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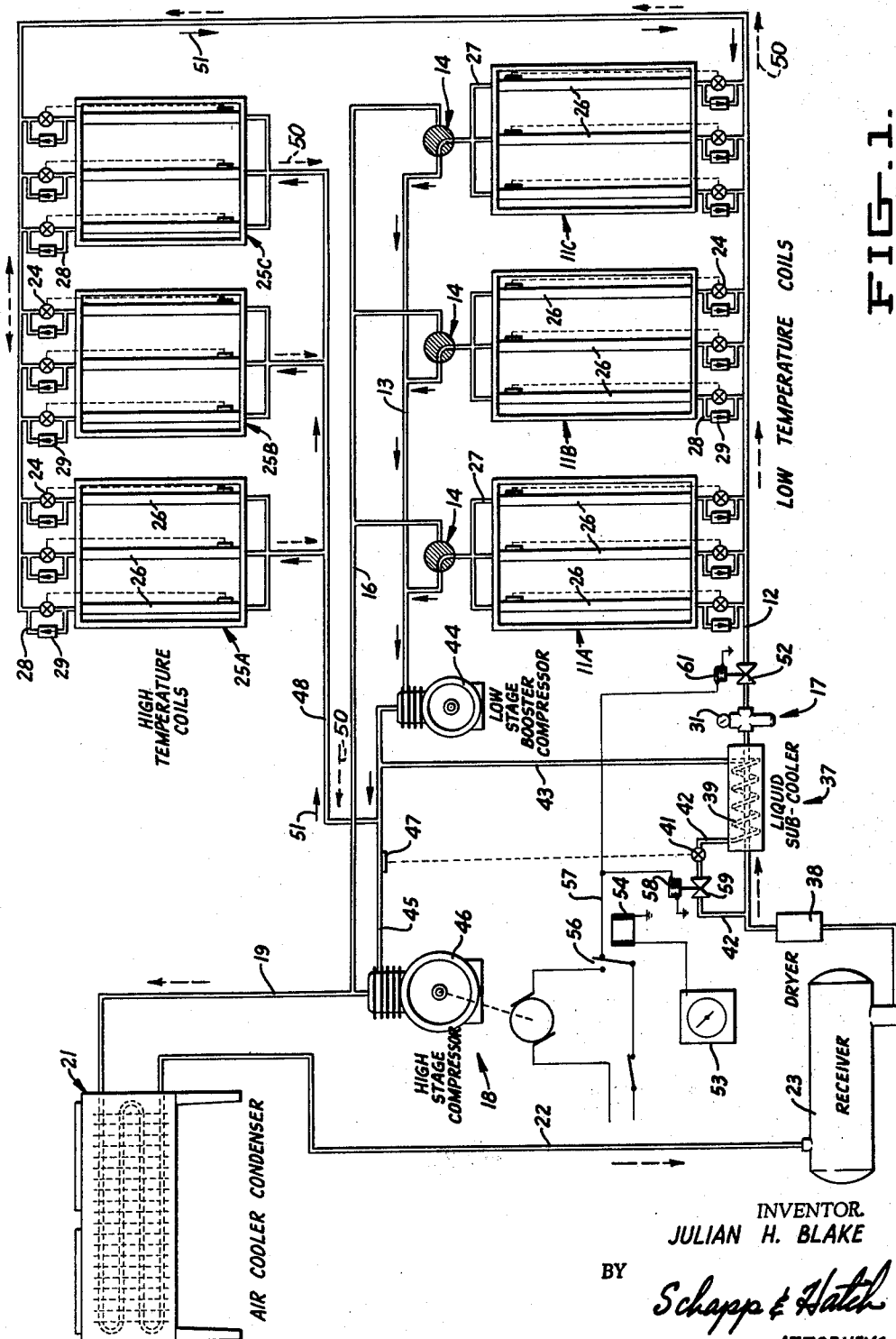
J. H. BLAKE

3,184,926

REFRIGERATION SYSTEM

Filed Oct. 10, 1963

2 Sheets-Sheet 1



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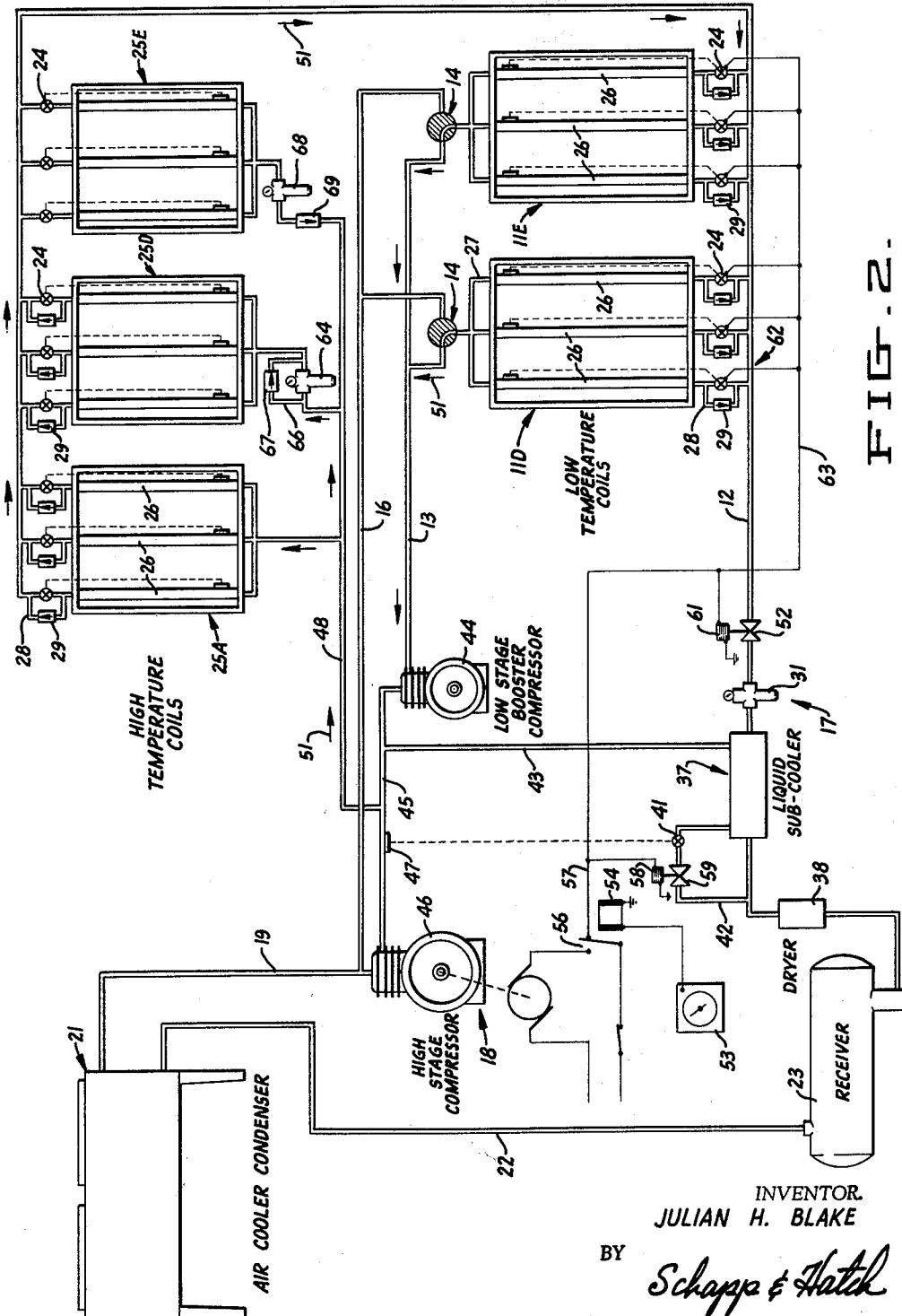
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2 Sheets-Sheet 2



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3,184,926

REFRIGERATION SYSTEM

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11 Claims. (Cl. 62-155)

This invention relates to improvements in a refrigeration system and more particularly to an improved method and apparatus for defrosting refrigerator systems including both low temperature coils and high temperature coils.

Specifically, this application is a continuation-in-part of my co-pending application Serial No. 178,408, filed March 8, 1962, entitled Method and Apparatus for Defrosting Refrigeration Systems, and this application is now issued as United States Patent No. 3,150,498.

The great increase in the frozen food industry and the widespread tendency to centralize food stores into large supermarket operations has created a huge demand for multiple evaporator refrigeration systems. Economy of installation and operation makes it highly desirable to incorporate the evaporator coils of the frozen food counters, and other refrigeration requirements such as walk-in boxes and even air conditioning in a single centralized refrigeration system.

Frozen foods must be maintained at a temperature of 0° F. or below and these low temperature requirements create considerable problems in connection with the frosting up of the evaporator coils. In order to prevent unwanted rise in temperature in the frozen food counter, defrosting of the evaporator coils must be performed as expeditiously as possible.

Developments have lagged in the art of defrosting multiple evaporators of the type set forth. In general, the methods used are the same as the methods originally conceived for use with small refrigerators and the like. These methods fall into two basic groups: (1) defrosting by the application of external heat such as the ambient heat of the atmosphere or heat from other external sources, and (2) the heat of compression produced during the refrigeration cycle and which is normally removed from the refrigerant by the condenser. It is the latter basic method of defrosting, commonly known as the "hot gas defrost method," with which the present application is concerned.

Previous hot gas defrost systems have circulated the hot gas to the evaporator either by valving the system to cause the hot gas to cycle through the evaporator in a reverse direction or by isolating the evaporator in such manner as to permit a liquid vapor cycle wherein the liquid returns to the heating point under the influence of gravity. The latter system is much too slow for large scale operation and requires an excessive amount of plumbing.

The reverse cycling hot gas defrost systems present a major disadvantage in that at least a portion of the hot gas is usually condensed into liquid form in the evaporator coil during the defrosting operation. The liquid refrigerant is then drawn into the suction line of the compressor and passes therethrough in the form of liquid slugs. If these slugs reach the compressor in liquid form they can cause breakage and other damage. This is commonly called "slugging the compressor."

To prevent damage to the compressor it has heretofore been necessary to distribute the liquid by revaporizing the slugs or by entraining the liquid in the stream of vaporized refrigerant in the form of small atomized particles. Either of these methods requires additional expensive apparatus such as heat means for effecting the revaporization or injection devices for atomizing the liquid slugs plus accumulating chambers which act somewhat in the

manner of surge tanks. Not only is the added apparatus expensive but under certain conditions slugging of the compressor is still possible.

It has been proposed to avoid the slugging problems by connecting a pair of evaporators in series with the first evaporator operating at subfreezing temperatures and the second evaporator operating at above freezing temperatures. With this system only the subfreezing evaporator needs defrosting and it is possible to cycle the hot gas from the compressor through the subfreezing evaporator, to effect defrosting thereof, and into the above-freezing evaporator where any liquefied refrigerant will be expanded into gaseous form. This is really only an adaptation of the revaporizing technique wherein the revaporizing heat is acquired from the air passing over the above-freezing evaporator coil. While this system is somewhat more efficient than revaporizing by the addition of external heat or by utilizing the heat of compression, it is rather tricky in operation and will function only where high and low temperature coils are connected in series.

In both the present application and my prior application, there is provided a hot gas defrost system wherein the refrigerant liquefied during the defrosting process is utilized for refrigerating without revaporizing or passing through the compressor, thus adding to the thermal efficiency of the system and obviating any requirement for separate vaporizing or atomizing means.

In particular, my prior application shows a system where the low temperature refrigeration coils may be defrosted in accordance with such a principle. However, it is sometimes desirable to provide means for defrosting high temperature refrigeration coils and the present invention relates to a system whereby high temperature coils which are desired to be defrosted may be defrosted in accordance with the principles of my co-pending application by adding a minimum amount of equipment to a normal system. In its preferred form, the present invention is combined with that shown in my co-pending application cited above.

According to it is a principal object of this invention to provide an improved refrigeration system wherein multiple evaporator coils may be selectively defrosted by reverse cycling of the compressed hot gaseous refrigerant and wherein the cooled and partially liquefied refrigerant will be returned to the liquid refrigerant supply line for use in refrigerating the other evaporators in the system.

Another object of the present invention is to provide a system of the character described in which both high temperature coils and low temperature coils may be defrosted.

A further object of the invention is to provide an apparatus of the character described in which the defrosting is accomplished by a pressure differential wherein the pressure in a hot gas defrost line is maintained at a pressure above the pressure in the liquid supply line.

Another object of the invention is to provide a method of defrosting an evaporator coil by supplying hot vaporized refrigerant to the suction line end of the evaporator and controlling the pressure in the liquid refrigerant supply line so as to create a pressure differential across the evaporator unit sufficient to urge refrigerant condensed therein into the liquid refrigerant supply system.

Still another object of the invention is to provide a method and apparatus for accomplishing hot gas defrosting of a plurality of evaporators including both low temperature and high temperature evaporators which are connected in parallel between a liquid refrigerant supply line and their compressor suction lines in which the individual low temperature evaporators may be selectively disconnected from their compressor suction line and connected to a hot gas supply line having a pressure higher than the pressure in the liquid refrigerant supply line, and

in which reverse flow is provided through the high temperature evaporators.

Yet another object of the invention is to provide a large-scale multiple evaporator refrigeration system capable of accomplishing rapid hot gas defrosting of the individual evaporators on demand and with a minimum of controls and plumbing.

Yet still another object of the invention is to provide a refrigeration system of the character described in which slugging of the compressor is completely avoided.

Further objects and advantages of my invention will be apparent as the specification progresses, and the new and useful features of my refrigeration system will be fully defined in the claims attached hereto.

In general, the present invention provides a method and apparatus for defrosting all units of a refrigeration system including both high temperature evaporator coils and low temperature evaporator coils by passing hot vaporized refrigerant through the evaporator being defrosted under the influence of a pressure differential sufficient to cause cooled and partially liquefied refrigerant to flow into the liquid refrigerant supply line. The method and apparatus are particularly suited for effecting hot gas defrosting of multiple evaporators connected in parallel, the apparatus having valves for controlling the pressures in the hot gas supply line and in the liquid refrigerant supply line together with valve means for selectively connecting each of the evaporators to either the compressor suction line, for refrigerating action, or to the hot gas defrost line, for defrosting action. During the defrost action the cooled and partially liquefied refrigerant is injected into the liquid refrigerant supply line by reason of the described pressure differential, thus making the liquefied refrigerant available for refrigerating action in others of the multiple evaporators and at the same time avoiding problems of slugging the compressor.

As used herein, the term high temperature evaporator means an evaporator which has its suction line connected to the high stage suction of a two-stage refrigeration system at a sufficiently high pressure so that the evaporation temperature of the refrigerant in the coils is higher than the evaporation temperature of the refrigerant in the low temperature evaporator connected to the low stage suction. Where the coil temperatures are above freezing, frost does not form on the high temperature evaporator coils and, in such a case, means may be provided to prevent any hot gas from entering these coils and unduly heating them. On the other hand, the term high temperature coils also includes coils in which the evaporation temperature of refrigerant is below freezing although near freezing and frost does form on such coils. The term low temperature coils is used to mean the coils in which the refrigerant is generally evaporated to provide a coil temperature of from about minus 10° F. to about minus 40° F. and frosting of the coils is particularly acute.

In my prior application, means were provided whereby the low temperature coils could be efficiently evaporated, but the defrost of the high temperature coils was left to be accomplished according to any of the conventional methods. However, in the present application, an improved method of defrosting the high temperature coils is provided and this method is particularly adapted to be used in combination with and as an improvement over the defrost system described in my co-pending application. However, it will be appreciated that the system for defrosting high temperature coils may also be used with other types of refrigeration systems.

In a typical system such as a supermarket, as many as ten or more groups of high temperature evaporators cool various rooms and fixtures such as vegetable display cases, meat storage coolers, and the like. These evaporators are conventionally defrosted by time clocks turning off their flow of refrigerant until the above freezing air passing over the coils melts them off. Alternately,

they may be defrosted by using a three way valve and separate suction line with control of hot gas to effect any of the prior known hot gas defrosting systems. However, the latter method requires all of the controls necessary to effect defrost of low temperature coils.

In accordance with the present invention, the defrost of the high temperature loads are accomplished by using hot gas from the discharge of the low stage booster compressor in a two stage compressor system. This is accomplished by isolating the evaporator systems from the high stage compressor and receiver so that a new refrigeration cycle is provided in which the low stage booster drives the refrigerant in reverse through the high temperature coils and then back to the liquid refrigerant line where it passes into the low temperature coils, is vaporized and returns to the low stage compressor. This new cycle is formed by simply shutting off the high stage compressor while simultaneously shutting off the communication between the liquid refrigerant supply line and the receiver and any other associated equipment.

In a typical system, the defrost is initiated and terminated by a simple time clock control. At the start of the cycle, the clock will actuate a relay which stops the high stage compressor and also shuts off the liquid refrigerant supply. In addition, means are preferably provided to retain the low temperature evaporators in refrigeration condition and avoid a defrost position of these evaporators in order to provide maximum return of gas to complete the defrost cycle. Defrosting is generally accomplished in about fifteen (15) minutes; and at the end of this period the control clock switches the system back to normal operation and the original balance of pressure is generally reached in two or three minutes.

The preferred forms of my invention are illustrated in the accompanying drawings forming part of this description, in which:

FIGURE 1 is a schematic plan view illustrating a preferred embodiment of the refrigeration system of the present invention, particularly adapted for use in supermarkets or the like; and

FIGURE 2, a schematic plan view illustrating modified forms of certain of the components of FIGURE 1 shown in operative association.

While I have shown only the preferred forms of my invention, it should be understood that various changes or modifications may be made within the scope of the claims attached hereto without departing from the spirit of the invention.

Referring to the drawings in greater detail and particularly to FIGURE 1, it is seen that the defrosting apparatus for refrigeration systems of the present invention is particularly adapted for use in a system having one or more low temperature evaporator units 11, such as units 11A, 11B and 11C connected between a liquid refrigerant supply line 12 and a compressor suction line 13 together with valve means 14 for selectively connecting a hot gas supply line 16 to the evaporator units 11 while at the same time disconnecting the latter from the compressor suction line 13, the system also including means 17 for regulating the pressure in the liquid refrigerant supply line 12 so as to create a pressure differential across the evaporator unit 11 sufficient to urge refrigerant condensed therein into the liquid refrigerant supply line when the hot gas supply line 16 is connected to the evaporator unit.

The method and apparatus of the present invention is particularly suited for use in connection with conventional refrigeration systems in which compressor means 18 compresses a gaseous refrigerant and propels it through a conduit 19 into a condensing means 21 adapted to remove a portion of the heat energy from the refrigerant and condense it into liquid form. The liquid refrigerant then passes through a conduit 22 into a receiver 23 and from the receiver into the liquid refrigerant supply line 12 for the evaporator unit 11.

The evaporator units 11 each include expansion valves 24 adapted for expanding the liquid refrigerant in the

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evaporator coils 26, this action serving to absorb heat energy and reduce the temperature of the coil 26 for refrigeration purposes.

In accordance with the invention of my co-pending application which is used in the preferred form of the present invention, a predetermined pressure differential is maintained between the pressure in the hot gas defrost line, leading from the compressor discharge conduit 19 and the liquid refrigerant supply line 12, the pressure differential being sufficient to urge the cooled and at least partially liquefied refrigerant from defrosting evaporator coil 26 into the liquid refrigerant supply line 12 where it will be available for refrigerating the evaporator units not being defrosted. As here shown, the valve means 14 is adapted for selectively connecting the end 27 of the evaporator coil remote from the expansion valve 24 to the compressor suction line 13 during the refrigeration cycle or to the hot gas defrost line 16 during the defrost cycle. When the evaporator unit 11 is in the defrost cycle, the cooled and partially liquefied refrigerant is diverted around the expansion valve 24 by means of a by-pass 28 containing a one-way check valve 29.

As here shown, the means 17 for controlling the pressure in the liquid refrigerant supply line 12 so as to achieve the desired pressure differential between lines 12 and 16 comprises a conventional pressure-regulator valve 31 interposed in the line 12 between the receiver 23 and the first evaporator unit 11. The pressure-regulator valve 31 may be of any suitable type and it is preferred to use a conventional pressure-reducing valve of the type well known in the art.

The valve 31 is adjusted to provide for a pressure in line 12 which is lower than the pressure in the hot gas defrost line 16. The pressure differential should be sufficient to cause the refrigerant to move rapidly through the evaporator coil 26 in the direction opposite to its normal direction of flow, the refrigerant passing through by-pass 28 and check valve 29 and arriving at liquid refrigerant supply line 12 at a pressure higher than the pressure maintained in line 12 by the pressure-regulator valve 31. The cooled refrigerant will thus enter the line 12 and supplement the supply of liquid refrigerant therein for subsequent use in the refrigerating cycles of other evaporator units communicating with line 12, or of the evaporator unit being defrosted, after the defrost cycle is completed.

In general, the pressure differential between lines 12 and 16 is maintained by pressure-regulator valve 31. For example, in a typical installation where the discharge pressure of the compressor means is 180 p.s.i., the valve 31 is regulated to provide a pressure of about 165 p.s.i. in the liquid refrigerant supply line 12, thus providing a pressure differential of about 15 p.s.i. The exact pressure differential to be used will depend upon the flow characteristics through the evaporator units, but I have found in actual practice that a pressure differential of about 10 p.s.i. to 20 p.s.i. will be sufficient in most installations.

As previously stated, the method and apparatus of the present invention is particularly adapted for use with multiple evaporator installations such as those encountered in large food markets wherein a plurality of evaporator units such as units 11A, 11B and 11C are provided for maintaining subzero temperatures in frozen food cabinets and in which additional higher temperature evaporator units 25 are employed for other purposes such as walk-in refrigerators, etc. A system of this character is depicted schematically in FIGURES 1 and 2 of the drawings. As here shown, each of the evaporator units 11 and 25 comprise three evaporator coils 26. It should be understood, however, that the number of units and the evaporator coils in the particular unit may be varied so long as the described connections are provided.

It is necessary to the purposes of the present invention that the evaporator units 11 be connected in parallel between the liquid refrigerant supply line 12 and the com-

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pressor suction line 13 so that the refrigerant injected into supply line 12 from the evaporator unit being defrosted may be utilized in the refrigeration cycles of the other evaporator units. I have found it desirable for at least two of the evaporator units to be in their refrigeration cycles for each evaporator unit being defrosted. In order to accomplish such action, the means 14 may be provided in the form of a two-position valve operated by an electrically operated actuating device supplied with electrical energy through appropriate leads. The valves may then be controlled by manual switches or by automatic defrost switching means having provision for ensuring that no more than the desired number of evaporator units are being defrosted at once. In order to synchronize the defrost action with that of the high temperature coils, the controls may be actuated by a common timing device.

As described in my prior application, sub-cooler means 37 is provided for maintaining the liquid refrigerant in the supply line 12 at a temperature sufficiently low to prevent flash vaporization as the liquid refrigerant passes from the receiver 23 and dryer 38 through the pressure-regulator valve 31. The sub-cooling of the liquid refrigerant also tends to cool the refrigerant being injected into line 12 from the evaporator unit undergoing the defrost cycle sufficiently to ensure that any vaporized refrigerant not condensed in the evaporator unit will be condensed to liquid form as it enters the supply line 12.

As here shown, the sub-cooler means includes a sub-cooler evaporator coil 39 surrounding the liquid refrigerant supply line 12 and having an expansion valve 41 interposed in a conduit 42 connected to the liquid refrigerant supply line 12. An opposite end of coil 39 is connected by means of conduit 43 to the compressor connecting line 45.

As may be seen in the drawings, I prefer to provide a two-stage compressor means 18. This means includes a low-stage booster compressor 44 interposed in the suction line 13 and discharging into a high-stage compressor 46 which discharges into the conduit 19. The conduit 43 is connected to line 45 between the compressors 44 and 46 in the conventional manner for desuperheating the gas entering compressor 46. The sub-cooler evaporator valve 41 may conveniently be operated by a sensing device 47 positioned at the intake side of compressor 46 in the conventional manner.

As best seen in FIGURE 1, the high temperature coils are disposed in parallel between the liquid refrigerant supply line 12 and a high temperature suction line 48 which communicates with the connecting line 45 between the low stage compressor 44 and the high stage compressor 46. In other respects, the high stage evaporators 25A, 25B and 25C are similar to the low stage evaporators and are equipped with expansion valves 24 and by-passes 28 containing check valves 29. The purpose of these check valves is to allow reverse flow at defrosting as is accomplished when the low temperature coils are defrosted. However, there is no need for the two position valves 14 as will be explained more fully hereinafter.

In FIGURE 1, the refrigeration system is shown with the high temperature coils defrosting, but the drawing will also illustrate the normal cycle simply by considering that the flow through line 48, the high temperature coils and liquid line 12 has refrigerant flowing in the direction opposite that shown by the arrows 51. Thus, in the normal refrigeration cycle where movement of refrigerant is shown by dotted arrows 50 in FIGURE 1, evaporated refrigerant from the low stage compressors enters compressor suction line 13 and goes through low stage compressor 44 through connecting line 45 to high stage compressor 46. In the branch line 45 between compressors, additional refrigerant is picked up from line 43 when the liquid sub-cooler is in refrigerating position and from the high temperature suction line 48 where evaporated refrigerant in the high temperature coils is fed.

In normal operation, the pressure in line 45 between compressors will be say about 33 pounds per square inch so that the evaporation temperature of refrigerant in the high temperature coils will be higher than that in the low temperature coils. The refrigerant thus entering the high stage compressor 46 is discharged through line 19 to condenser 21 where it is liquefied and passes to receiver 23. From the receiver 23, the refrigerant passes through the dryer 38, liquid sub-cooler 37, and pressure regulator valve 31 to liquid refrigerant supply line 12. Liquid refrigerant from supply line 12 then passes through the expansion valves 24 as required to supply refrigerant to the evaporators 11 and 25.

In order to defrost the high temperature coils, the liquid refrigerant supply line is isolated from the receiver by any suitable means such as valve 52 and switch means for simultaneously shutting off the high stage compressor. As the high stage compressor is shut off, the flow through line 43 from the liquid sub-cooler is also shut off in any typical system utilizing liquid sub-cooler in this manner in order to protect the compressor. Accordingly, means are also provided for shutting off the flow through the liquid sub-cooler and this provides complete isolation of these components from the system.

For example, as here shown, timer 53 is constructed to provide a signal to the solenoid 54 which in turn opens switch 56 to shut off the compressor and at the same time provide line voltage into line 57. With line 57 energized, solenoid 58 operates to shut off the valve 59 and stop the flow of refrigerant through the coils of liquid sub-cooler 37 and into line 43. Simultaneously, solenoid 61 is energized to shut off valve 52. With this operation completed, the low stage compressor 44 and the high temperature coils and low temperature coils operate a different refrigeration cycle automatically with the high temperature coils serving as a condenser and simultaneously becoming defrosted.

This refrigeration cycle goes into effect because when the high stage compressor 46 and line 12 are shut off, the pressure in lines 45 and 48 build up from their normal of about 33 pounds to a pressure of about 80 to 90 pounds. During the defrost of the high temperature coils, the low stage compressor is continuously operated in a conventional manner such as that shown in United States Patent No. 2,895,306. Hot gas will be forced backward through all of the high temperature suction lines building up pressures and temperatures in all high temperature evaporators. In this way, the high temperature evaporators will defrost and simultaneously condense this discharge gas. The condensed liquid will then leave the evaporators via their check valves 29 and will enter the liquid supply line 12 where it will be reused by the low temperature evaporators. The refrigeration in the low temperature evaporators operates normally supplying the necessary load on the low stage booster compressor 44 so that it can deliver the necessary hot gas to continue the cycle.

Defrosting is generally accomplished in about fifteen (15) minutes, and the control timer 53 switches the system back to normal operation by de-energizing solenoid 54 and replacing switch 56. With the high stage compressor back in operation, the pressure in line 45 is soon back to its normal of 33 and all systems operate in the normal way. This return is generally accomplished in about two to three minutes. Accordingly, it is seen that the high temperature coils may be defrosted in a system of this nature by a simple operation requiring a minimum of valving, controls and only a common high temperature suction line, the operation also maintaining a high level of refrigeration efficiency.

In order to defrost one of the low temperature coils, the valve means 14 for the particular evaporator will be displaced to its other position communicating the evaporator coils with the hot gas supply line 16. For example,

assume valve 14 of evaporator 11B is changed to the defrost position.

With the pressure in line 16 at say 180 p.s.i., the hot gas will flow in a reverse direction through the evaporator coils 26, the by-pass 28 and the check valve 29 of unit 11B and into the liquid refrigerant supply line 12. Should a more rapid defrosting action be desired, the pressure-regulating valve 31 should be adjusted to provide a greater pressure differential between lines 12 and 16. Conversely, if it is desired to slow down the defrosting action, the valve 31 could be adjusted to provide a lesser pressure differential. For most purposes, a differential of approximately 15 p.s.i. will be preferred.

As the hot vaporized refrigerant passing through coils 26 gives up its heat energy to effect defrosting, it becomes wholly or partially condensed and the cooled refrigerant passes through by-pass 28 and check valve 29 into the liquid refrigerant supply line 12. This cooled refrigerant adds to and supplements the liquid refrigerant flowing through the line 12 and is used during the refrigeration cycles of the other evaporator units 11A, 11C and the high temperature units 25.

It is highly desirable that at least two evaporator units be in refrigeration condition for each evaporator unit which is in defrost condition in order to provide a supply of gas to the compressor which is adequate for rapid defrosting. If desired, one or more of the evaporator units in the refrigeration cycle can be blocked open while another unit is being defrosted so as to permit constant operation of the compressor and consequent continuous defrosting action.

A more complete description of the defrosting operation of the low temperature coils is given in my co-pending application cited above.

In FIGURE 2, there is shown a refrigeration system somewhat similar to that shown in FIGURE 1 except that it illustrates certain alternative forms of the invention. Although all of these alternatives are illustrated in FIGURE 2, it will be appreciated that they may be used severally in any desired combination or in total as shown.

As there shown, the system is similar to that shown in FIGURE 1 except for modifications in the evaporators. Thus, there are two low temperature evaporator units 11D and 11E and three high temperature evaporators 25A, 25D and 25E.

The evaporator units 11D and 11E are similar to units 11A, 11B and 11C except that means 62 are provided to by-pass the thermostats and maintain liquid supply to expansion valves 24 at all times the high temperature coils are defrosting. This is accomplished by a signal in line 63 that overrides the thermostats.

The purpose of keeping these units open to the supply line is to positively assure movement of refrigerant through the high temperature coils and thereby complete the defrost operation during the programmed time of say fifteen (15) minutes. No harm is done by operating the low temperature coils in this way without demand from the thermostats, because the duration is short and the resulting overcooling is allowable. Such a system is important where the high temperature load is large in comparison to the low temperature load.

The high temperature evaporator units include the unit 25A similar to that of FIGURE 1, unit 25D which operates at a higher coil temperature than unit 25A and unit 25E which requires no defrosting at all. Unit 25D has a controlled coil temperature which is regulated by pressure regulator 64. This regulator is used to control the pressure in the coil at the pressure corresponding to the desired boiling temperature of refrigerant.

The coil temperature of unit 25D is still below freezing, and the unit is designed to defrost in the same manner as unit 25A. However, it is found that when gas is forced in reverse through a typical pressure regulator valve, a pressure drop of 7 to 10 p.s.i. usually results. In order to avoid this resistance to the flow of hot gas during

defrost, a by-pass 66 is provided. A check valve 67 is provided to prevent flow through the by-pass during the refrigeration operation of unit 25D.

Unit 25E has a pressure regulator 68 to control its coil temperatures at 32° F. or above. Accordingly, no frost forms and no defrosting is necessary. In order to avoid wasted passage of hot gas through this unit and the corresponding inefficient operation that would otherwise result, a check valve 69 is provided to prevent defrost gas from entering the unit. With no reverse flow required, by-pass 28 and check valves 29 are omitted from this embodiment. Since the high temperature defrost operation takes place in about fifteen (15) minutes, the temperature conditions of the unit ordinarily do not change substantially and isolation thereof is harmless.

From the foregoing it will be seen that I have provided a novel method and apparatus for defrosting a refrigeration system in which the thermal efficiency of the system is increased while completely eliminating any necessity of separate apparatus for reevaporizing or atomizing the cooled defrost refrigerant, since such refrigerant is not returned to the compressor directly, but rather is added to the liquid refrigerant supply. In addition I have provided a novel means for controlling the pressure differential between the hot gas supply and the liquid refrigerant supply line so as to afford the described mode of operation of the invention.

I claim:

1. A refrigeration system, comprising a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and the compressor suction line, a low stage compressor in position to receive gas from the compressor suction line, a high stage compressor, a connecting line between the low stage compressor and the high stage compressor, a high temperature suction line connected to said connecting line, a high temperature coil between said high temperature suction line and said liquid refrigerant supply line, means for simultaneously shutting off the high stage compressor and the supply to the liquid refrigerant supply line during a timed period when the low temperature evaporators are maintained in refrigeration condition whereby the low stage compressor will supply hot gaseous refrigerant in reverse flow through the high temperature coils to defrost the coils and liquefy the gas which then enters the liquid refrigerant supply line to supply liquid refrigerant to the low temperature evaporators and back to the low stage compressor to complete the cycle.

2. A refrigeration system, comprising a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and the compressor suction line, a low stage compressor in position to receive gas from the compressor suction line, a high stage compressor, a connecting line between the low stage compressor and the high stage compressor, a high temperature suction line connected to said connecting line, a plurality of high temperature coils between the liquid refrigerant supply line and the high temperature suction line, at least one of said high temperature coils having a check valve between the coil and the high stage compressor suction line to prevent defrosting thereof while at least some of the high temperature coils have open lines to allow refrigerant to pass therethrough in reverse direction, and means for simultaneously shutting off the high stage compressor and the supply to the liquid refrigerant supply line during a timed period when the low temperature evaporators are maintained in refrigeration condition whereby the low stage compressor will supply hot gaseous refrigerant in reverse flow through the high temperature coils to defrost the coils and liquefy the gas which then enters the liquid refrigerant supply line to supply liquid refrigerant to the low temperature evaporators and back to the low stage compressor to complete the cycle.

3. The refrigeration system defined in claim 2 in which certain of the high temperature coils contain a pressure regulator valve between the coil and the high stage compressor suction line whereby the evaporation pressure of liquid refrigerant in the coils is regulated, and a bypass is provided around said pressure regulator valve to allow hot gas to flow freely in reverse direction during the defrost cycle.

4. A refrigeration system, comprising a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and the compressor suction line, a low stage compressor in position to receive gas from the compressor suction line, a high stage compressor, a connecting line between the low stage compressor and the high stage compressor, a high temperature suction line connected to said connecting line, a high temperature coil between said high temperature suction line and said liquid refrigerant supply line, a condenser, a line between the high stage compressor and the condenser, a receiver, a line between the receiver and the condenser, said receiver being in communication with said liquid refrigerant supply line, a hot gas defrost line in communication with the lines between the high stage compressor and the condenser, valve means on each of the low temperature evaporators for changing the communication of the evaporator coils from the compressor suction line to the hot gas defrost line, and means for shutting off the high stage compressor and the liquid refrigerant supply line and provide a defrost refrigeration cycle in which hot gas from the low stage compressor is forced in reverse fashion through the high temperature suction line to the high temperature coils being defrosted in which it is condensed and thence to the liquid refrigerant supply line.

5. A refrigeration system, comprising a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and the compressor suction line, a low stage compressor in position to receive gas from the compressor suction line, a high stage compressor, a connecting line between the low stage compressor and the high stage compressor, a high temperature suction line connected to said connecting line, a high temperature coil between said high temperature suction line and said liquid refrigerant supply line, a condenser, a line between the high stage compressor and the condenser, a receiver, a line between the receiver and the condenser, said receiver being in communication with said liquid refrigerant supply line, a hot gas defrost line in communication with the lines between the high stage compressor and the condenser, valve means on each of the low temperature evaporators for changing the communication of the evaporator coils from the compressor suction line to the hot gas defrost line, and means for simultaneously shutting off the high stage compressor and the supply to the liquid refrigerant supply line during a timed period when the low temperature evaporators are maintained in refrigeration condition whereby the low stage compressor will supply hot gaseous refrigerant in reverse flow through the high temperature coils to defrost the coils and liquefy the gas which then enters the liquid refrigerant supply line to supply liquid refrigerant to the low temperature evaporators and back to the low stage compressor to complete the cycle.

6. A refrigeration system, comprising a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and the compressor suction line, a low stage compressor in position to receive gas from the compressor suction line, a high stage compressor, a connecting line between the low stage compressor and the high stage compressor, a high temperature suction line connected to said connecting line, a plurality of high temperature coils between the liquid refrigerant

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supply line and the high temperature suction line, at least one of said high temperature coils having a check valve between the coil and the high stage compressor suction line to prevent defrosting thereof while at least some of the high temperature coils have open lines to allow refrigerant to pass therethrough in reverse direction, a condenser, a line between the high stage compressor and the condenser, a receiver, a line between the receiver and the condenser, said receiver being in communication with said liquid refrigerant supply line, a hot gas defrost line in communication with the lines between the high stage compressor and the condenser, valve means on each of the low temperature evaporators for changing the communication of the evaporator coils from the compressor suction line to the hot gas defrost line, and means for simultaneously shutting off the high stage compressor and the supply to the liquid refrigerant supply line during a timed period when the low temperature evaporators are maintained in refrigeration condition whereby the low stage compressor will supply hot gaseous refrigerant in reverse flow through the high temperature coils to defrost the coils and liquefy the gas which then enters the liquid refrigerant supply line to supply liquid refrigerant to the low temperature evaporators and back to the low stage compressor to complete the cycle.

7. The refrigeration system defined in claim 6, in which certain of the high temperature coils contain a pressure regulator valve between the coil and the high stage compressor suction line whereby the evaporation pressure of liquid refrigerant in the coils is regulated, and a bypass is provided around said pressure regulator valve to allow hot gas to flow freely in reverse direction during the defrost cycle.

8. In a refrigeration system containing a liquid refrigerant supply line, a compressor suction line, a plurality of low temperature evaporators connected in parallel between said liquid refrigerant supply and compressor suction lines, and the following units connected in series between the compressor suction line and liquid refrigerant supply line to provide a complete cycle including a low stage compressor, a high stage compressor, a condenser, a receiver, and a liquid sub-cooler, in combination, a high temperature suction line connected between the low stage and high stage compressor, a plurality of high temperature evaporator coils connected in parallel

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between the high temperature suction line and the refrigerant supply line, a valve in the liquid refrigerant supply line, and means for simultaneously shutting off the high stage compressor and the valve in the liquid refrigerant supply line whereby refrigerant discharge gas from the low stage compressor is forced in reverse fashion through the high temperature suction line to the high temperature coils in which it condenses while defrosting the high temperature coils and the condensed refrigerant moves to the liquid refrigerant supply line and thence back to the low stage compressor.

9. The refrigeration system defined in claim 8, in which the means for simultaneously shutting off the high stage compressor and the valve in the liquid refrigerant supply line includes an electrical control system operated from a timer.

10. The refrigeration system defined in claim 9, in which the control system includes means for retaining flow of refrigerant to the low temperature coils whereby all low temperature coils are operative to receive refrigerant during the defrost of the high temperature coils.

11. The refrigeration system defined in claim 8, in which certain of the high temperature coils contain a pressure regulator valve between the coil and the high stage compressor suction line whereby the evaporation pressure of liquid refrigerant in the coils is regulated, and a bypass is provided around said pressure regulator valve to allow hot gas to flow freely in reverse direction during the defrost cycle, at least one of said high temperature coils having a check valve between the coil and the high stage compressor suction line to prevent defrosting thereof while at least some of the high temperature coils have open lines to allow refrigerant to pass therethrough in reverse direction.

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