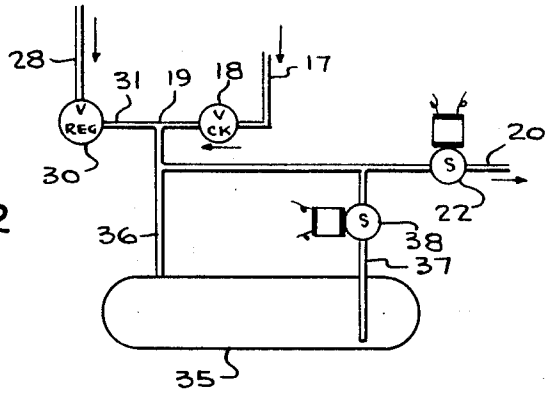


Fig-2



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HOT GAS DEFROSTABLE REFRIGERATION SYSTEM

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Fig-3

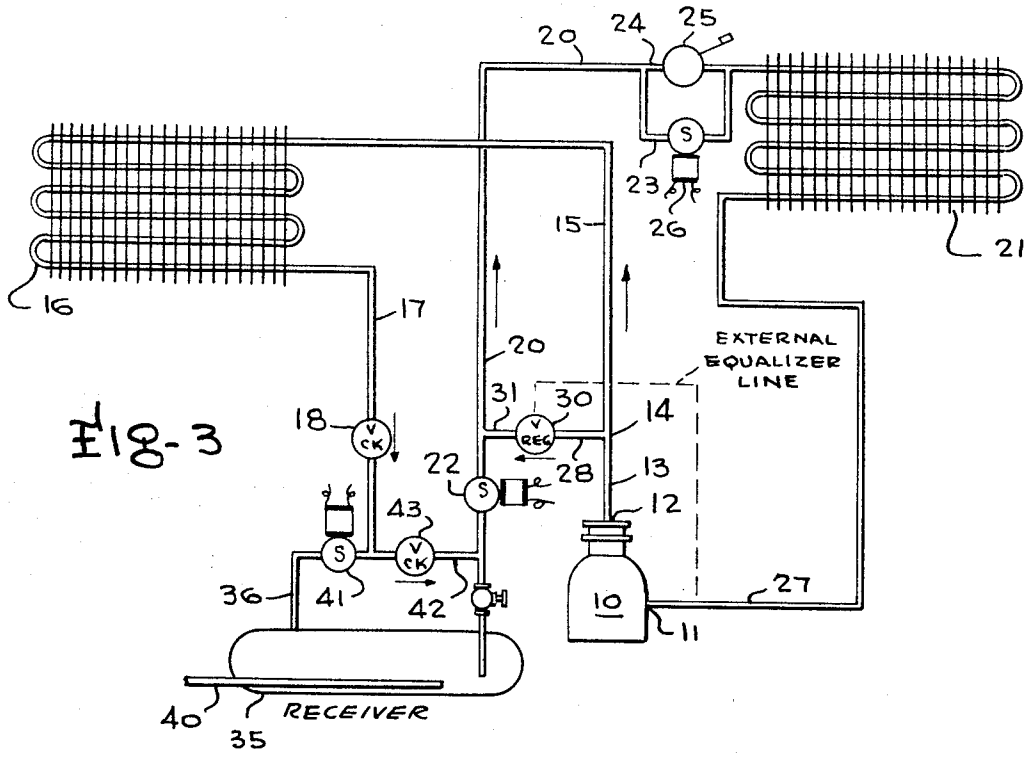
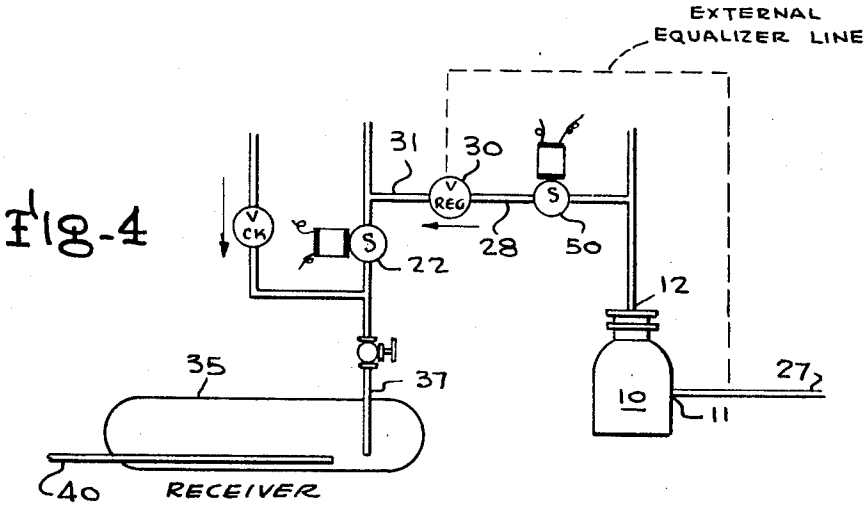


Fig-4



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HOT GAS DEFROSTABLE REFRIGERATION SYSTEM

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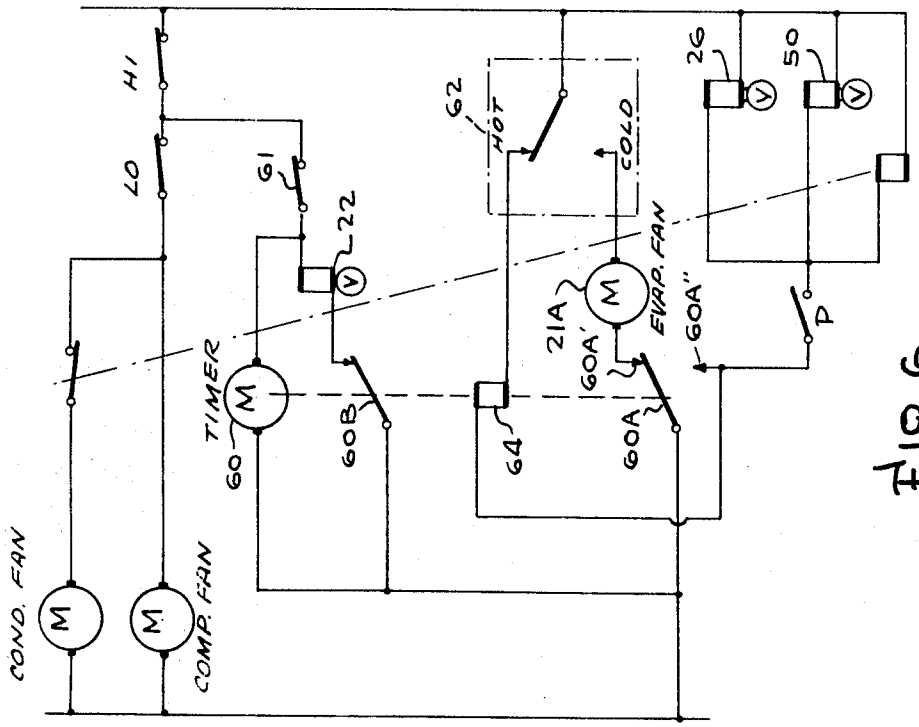


FIG-6

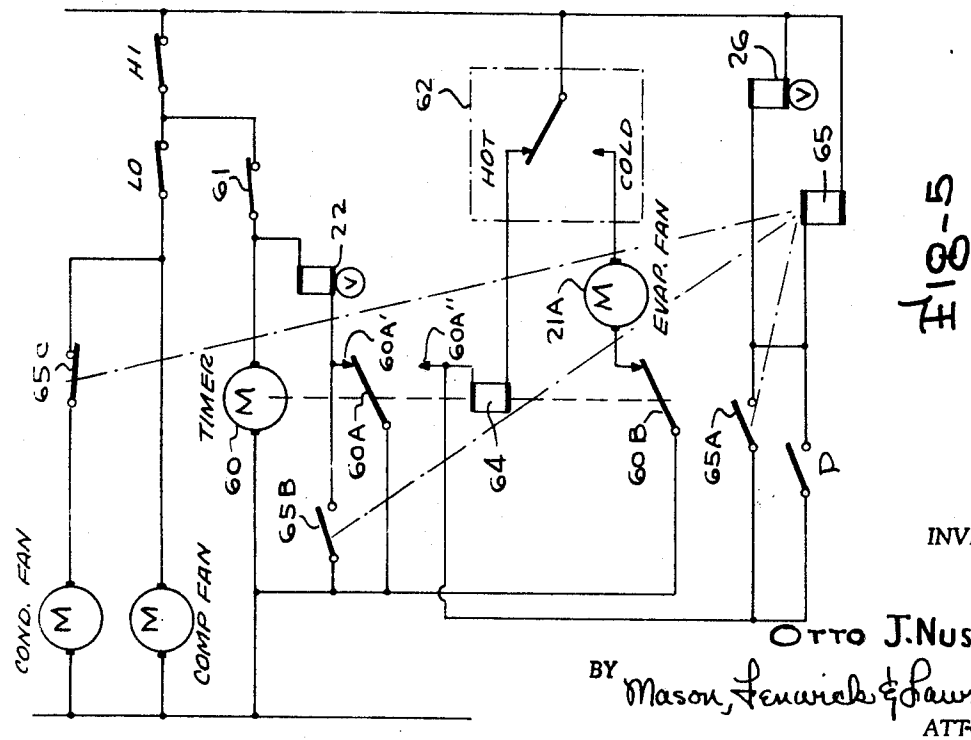


FIG-5

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HOT GAS DEFROSTABLE REFRIGERATION SYSTEM

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8 Claims. (Cl. 62—196)

ABSTRACT OF THE DISCLOSURE

A hot gas defrostable refrigeration system wherein the conduit means connecting the condenser with the evaporator includes a single conduit extending between the high side and the low side of the system serving as a combined liquid and hot gas line conducting condensed refrigerant to the evaporator during the refrigeration cycle and conducting gaseous refrigerant without any liquid refrigerant intermixed therewith to the evaporator during the defrost cycle, together with suitable valve means, the hot gaseous refrigerant being delivered to the evaporator at suitable temperature and pressure during the defrost cycle to cause defrosting without any condensation of refrigerant in the evaporator.

The present invention relates in general to refrigeration systems, and more particularly, to an improved refrigeration system having a hot gas defrosting system incorporated therein for periodic defrosting of the evaporator by admission of hot gaseous refrigerant thereto from the compressor, without providing the usual separate hot gas line.

Although, hot gas defrost systems are generally recognized as being the most efficient and fastest available defrost systems, the general acceptance is still hampered by the fact that by comparison with other defrosting systems, hot gas defrost systems are more costly to install because they require the refrigeration contractor to run a separate by-pass line from the condensing unit to the evaporator. Such hot gas defrosting systems generally supply the hot gaseous refrigerant from the discharge or high side of the compressor to the evaporator by way of a separate branch conduit or by-pass line which is connected to the usual conduit from the high pressure side of the compressor to the condenser. It is a common characteristic of any such hot gas defrost systems that during the defrost operation, the liquid line extending from the condenser to the evaporator, in a receiverless system, or from the receiver to the evaporator in a receiver system, is unused because flow to the evaporator goes through the hot gas by-pass line and flow from the evaporator occurs through the suction line. Thus, in such hot gas defrost systems, while the cost-increasing separate hot gas line for bypassing the hot gas to the evaporator is used during the defrost operation, that portion of the liquid line extending from the condensing unit to the evaporator remains idle throughout the period of the defrost operation.

It is therefore an object of the present invention to provide a novel refrigeration system having a hot gas defrost system incorporated therein, wherein the liquid line extending from the condensing unit to the evaporator, which normally conveys the condensed liquid refrigerant to the evaporator during normal refrigeration operation, is utilized as a hot gas line during the defrost operation to convey hot gaseous refrigerant directly from the compressor to the evaporator, thus eliminating the need for the installation work attendant to the provision of a separate by-pass line for hot gaseous refrigerant.

Another object of the present invention, is the provision of a novel refrigeration system having a hot gas defrosting system incorporated therein, utilizing the same conduit line from the condensing unit to the evaporator for the conduction of liquid refrigerant during the refrigeration cycle and for the conduction of hot gaseous refrigerant during the defrosting cycle.

Another object of the present invention, is the provision of a novel refrigeration system having a hot gas defrost system incorporated therein, of the character described in the immediately preceding paragraph, wherein the need for oversizing the combined liquid and hot gas defrost line extending from the condensing unit to the evaporator is avoided.

Another object of the present invention is the provision of a novel refrigeration system having a hot gas defrost system incorporated therein, wherein the system is arranged so that the defrost pressure control valve may be incorporated as part of the condensing unit and a hot gas defrost solenoid valve may be provided in the evaporator assembly, thus facilitating the provision of a packaged system without requiring separate installation by a refrigeration contractor of a separate valved by-pass line from the condensing unit to the evaporator.

Other objects, advantages, and capabilities of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings illustrating several preferred embodiments of the invention.

In the drawings:

FIGURE 1 is a diagrammatic view of a refrigeration and hot gas defrosting system, embodying the present invention in a receiverless system;

FIGURE 2 is a fragmentary diagrammatic view of a modification of the system of FIGURE 1 for a receiver system, repeating only the illustration of those components of the system of FIGURE 1 necessary to an undertanding of the location of the receiver and its associated components in that system;

FIGURE 3 is a diagrammatic view of a modified refrigeration and hot gas defrosting system embodying the present invention, employing head pressure control features utilizing a heated receiver;

FIGURE 4 is a fragmentary diagrammatic view representing a modification of FIGURE 3 and employing a heated receiver in the head pressure control system; and

FIGURES 5 and 6 are schematic control wiring diagrams disclosing examples of control circuits which may be used with the systems of the present invention.

The invention will be specifically described in conjunction with the type of hot gas defrosting method disclosed in the Shrader Patent No. 3,098,363 or the White Patent No. 2,688,860 as an aid to understanding the preferred forms of the invention, wherein the formation of liquid in the evaporator during the defrost operation is prevented by controlling the pressure of the hot gas entering the evaporator so that the saturation temperature of the refrigerant will be below that of the surrounding evaporator tube and frost. In such a system, no condensation takes place in the evapoartor during the defrost operation so that no supplementary devices such as re-evaporators are necessary to prevent passage of liquid refrigerant to the compressor. However, the hot gaseous refrigerant delivered to the evaporator surrenders only sensible heat to the tube surface for defrosting, as distinguished from the "latent" heat which is surrendered by the more conventional systems where condensation takes place in the evaporator, although the temperature of the superheated gaseous refrigerant entering the evaporator during the defrosting cycle is considerably higher than what would be the case in the "latent" heat systems, so that the greater temperature difference between the hot gas and the coil surface results in more intensive heating of the evaporator during defrost.

Referring particularly to the system illustrated in FIGURE 1, the refrigeration system comprises a compressor **10** of conventional construction, having a suction intake or low side **11** and a discharge or high side **12**. The condenser discharge is connected through conduit **13** to a junction **14**, such as a T fitting, an extension conduit **15** of the discharge conduit **13** extending to the condenser **16**, such for example, as an air-cooled condenser disposed at an exterior location having the usual fan associated therewith. The outlet end of the condenser **16** is connected by conduit **17** having a check valve **18** therein, which extends to a junction point **19** and has a liquid line **20** extending therefrom to the inlet end of the evaporator **21**, the conduit **20** serving as the combined liquid line and hot gas defrost line in a manner to be hereafter described in detail. The liquid line **20** has a liquid solenoid valve **22** therein and a branched pair of paralleled conduits near the evaporator **21**, indicated by reference characters **23** and **24**, either one of which may be a continuation of the liquid line **20** and the other may be a parallel conduit connected at both ends to the liquid line **20** at spaced points along the same, one of which conduits **23**, **24** contains a thermostatic expansion valve **25** for regulating the flow of liquid refrigerant to the evaporator during the refrigeration cycle, and the other of which contains a defrost solenoid valve **26**. The evaporator outlet is connected by the usual suction line **27** to the suction intake or low side **11** of the compressor **10**. A branch conduit **28** extends from the junction point **14** of the discharge conduit **13** to an outlet pressure responsive control valve **30**, the outlet end of the valve being connected by conduit **31** to the junction point **19** of the line **17** extending from the outlet of the condenser **16**.

In the refrigeration cycle of the system, refrigerant is discharged by the compressor **10** through the conduits **13**, **16** to the condenser **16**. The outlet pressure responsive control valve **30** is set to remain closed as long as the pressure at its outlet is above the predetermined defrosting pressure, so that during the refrigeration cycle this valve **30** is closed and no gaseous refrigerant flows through the conduits **28**, **31**. From the condenser **16**, the liquid refrigerant flows through check valve **18** in conduit **17** and through the liquid line **20**, the liquid solenoid valve **22** which is open during the refrigeration cycle, and the thermostatic expansion valve **25**, to the evaporator **21**. The defrost solenoid valve **26** in the parallel section **23** of the liquid line is closed during the refrigeration cycle. From the evaporator **21**, vaporized refrigerant returns to the compressor **10** through the suction line **27** and the cycle repeats.

When it is desired to defrost the evaporator, the defrost operation is initiated by a suitable timer and the system is caused to undergo three separate phases of the defrost cycle. During the first phase, the liquid solenoid valve **22** is closed and the defrost solenoid valve **26** remains closed while the fan on the evaporator **21** is stopped. The effect of closure of the liquid solenoid valve **22** while continuing operation of the compressor will be to rapidly evacuate the liquid line **20** between the solenoid valve **22** and the evaporator of all residual liquid refrigerant. Termination of this phase may either be timed or it may be signaled by a reduction in the evaporator pressure to a selected level, for example, about 15 p.s.i. gauge. The second phase of the defrost operation starts with opening of the defrost solenoid **26** and the liquid solenoid valve **22**. The evaporator fan for evaporator **21** remains off. This will cause a very sharp drop in pressure at the outlet of the outlet pressure sensitive control valve **30**, as a result of which the valve **30** opens and discharge gas from the compressor **10** will be diverted directly through line **28**, valve **30** and line **31** into the liquid line **20**. At the same time, the condenser fan motor is stopped, for example, by a high side pressure switch sensing the sharp drop in pressure which occurs at this point, or by switch means responding to the previously mentioned reduction in evaporator pressure to the selected level. The hot gaseous refrigerant thus flows through the line **28**, valve **30** and line **31**, and thence through liquid line **20** and its open valves **22** and **26**, to the evaporator **21**. Here, the highly superheated gas is de-superheated, surrrendering heat to the frost on the evaporator surface and returns to the compressor **10** through the suction line **27**, where the cycle is again repeated until defrost is complete. Completion of defrost is signaled by a rise in temperature of the suction line **27** near the outlet of the evaporator **21**. This signal may conveniently be sensed to close the defrost solenoid **26**, thus initiating the third phase of the defrost operation wherein the evaporator fan for evaporator **21** remains off, and the liquid solenoid valve **22** may be closed, if desired, to permit reduction of the pressure and temperature in the evaporator to the normal operating level. This third phase is terminated when the temperature of the suction line **27** at the outlet of the evapoartor **21** is reduced back to its normal operating level, at which point the evapoartor fan is started and the liquid solenoid valve **22**, if closed during the third phase, is opened. During the third phase of the defrost cycle, a rise of pressure at the outlet of the outlet pressure responsive control valve **30** will have occurred, causing that valve to close, so that refrigerant will again resume its normal pass through discharge line **13**, **15**, condenser **16**, check valve **18**, and liquid line **20** to the evapoartor **21**.

Operation of the refrigeration cycle is terminated when the thermostat sensing the temperature in the space served by the refrigeration system is satisfied, signaling the liquid solenoid valve **22** to close. With the system otherwise in the refrigeration mode, the pressure at the suction inlet of the compressor **10** will be rapidly reduced by this closure of the liquid solenoid valve **22**, causing the conventional low pressure switch of the compressor **10** to stop operation of the compressor until that thermostat again calls for cooling and opens the liquid solenoid valve **22**.

It should be noted that the outlet pressure sensitive control valve **30** performs no function during refrigeration because it will always be closed as long as the condenser functions as such.

Operation of the timer motor used for defrost may be in such a manner that starting of the timer is permitted only during periods when the space thermostat is calling for cooling and the timer is prevented from operating when the space thermostat is in a satisfied condition. This will prevent a defrost from being initiated while the compressor **10** is not in operation. This prevents unnecessary defrost operations, because if the space thermostat is in satisfied condition, no frost is accumulated on the evaporator and consequently, no defrost will be needed.

FIGURE 2 discloses a system similar to FIGURE 1 but incorporating a liquid receiver, such as would be used for larger systems in which the condenser will not be capable of holding the total refrigerant charge during pumpdown. The use of the receiver dictates the need for an additional receiver solenoid valve at the receiver outlet, which is closed during defrost while the liquid solenoid and defrost solenoid are both open. In this modified arrangement employing the receiver indicated by the reference character **35**, a receiver inlet branch conduit **36** is connected from the liquid line **20** at a point near the upstream end thereof adjacent the junction point **19** to the receiver **35** and a receiver outlet conduit **37** in the form of a branch line is connected between the receiver and the liquid line at a point spaced somewhat downstream from the point of connection between the conduit **36** and the liquid line. The receiver outlet conduit **37** has a receiver solenoid valve **38** therein. The defrost cycle in this system of FIGURE 2 is very similar to that of FIGURE 1, in that when the defrost operation is initiated by the timer, the liquid solenoid valve **22** is closed during the first phase while the defrost solenoid valve **26** remains closed, and the fan on the evaporator **21** is stopped. The liquid line **20** is thereupon rapidly evacuated of all liquid re-

frigerant, and the second phase of the defrost operation is initiated by opening the defrost solenoid valve **26** and opening of the liquid solenoid valve **22**, with simultaneous closing of the receiver solenoid valve **38**. This causes a very sharp drop in pressure at the outlet of the outlet pressure sensitive control valve **30**, opening this valve to permit flow of discharge gas from the compressor **10** through the discharge line **13**, by-pass conduit **28**, control valve **30**, and line **31**, and thence through the liquid line **20** and open valves **22** and **26** to the evaporator **21**, where the highly superheated gas is de-superheated, surrendering heat to the frost on the evaporator surface to melt the same.

The de-superheated gas returns to the compressor **10** through the suction line **27** where the cycle is again repeated until defrost is complete. The rise in temperature of the suction line **27** near the outlet of the evaporator **21** signaling completion of defrost serves to close defrost solenoid valve **26** while the evaporator fan remains stopped, to permit reduction of the pressure and temperature in the evaporator to the normal operating level. Valve **22** may also be closed during this terminal phase of the defrost cycle. When the temperature of the suction line **27** at the outlet of the evaporator **21** is reduced back to its normal operating level, the evaporator fan is started and the liquid solenoid valve **22**, if closed during the third phase, is opened. The receiver solenoid valve **38** in the receiver outlet line **37** may be opened at the initiation of the third phase of the defrost cycle when the defrost solenoid valve **26** is closed, or it may be opened at the completion of the third phase of the defrost cycle. Upon reopening of the receiver solenoid valve **38**, closing of the defrost solenoid valve **26** and opening of the liquid solenoid valve **22**, the refrigeration system resumes the normal operating cycle for refrigeration.

FIGURE 3 illustrates an embodiment of the basic refrigeration and hot gas defrost system of the two preceding embodiments employing the combined liquid and hot gas line **20**, in conjunction with a head pressure control system using a heated receiver. In the embodiment of FIGURE 3, the components of the system corresponding to those described in the preceding embodiments are identified by the same reference characters as previously used. The receiver **35** in the FIGURE 3 embodiment, however, is a heated receiver, having for example, an internal electric heater therein, identified by the reference character **40**, which is controlled by a suitable switch, such as a pressure sensitive switch, responsive to receiver pressure or receiver temperature, in accordance with the principles disclosed in the earlier U.S. Patent No. 3,238,-737 granted Mar. 8, 1966, to Raymond M. Shrader et al., and owned by the assignee of this application, so as to elevate the temperature, and consequently the pressure, in the receiver **35** when the receiver pressure falls below a selected level. Thus, means are provided to energize the heater **40** so as to heat the liquid refrigerant in the receiver **36** to elevate the vapor pressure in the receiver to a desired degree whenever the head pressure, or other criteria sensed, indicates that excessive capacity of the condenser **16** is lowering head pressure. The receiver inlet line **36** extending from the downstream end of the condenser outlet line **17**, has a normally open solenoid valve **41** therein, and the condenser outlet line **17** below the check valve **18** therein is connected at the junction with the receiver inlet line **36** by a by-pass line **42** having a check valve **43** therein, which connects to the receiver outlet line **37**. The junction of the by-pass line **42** and receiver outlet line **37**, above the usual manual valve in the latter, is connected to the liquid line **20**, which serves as the combined liquid and hot gas line, similar to the liquid line of the preceding embodiments, having the liquid line solenoid valve **22** therein. The hot gas by-pass line by-passing the condenser **16** during the defrost cycle, and composed of line **28**, outlet pressure responsive valve **30** and line **31** connects to the liquid line **20** in the FIGURE 3 embodiment downstream of the liquid solenoid valve **22**, between the latter and the paralleled thermostatic expansion valve **26** and defrost solenoid valve **26**. The outlet pressure responsive control valve **30** in this embodiment is also equipped with an external equalizer line indicated at **45**, coupled to the suction line **27** near the compressor intake **11**, to enable the control valve **30** to respond directly to compressor suction pressure.

In the summer mode of operation of the FIGURE 3 system, when the ambient conditions are appropriate for ordinary efficient operation of the refrigeration system, the solenoid valve **41** is open and the condensed liquid refrigerant in the line **17** delivered by the condenser **16** passes through the open valve **41** and receiver inlet **36** through the reeciver **35** and hence through the receiver outlet line **37** and combined liquid and hot gas line **20** to the thermostatic expansion valve **25**, for delivery to the evaporator **21** and evaporation therein in the normal manner. In the winter operation of the system during seasons when low ambient conditions occur which might undesirably reduce head pressure, the solenoid valve **41** is closed so that the receiver **35** is connected to the system only by the one line and a T connection whereby automatic heating of the receiver **35** will boost head pressure and vary condenser capacity for efficient expansion valve operation as ambient conditions require.

The operation of the system disclosed in FIGURE 3 is similar to that of FIGURE 1 insofar as the defrost cycle is concerned. In the first phase following initiation of defrost, the liquid solenoid valve **22** is closed and the defrost solenoid valve **26** remains closed while the fan of the evaporator **21** is stopped. The combined liquid and hot gas line **20** is thus evacuated of all residual liquid refrigerant. The defrost solenoid valve **26** is then opened and liquid solenoid valve **22** remains closed, initiating the second phase, while the evaporator fan remains off. The resultant sharp drop in pressure at the outlet of the control valve **30** opens the control valve **30** to permit discharge gas to be diverted through lines **28**, **31** directly into the combined liquid and hot gas line **20**, and thence through the valve **26** to the evaporator **21**. When the defrost is completed, the third phase is initiated wherein the defrost solenoid valve **26** is closed while the avaporator fan remains stopped for a short period and the liquid solenoid valve **22** remains closed to permit reduction of the pressure and temperature in the evaporator to the normal operating level.

The FIGURE 4 system is very similar to that of FIGURE 3, employing a heated receiver **35** like the FIGURE 3 embodiment, but having a slightly simplified head pressure control arrangement. In the system of FIGURE 4, the receiver outlet line **37** is retained as the single receiver connection with the condenser outlet line **17** and the combined liquid and hot gas line **20**, the solenoid valve **41** and the receiver inlet line **36** being eliminated. The liquid solenoid valve **22** is located between the downstream end of the condenser outlet line **17** and the outlet line **31** connected to the outlet of the control valve **30** as in the FIGURE 3 embodiment. However, in this version of FIGURE 4, the downstream pressure sensitive control valve **30** has a shut-off solenoid valve **50** installed on its inlet side to permit operation on a pump-down cycle; in other words, the control valve **30** is prevented from feeding hot gas to the combined liquid and hot gas line **20** when the liquid solenoid valve **50** closes in response to a signal from the thermostat. The control valve **30** and solenoid shut-off valve **50** may be combined into a single device which is commercially available. A distinctive property of these systems herein above described is that they never run out of heat during defrost as some other methods now presently commercially available do. The reason is that the defrosting circuit is completely self-contained and no refrigerant is either added or taken away from the defrosting circuit. Furthermore, the compressor is the sole source of heat on which the

system relies and in view of the fact that the compressor always operates during defrost, it provides an inexhaustible source of heat. Since no condensation takes place during defrost in the particular versions herein described, only vapor circulates in the defrost cycle so that the refrigerant charge required for the defrosting circuit is minimal.

As previously described, however, the present systems may also be used with defrost methods involving condensation of hot gaseous refrigerant in the evaporator, so long as a source of heat is included in the circuit between the evaporator and the compressor intake during the defrost cycle to ensure that no liquid refrigerant reaches the compressor.

FIGURE 5 illustrates schematically one control wiring circuit which may be used for the systems of FIGURES 1 or 2, the solenoid valves in the control wiring circuit of FIGURE 5 corresponding to solenoid valves of the refrigeration circuit of FIGURES 1 and 2 being designated by the same reference characters used in FIGURES 1 and 2. As shown in the control wiring circuit of FIGURE 5, the timer motor **60** is connected in series with the space thermostat **61** so that the timer-motor operates only when the thermostat **61** is closed. Therefore, the defrost operation can start only when the thermostat **61** is closed, and consequently, the system is in operation. This is particularly desirable in cold climates because if defrost is initiated with the compressor off, considerable time will elapse until a sufficient head pressure is generated to produce defrost. The timer motor **60** operates a double throw switch **60A** having normally closed contact **60A'** and normally open contact **60A''**, and a normally closed single throw switch **60B**. During the refrigeration cycle, the switches **60A** and **60B** are in the positions shown in FIGURE 5, wherein the supply circuit to liquid line solenoid valve **22** is completed through contact **60A'** of switch **60A** and space thermostat **61**, maintaining the valve **22** open as long as the refrigerated space needs cooling. At the same time, the evaporator fan motor **21A** is energized through switch **60B** as long as defrost termination thermostat **62** is in the cold position, indicating that the evaporator coil is on the refrigeration cycle.

When defrost is initiated, switch **60A** shifts to open contact **60A'**, closing valve **22**, and to close contact **60A''**. However, hot gas solenoid valve **26** is not energized, because of open pressure switch P, util the evaporator has been evacuated, whereupon the pressure switch P closes and energizes the relay coil **65** and solenoid valve **26** to open the valve **22**. This signals completion of the first phase and commencement of the second phase of the defrost cycle. Energizing of the relay coil **65** closes its contacts **65A** to maintain the coil **65** energized even though the pressure switch P breaks contact after a short period of time, and thus maintaining hot gas solenoid valve **26** energized and therefore in open condition. Simultaneous closure of a second set of contacts **65B** of coil **65** also re-energizes and opens liquid line solenoid valve **22**, and normally closed contacts **65C** of relay coil **65** in the supply circuit for the condenser fan opens to stop the condenser fan. When the thermostat **62** senses that the evaporator coil has been heated up to a predetermined temperature, as indicated by the thermostat **62** assuming the hot position, a timer release solenoid coil **65** is energized, which returns the switches **60A** and **60B** to the refrigeration position. This recloses solenoid valve **26** for the third phase of the defrost cycle, during which operation of the compressor, while the evaporator fan is stopped, reduces the pressure and temperature of the evaporator to the normal operating level, signaled by the return of the thermostat **62** to the cold position, which restarts the evaporator fan **21A** and resumes normal refrigeration. The pressure switch P is of the type having a wide differential, and is set so that it will break when the evaporator pressure or suction pressure exceeds the maximum which the compressor can safely tolerate. Therefore, the pressure switch P performs the double function of a defrost control and a high back pressure safety control. The cut-in point of the pressure switch must be above the setting of the conventional low pressure cutout of the system, so that the system will not be stopped after initiation of defrost.

FIGURE 6 shows a similar control wiring circuit which may be used with the system of FIGURE 4, the single throw switch **60B** controlled by timer **60** in this case opening the circuit to liquid line solenoid valve **22** to close this valve throughout the first and second phases of the defrost cycle and the double throw switch **60A** de-energizing the evaporator fan motor **21A** throughout the entire defrost cycle. Following evacuation of the liquid line **20**, and evaporator **21**, during the first phase of defrost, pressure switch P closes, energizing hot gas solenoid valve **26** and valve **50** to open the conduit **23** by-passing the expansion valve **25** and open valve **50** in the inlet line to valve **30**. Closure of valve **50** during the first or pumpdown phase of defrost therefore ensures no by-passing of hot gaseous refrigerant through lines **28**, **31** and valve **30** until liquid line **20** and the evaporator have been evacuated. As with the earlier described circuit of FIGURE 5, making of the hot contact of defrost termination thermostat **62** energizes the release solenoid coil **64** to return switches **60A** and **60B** to the refrigeration position, reclosing valves **26** and **50**, but leaving the evaporator fan motor **21A** de-energized for the third phase of the defrost cycle until thermostat **62** returns to the position closing its cold contact.

In each of these systems, it will be recognized that a pressure signal is utilized, sensed by a pressure switch P, to indicate proper evacuation of liquid from the refrigerant circuit downstream of the liquid line solenoid valve **22** before the second phase of the defrost cycle begins wherein the hot gaseous refrigerant is admitted to the evaporator. If mere timed delay for the evacuation phase were to be employed, this would establish a fixed time period for an occurrence which requires a time period varying with ambient temperature and evaporator frost load.

If liquid return to the compressor is to be positively prevented, all liquid must be removed from the defrost circuit prior to opening of the defrost solenoid valve **26**, since the quantity of liquid in the circuit will vary with factors of ambient temperature and evaporator frost load. Removal of liquid from the defrost circuit prior to opening of the solenoid valve **26** can be positively assured only by reducing the saturation pressure in the circuit to a predetermined value ensuring evacuation of the liquid, preferably sensed by some pressure sensing means.

While several preferred examples of the present invention have been particularly shown and described, it is apparent that various modifications may be made therein within the spirit and scope of the invention, and it is desired, therefore, that only such limitations be placed on the invention as are imposed by the prior art and set forth in the appended claims.

What is claimed is:

1. A hot gas defrostable refrigeration system having a refrigeration cycle and a defrost cycle, comprising a compressor having discharge and suction sides, the system including a highside portion wherein higher pressures prevail and a lowside portion wherein lower pressures prevail, a condenser in said highside portion coupled to said discharge side to receive refrigerant gas from the compressor during the refrigeration cycle, an evaporator in said lowside portion coupled to said suction side for return of refrigerant vapor from the evaporator to the compressor, conduit means connecting said condenser with said evaporator for flow of condensed refrigerant to the evaporator during the refrigerant cycle and for flow of gaseous refrigerant without intermixture of any

liquid refrigerant therewith during said defrost cycle including a single conduit extending between the highside and lowside of the system serving as a combined liquid and hot gas line conducting condensed refrigerant to the evaporator during the refrigerant cycle and conducting gaseous refrigerant to the evaporator during the defrost cycle, means for delivering condensed refrigerant from said condenser to said single conduit during said refrigeration cycle, by-pass conduit means for delivering hot gaseous refrigerant from said discharge side to said single conduit in by-passing relation to said condenser during said defrost cycle, and first and second valve regulated conduit sections for conducting refrigerant from said single conduit to said evaporator respectively through said second conduit section during said refrigeration cycle and through said first section by-passing said second section during said defrost cycle, said by-pass conduit means including an outlet pressure sensitive valve responsive to pressure conditions reflected from said evaporator through said single conduit when said first valve regulated conduit section is open for maintaining said valve closed during the refrigerant cycle and for opening the same during a selected portion of the defrost cycle.

2. A hot gas defrostable refrigeration system as defined in claim 1 wherein additional valve means controlling said single conduit are provided adjacent the end thereof nearest the condenser to close the single conduit during a selected initial portion of the defrost cycle for evacuating the single conduit of liquid refrigerant before admission of hot gaseous refrigerant to said single conduit.

3. A hot gas defrostable refrigeration system as defined in claim 2, wherein said means for delivering hot gaseous refrigerant from the compressor discharge side to said single conduit comprises a branch conduit having an upstream end communicating with said discharge side and a downstream end in communication with said single conduit and having said outlet pressure sensitive control valve intermediate said ends automatically responsive to pressure conditions at said downstream end to close said branch conduit throughout the refrigeration cycle and to automatically open said branch conduit during the defrost cycle responsive to pressure reduction in said single conduit during the defrost cycle for admitting hot gaseous refrigerant to said single conduit for delivery to the evaporator.

4. A hot gas defrostable refrigeration system as defined in claim 2, wherein said first conduit section includes a first electrically controlled valve, said valve means controlling said single conduit being a second electrically controlled valve and said system including electrical control means responsive to selected events to initiate a defrost cycle having three phases; the electrical control means having means for closing both said first and second valves during the first of said phases, means responsive to evaporator pressure conditions for opening both said first and second valves and establishing the second of said phases only when the sensed pressure signifies that the evaporator has been evacuated, and means responsive to evaporator temperature to reclose said first and second valves when the evaporator temperature reaches a selected level and initiate said third phase, said evaporator having fan means, and said control means including said means maintaining said fan means deactivated throughout said three phases.

5. A hot gas defrostable refrigeration system as defined in claim 1, wherein said first conduit section has a solenoid valve therein, and electrical control means for closing said solenoid valve throughout the refrigeration cycle to cause refrigerant to flow from said single conduit through said second conduit section to said evaporator and for opening said solenoid valve to admit hot gaseous refrigerant to said evaporator through said section first conduit section during selected portions of the defrost cycle.

6. A hot gas defrostable refrigeration system as defined in claim 1, wherein said means for delivering hot gaseous refrigerant from the compressor discharge side to said single conduit comprises a branch conduit having an upstream end communicating with said discharge side and a downstream end in communication with said single conduit and having said outlet pressure sensitive control valve intermediate said ends automatically responsive to pressure conditions at said downstream end to close said branch conduit throughout the refrigeration cycle and to automatically open said branch conduit during the defrost cycle responsive to pressure reduction in said single conduit during the defrost cycle for admitting hot gaseous refrigerant to said single conduit for delivery to the evaporator.

7. A hot gas defrostable refrigeration system as defined in claim 1, wherein said conduit means connecting the condenser with the evaporator includes a receiver adjacent the condenser, and means communicating the receiver with the condenser and the end of said single conduit nearest the condenser to receive condensed refrigerant from the condenser and to supply refrigerant to said single conduit.

8. A hot gas defrostable refrigeration system having a refrigeration cycle and a defrost cycle, comprising a compressor having discharge and suction sides, a condenser coupled to said discharge side to receive refrigerant gas from the compressor during the refrigeration cycle, an evaporator coupled to said suction side for return of refrigerant vapor from the evaporator to the compressor, conduit means connecting said condenser with said evaporator for flow of condensed refrigerant to the evaporator during the refrigerant cycle including a single conduit spanning the major portion of the distance between the condenser and evaporator serving as a combined liquid and hot gas line conducting condensed refrigerant to the evaporator during the refrigerant cycle and conducting gaseous refrigerant to the evaporator during the defrost cycle, means for delivering condensed refrigerant from said condenser to said single conduit during said refrigeration cycle, means for delivering hot gaseous refrigerant from said discharge side to said single conduit in by-passing relation to said condenser during said defrost cycle, means having an expansion device leg and a valved leg for conducting refrigerant from said single conduit to said evaporator through said expansion device leg during said refrigeration cycle and through said valved leg by-passing the expansion device during said defrost cycle, additional valve means controlling said single conduit adjacent the end thereof nearest the condenser to close the single conduit during a selected initial portion of the defrost cycle for evacuating the single conduit of liquid refrigerant before admission of hot gaseous refrigerant thereto, said means for delivering hot gaseous refrigerant from the compressor discharge side to said single conduit comprising a branch conduit having an upstream end communicating with said discharge side and a downstream end in communication with said single conduit and having an outlet pressure sensitive control valve intermediate said ends automatically responsive to pressure conditions at said downstream end to close said branch conduit throughout the refrigeration cycle and to automatically open said branch conduit during the defrost cycle responsive to pressure reduction in said single conduit during the defrost cycle for admitting hot gaseous refrigerant to said single conduit for delivery to the evaporator, said valved leg including a first electrically controlled valve, said valve means controlling said single conduit being a second electrically controlled valve and said system including electrical control means responsive to selected events to initiate a defrost cycle having three phases; the electrical control means having means for closing both said first and second valves dur-

ing the first of said phases, means responsive to evaporator pressure conditions for opening both said first and second valves and establishing the second of said phases only when the sensed pressure signifies that the evaporator has been evacuated, and means responsive to evaporator temperature to reclose said first and second valves when the evaporator temperature reaches a selected level and initiate said third phase, said evaporator having fan means, and said control means including said means

maintaining said fan means deactivated throughout said three phases.

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MEYER PERLIN, *Primary Examiner.*