United States Patent

Quick

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[54] REFRIGERATION SYSTEM WITH HOT GAS DEFROSTING

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[52] **U.S. Cl.** **62/196,** 62/278, 62/510, 62/512

[51] **Int. Cl.** **F25b 41/00**

[58] **Field of Search** 62/196, 510, 278, 512

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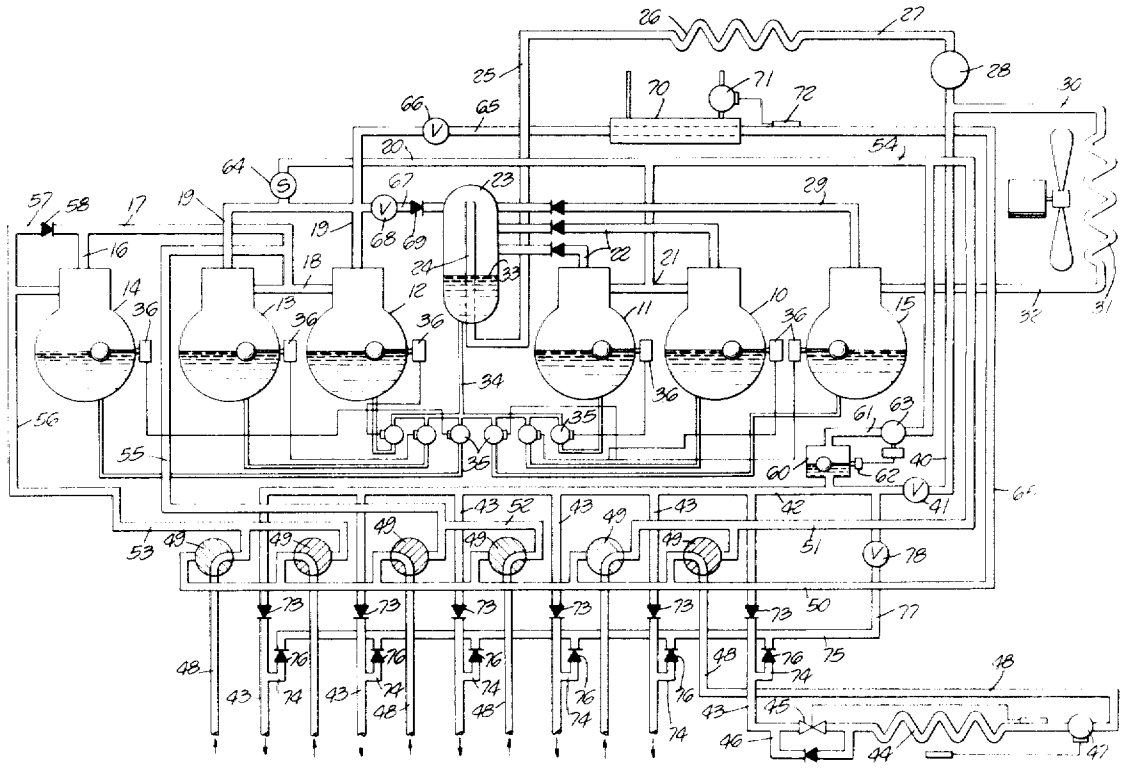
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[57] **ABSTRACT**

A refrigeration system particularly adapted for supermarkets and the like employing a multiplicity of refrigerated fixtures wherein centrally located compressors operate all the evaporators and each of the evaporators may be selectively defrosted with hot gaseous refrigerant from the high-pressure side of the system. In the various embodiments a chamber of reduced pressure is provided for receiving the defrosting refrigerant after passing through the evaporator and the chamber serves to separate the gaseous and liquid refrigerant with the liquid refrigerant being returned to the normal supply of liquid refrigerant for the evaporators and the gaseous refrigerant being returned to the compressor suction in a controlled manner. In the preferred and two alternate embodiments the pressure reduction is in the liquid supply line to the evaporators with the chamber also serving to separate flash gas caused by such pressure reduction as well as the returning gaseous defrosting refrigerant while in the other embodiment the pressure reduction in the chamber does not change the liquid supply line pressure to the evaporators.

26 Claims, 5 Drawing Figures



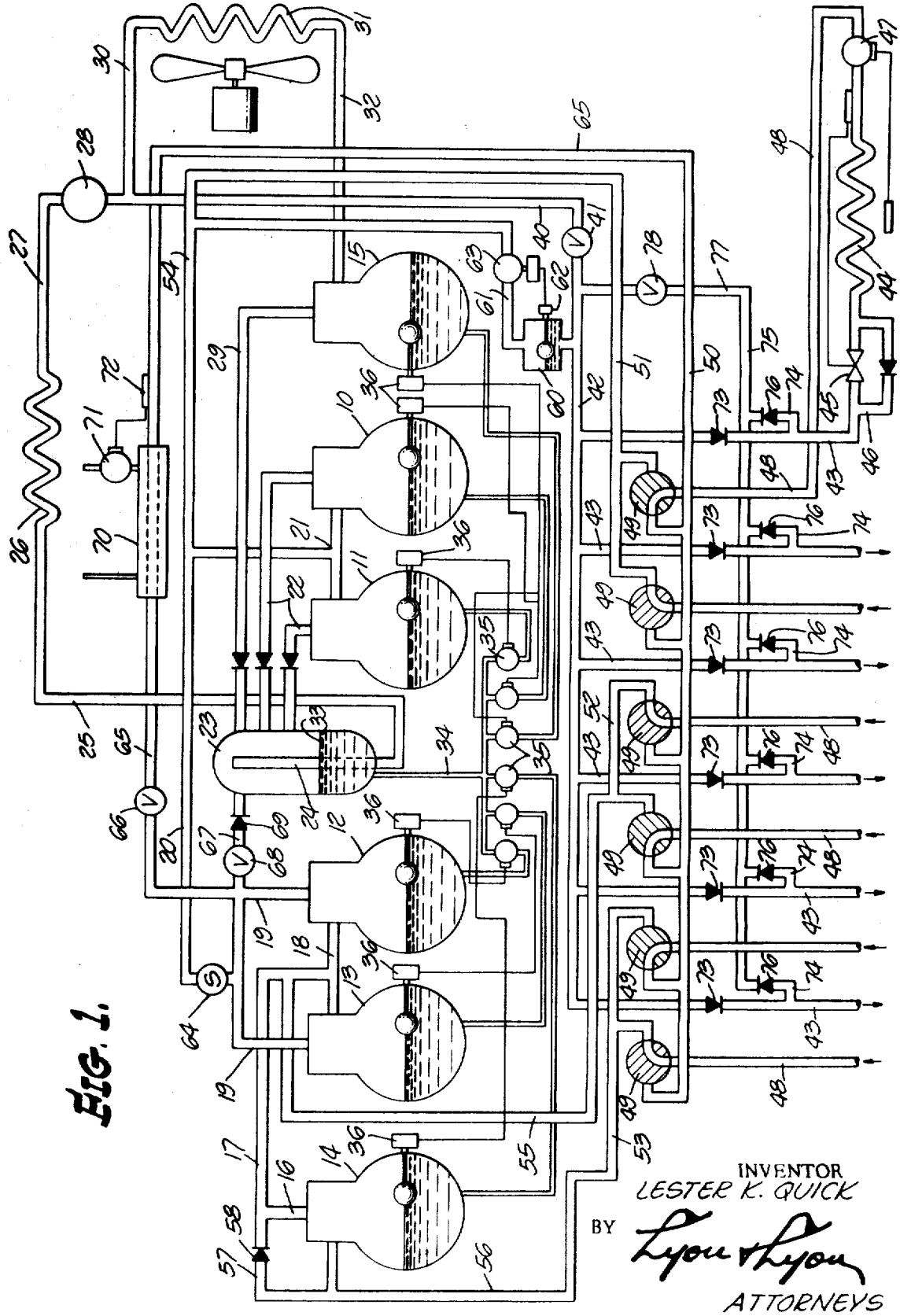


FIG. 1.

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FIG. 2.

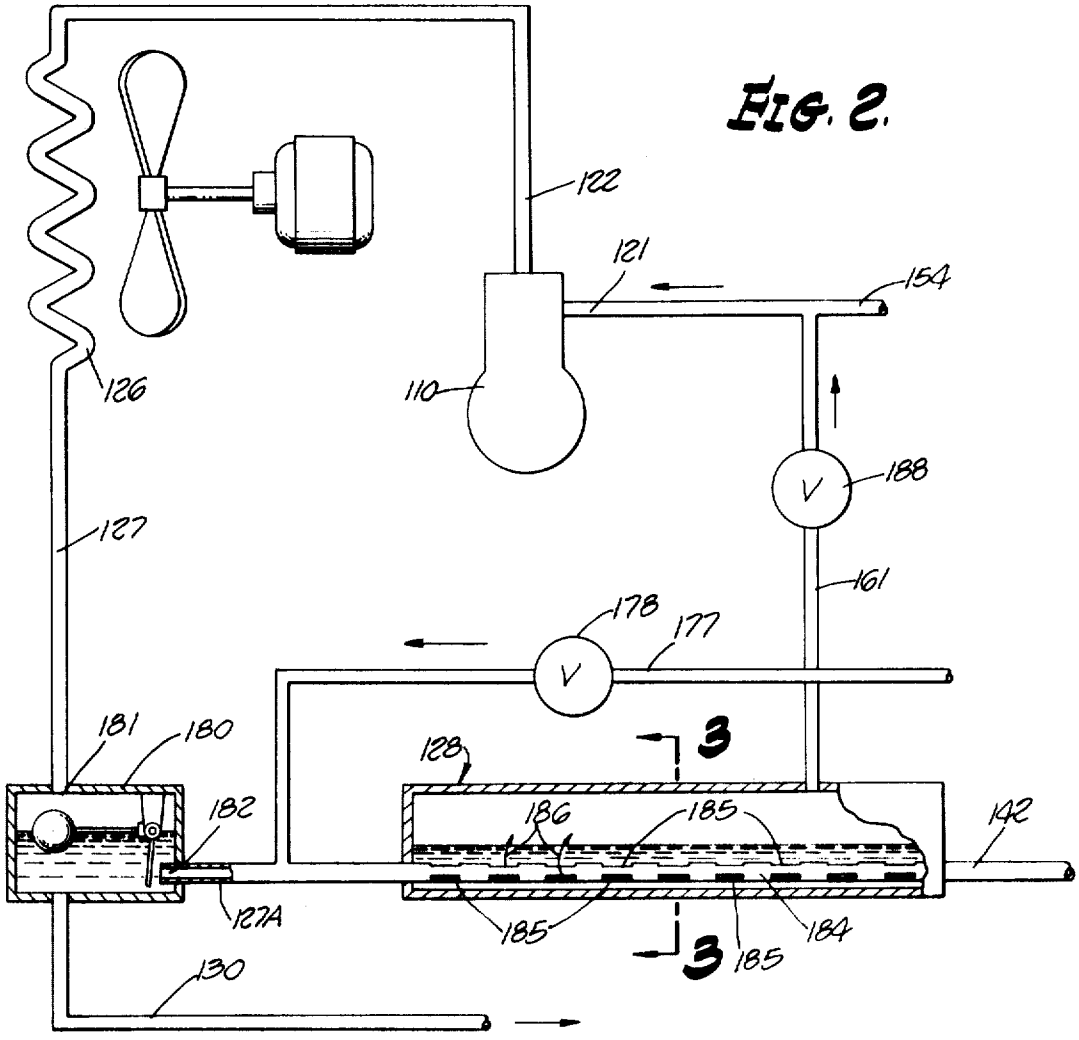
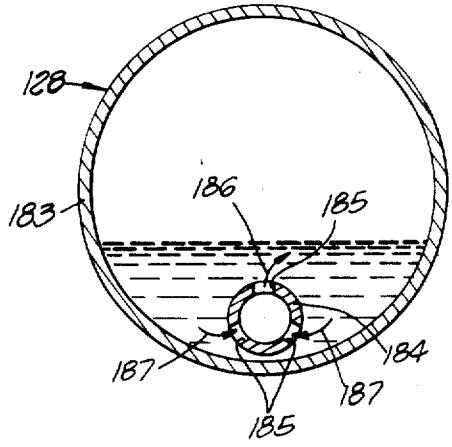


FIG. 3.



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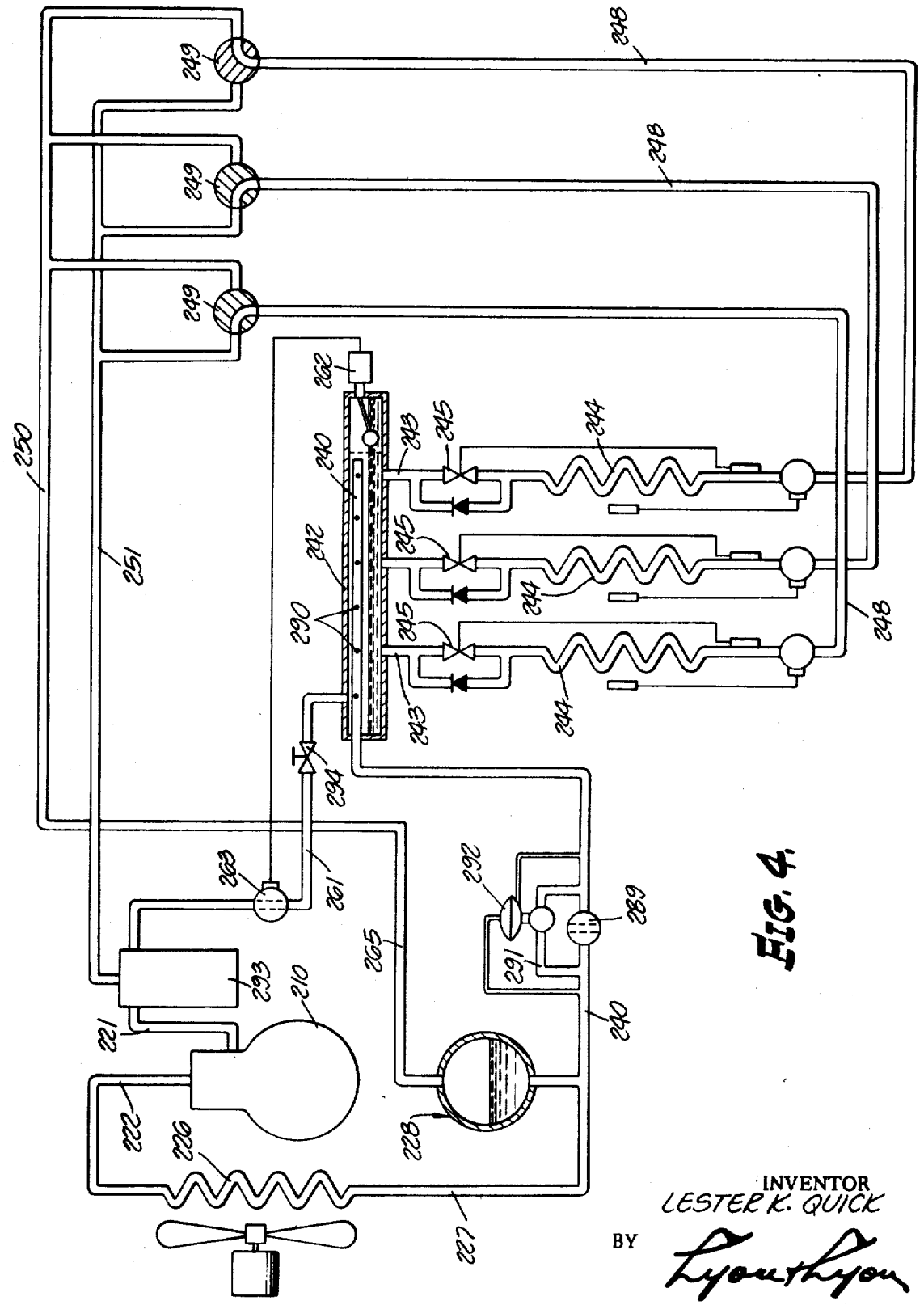


FIG. 4.

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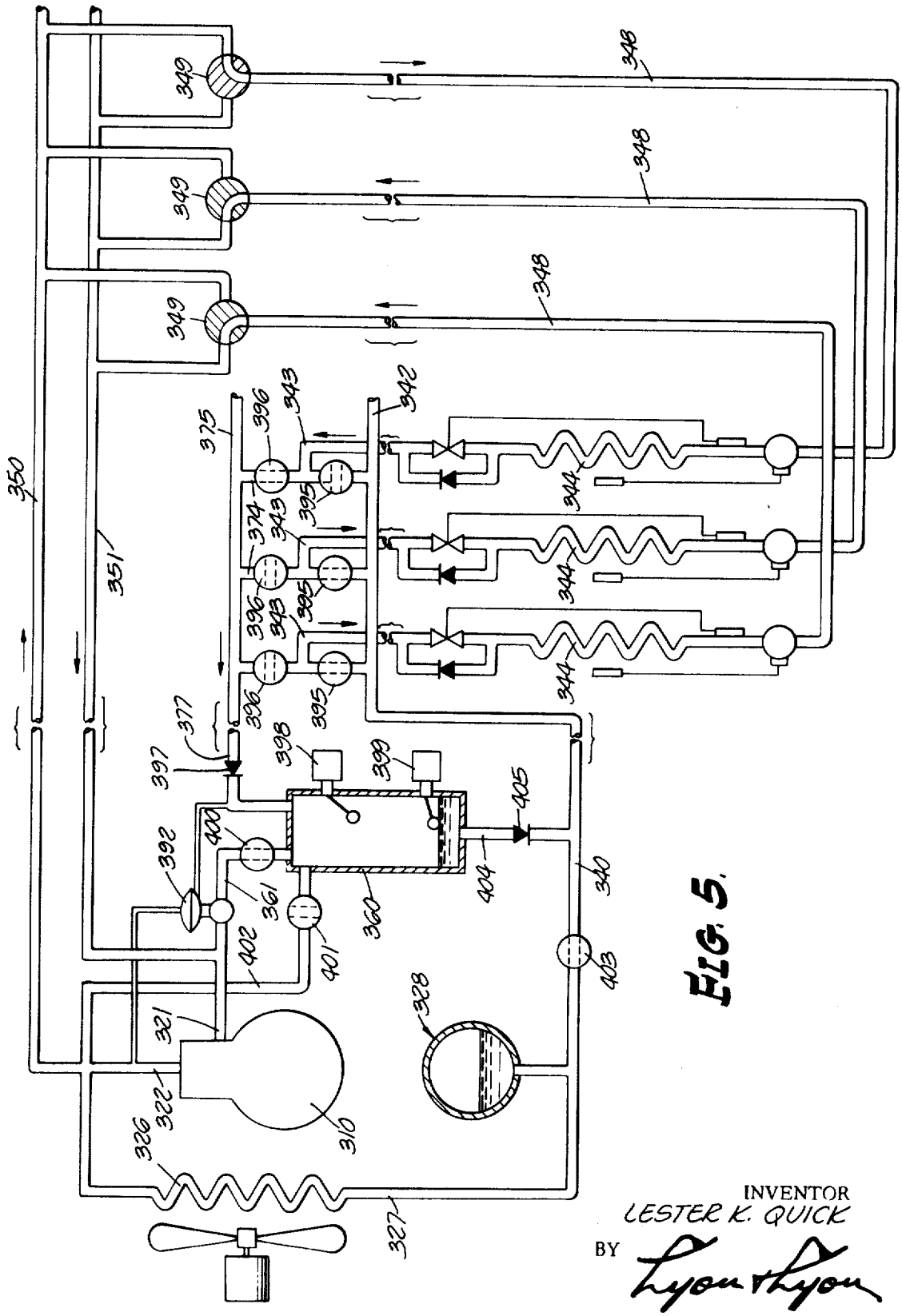


FIG. 5.

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REFRIGERATION SYSTEM WITH HOT GAS DEFROSTING

This invention relates to refrigeration systems for operating multiple refrigerated fixtures, such as in supermarkets, and in particular is directed to improvements in the system for efficiently and effectively accomplishing hot gas defrosting of the fixture evaporators.

In recent years there has been a trend toward the use of relatively large compressors centrally located in a supermarket installation for operating the refrigerated fixtures throughout the store. The plurality of evaporators operated by a single compressor or plural compressors combined in a parallel or compounded relationship produce a substantial heat load capable of producing the desired rapid and efficient hot gas defrosting of a limited proportion of those evaporators at any one time. This has led to an increased popularity in the use of hot gas defrosting in supermarket refrigeration systems in preference to other slower or more costly arrangements such as electrical defrosting or off-cycle defrosting.

While the advantages of employing hot gas defrosting in the central refrigeration systems of the type used in supermarkets is now rather well recognized, there has remained a number of disadvantages or problems with the heretofore developed systems. Among the most prominent problems has been the manner in which the refrigerant used in defrosting an evaporator is reintroduced into the normal refrigeration cycle with the least possible difficulty, expense and inefficiency. A number of methods for accomplishing this objective are possible, some of which are those shown in my following prior U.S. Pats. Nos. 3,151,470 entitled "Hot Gas Defrosting System," 3,234,748 entitled "Hot Gas Refrigeration Defrosting System With Purge Means," 3,234,752 entitled "Desuperheater for Refrigeration System," 3,234,753 entitled "Hot Gas Refrigeration Defrosting System" and 3,234,754 entitled "Reevaporator System for Hot Gas Refrigeration Defrosting Systems." In each of these prior patented systems and other systems of which I am aware there were specific advantages and disadvantages from system to system but there were also common disadvantages.

One common disadvantage of hot gas defrosting systems wherein the defrosting refrigerant was reintroduced into the liquid refrigerant supply for the evaporators was the presence of an indeterminate amount of gaseous refrigerant which, on occasion, would cause the malfunctioning of one or more evaporators that were not being defrosted by supplying gaseous refrigerant thereto. The amount of gaseous refrigerant returned with the defrosting refrigerant into the liquid refrigerant supply line in these prior systems was uncontrollable due to such factors as changing ambient conditions, differences in frost buildup, differences in the refrigeration system loads, etc. On the other hand the liquid refrigerant returned from defrosting an evaporator as capable of and did serve a useful refrigerating function in contrast to arrangements where the liquid refrigerant was merely heated and reevaporated for recompressing without performing any useful function.

Another difficulty that has plagued central refrigeration systems of the type used in supermarkets employing hot gas defrosting is the substantial variations in operating pressures throughout different portions of the system by reason of variations in ambient and load conditions. For example it is well known that functional characteristics of conventional expansion valves used on evaporators is dependent on the pressure differential across such valves yet the pressure in the liquid refrigerant supply line to the expansion valves may vary substantially with the highest pressure being perhaps more than double the lowest pressure. This pressure variation is principally due to ambient conditions since the condensing temperature and pressure will be substantially lower in winter than in summer. This variation in condensing or head pressure also normally produces a corresponding variation in the temperature of the gaseous refrigerant used for the hot gas defrosting whereby the lower gaseous refrigerant temperatures in the winter time will produce slower defrosting of any given evaporator. Since it is conventional to control the hot gas defrosting of evaporators by predetermined time periods, it is common to experience less than complete defrosting in winter with the lower temperature gaseous refrigerant or even excessive defrosting and heating in summer.

Accordingly, a summary of a principal object of this invention is to provide an improved refrigeration system with hot gas defrosting wherein a pressure differential is affirmatively created across each evaporator that is being defrosted for providing an incentive for the flow of defrosting refrigerant therethrough and a vessel or chamber is provided for separating the gaseous and liquid phases of refrigerant returned from defrosting an evaporator with the liquid refrigerant being used in the normal supply of liquid refrigerant and the gaseous refrigerant being removed and recompressed.

An object of this invention is to provide a novel arrangement in a refrigeration system for efficiently disposing of the condensate refrigerant produced in hot gas defrosting without limitation as to the proportions of liquid and gaseous refrigerant present in such condensate.

Another object of this invention is to provide a novel refrigeration system with hot gas defrosting wherein a predetermined reduction in the pressure of the liquid refrigerant being supplied to the evaporators is caused for producing the pressure differential necessary for the flow of hot gas defrosting refrigerant through selected evaporators into such liquid refrigerant supply and wherein the flash gas produced by such liquid line pressure reduction and any gaseous refrigerant returning with the condensed defrosting refrigerant are separated and controllably removed to preclude any such gaseous refrigerant from entering an evaporator during normal refrigeration operation.

Another object of this invention is to provide a novel refrigeration system with hot gas defrosting wherein the supply of liquid refrigerant to the evaporators is maintained at a predetermined constant pressure by reducing the variable condensing or head pressure to a predetermined low level and wherein the flash gas produced by such pressure reduction is continually removed by controlled return to the compressor suction. Another object of such a system is to permit the head pressure to drop to low levels thereby reducing the power consumption of the system. A still further object is to provide such a system wherein gaseous refrigerant returning with the condensate from hot gas defrosting of evaporators is also continually removed and returned to the compressor suction. A still more detailed object of this invention is to provide such a system wherein a novel form of refrigerant receiver for the entire system serves as the chamber for separating liquid and gaseous refrigerant with such gaseous refrigerant being returned from the receiver to the compressor suction in a controlled manner.

A still further object of this invention is to provide a novel refrigeration system with hot gas defrosting wherein a plurality of centrally located compressors operate a multiplicity of refrigerated fixtures at various evaporator suction pressures wherein the discharge of one or more selected compressors is employed for supplying the hot gaseous refrigerant for defrosting with the pressure of such discharge controlled to a predetermined level independent of the ambient temperature for supplying gaseous refrigerant to the evaporators selected for defrosting. Still another object is to provide such a system wherein pressure in the liquid refrigerant supply line to the evaporators is regulated to a level substantially below such preselected hot gas defrosting pressure and wherein an intermediate pressure is maintained in a header returning the defrosting refrigerant from the defrosted evaporators to the liquid refrigerant supply line.

Another object of this invention is to provide a novel central refrigeration system wherein the normal liquid refrigerant supply is greatly reduced in pressure and temperature at the location of the compressors with the flash gas produced by such reduction being directly and efficiently returned to such

compressors. A further object is to provide such a system wherein the lengthy refrigerant supply and suction lines to the remote fixtures may be reduced in size by reason of such direct flash gas return. A still further object is to provide such a system wherein the flash gas is returned only to compressors operating at higher suction pressures thereby improving the efficiency of the other compressors.

Other and more detailed objects and advantages of this invention will appear from the accompanying description and drawings wherein:

FIG. 1 is a schematic illustration of the preferred form of my invention illustrating a central refrigeration system employing compounded compressors operating at three suction pressures and an air-conditioning compressor together with the hot gas defrosting arrangement.

FIG. 2 is a schematic illustration of a modified from of the refrigeration system with hot gas defrosting shown in FIG. 1 but with substantial portions of the overall system omitted for simplicity of illustration.

FIG. 3 is a sectional elevation view of the refrigerant receiver illustrated in FIG. 2 taken substantially on the line 3—3 in FIG. 2.

FIG. 4 is a schematic illustration of a modified form of the refrigeration system with hot gas defrosting of this invention wherein only a pressure reduction on the liquid refrigerant supply line is employed with the flash gas from such pressure reduction and the gaseous refrigerant returned from defrosting both being separated and returned.

FIG. 5 is a schematic illustration of another modified form of the refrigeration system with hot gas defrosting of this invention wherein a pressure reduction only on the header returning defrosting refrigerant is employed and only gaseous refrigerant returned during defrosting is separated and returned to the compressor.

While FIG. 1 illustrates a virtually complete system employing multiple compressors and FIGS. 2, 4 and 5 illustrate only single compressors and less details, it is to be understood and will readily appear from the following descriptions that any of the illustrated systems may be used with one or multiple compressors and certain components and features of each illustrated system may be applicable to the other systems. In particular for clarity and simplicity of description FIGS. 2, 4 and 5 have been illustrated in very simplified form rather than including the many components illustrated in FIG. 1 or that would be included in any such refrigeration system.

Referring now more particularly to FIG. 1, a typical refrigeration system of this invention is illustrated for accomplishing all of the refrigeration requirements in the usual supermarket as well as providing air conditioning. In the usual supermarket there are three distinct levels of refrigerated fixture temperatures required which are normally referred to as standard temperature fixtures (i.e., diary, produce and fresh meat), low temperature fixtures (i.e., frozen foods and walk-in freezers) and ultralow temperature fixtures (i.e., ice cream cases and special frozen food fixtures requiring very low back pressures). To provide these three temperature levels in a supermarket or any installation having similar requirements, it is necessary to provide compressors operating at three distinct suction pressures, if the best operating efficiency is to be maintained, which compressors are commonly referred to by the corresponding temperature level of fixtures to which their suctions are connected. Thus in FIG. 1 there are two compressors 10 and 11 connected in parallel to operate the standard temperature fixtures and will be referred to as the standard temperature compressors. Two more compressors 12 and 13 are connected in parallel to operate the low temperature fixtures and compressor 14 is the ultralow temperature compressor. In addition, FIG. 1 illustrates and air conditioning system having air-conditioning compressor 15.

In their normal refrigeration operation compressors 10, 11, 12, 13 and 14 are compounded. The discharge 16 of ultralow temperature compressor 14 is connected through conduit 17 to the suction side 18 of low-temperature compressors 12 and 13. The discharge sides 19 of low-temperature compressors 12 and 13 are connected through conduit 20 to the suction side 21 of standard temperature compressors 10 and 11. The discharges 22 of standard temperature compressors 10 and 11 are separately connected to a discharge accumulator and oil separator 23 which has an outlet standpipe 24 connected to a conduit 25 leading to the system condenser 26 and thence through a conduit 27 to the system receiver 28. In this manner the entire system has a single condenser-receiver arrangement for supplying the liquid refrigerant requirements of all of the evaporators rather than separate condenser-receivers for each of the temperature levels. The ultralow temperature compressor 14 is compounded with the low-temperature compressors 12 and 13 which are in turn compounded with the standard temperature compressors 10 and 11.

Although it forms no part of this invention it may be seen that the air conditioning system is completely compatible with the refrigeration system of this invention. The air-conditioning compressor 15 has its discharge 29 connected to the discharge accumulator and oil separator 23 in parallel with the discharges 22 from compressors 10 and 11 and the compressed refrigerant output of air conditioning compressor 15 is condensed and conducted to receiver 28 in the aforedescribed manner. Liquid refrigerant from receiver 28 is supplied through conduit 30 to the air-conditioning evaporator 31 having the usual controls (not shown) and conduit 32 connects the evaporator 1 to the suction side of air-conditioning compressor 15 to complete the cycle.

Another portion of the overall system illustrate in FIG. 1 that forms no part of the invention of this application is the discharge accumulator and the oil separator 23 and its associated oil return means although it will be understood that some form of oil separator and return must be provided in a refrigeration system of this type. The arrangement illustrated in FIG. 1 is of the type more fully disclosed in my copending application Ser. No. 815,452 entitled "Refrigeration System Oil Separator" but will be briefly described here for completeness. The vessel comprising the discharge accumulator and oil separator 23 serves to separate the oil from gaseous refrigerant discharged from the compressors and to maintain an oil supply 33 in the bottom of the vessel. An oil line 34 is connected through a header to individual conduits returning to the crankcases of each of the compressors 10–15. Each such oil return conduit has a separate valve 35 the operation of which is individually controlled by a float-actuated sensor 36 associated with the compressor to which that oil return line and valve are connected. Thus as the sensor 36 associated with a compressor senses a drop in the desired oil level in that compressor the associated valve 35 is opened to return oil to that compressor whereby the desired oil levels in each of the compressors is independently maintained.

Returning to the refrigeration system of FIG. 1, the receiver 28 is connected through a conduit 40 through a pressure regulating valve 41 to a liquid refrigerant header 42. The pressure regulating valve 41 functions to maintain a reduced and constant pressure in liquid header 42 and valve 41 may be of the type commonly known in the industry as a "crankcase pressure regulator" or CPR valve. The predetermined pressure maintained in liquid header 42 by valve 41 is selected to be lower than the lowest condensing or head pressure likely to be encountered even under the most extreme conditions and higher than the highest evaporator suction pressure such as produced by standard temperature compressors 10 and 11. The liquid header 42 is connected through conduits 43 to the evaporators 44 of the refrigerated fixtures. For simplicity of illustration only one evaporator 44 and six branch conduits 43 are shown although one or more evaporators will be associated with each conduit 43 and in most commercial installations of this type there will be a great many more than six branch conduits 43.

As is conventional each evaporator 44 is provided with an expansion valve 45 and for purposes of bypassing expansion valve 45 during hot gas defrosting a bypass line 46 having a

check valve is provided. In addition each evaporator will be provided with a temperature responsive control such as a conventional liquid line solenoid or, as shown in the drawing, a suction pressure regulator valve **47**. Each evaporator **44** is connected through a suction conduit **48** to a three-way valve **49** adapted to selectively connect the suction line **48** to either a common hot gas header **50** or one of the three suction headers **51**, **52** or **53**. It is to be noted that as viewed in FIG. **1** the two right hand three-way valves **49** are connected to standard temperature suction header **51** whereby the associated fixtures would be standard temperature fixtures, the two middle three-way valves **49** are connected to low temperature suction header **52** whereby the associated fixtures would be low temperature fixtures, and the two left hand three-way valves **49** are connected to ultra-low temperature suction header **53** whereby the fixtures associated with those two valves would be ultralow temperature fixtures. Standard temperature suction header **51** is connected through conduit **54** to the suction side **21** of compressors **10** and **11**. Low temperature suction header **52** is connected through conduit **55** to the suction side **18** of low temperature compressors **12** and **13**. Ultralow temperature suction header **53** is connected through conduit **56** to the suction side of compressor **14**. During normal refrigerating operation of a given evaporator **44** the associated three-way valve **49** is positioned to connect the suction conduit **48** to the associated suction header (**51**, **52** or **53**) to return the evaporated refrigerant to the appropriate compressor whereby the appropriate suction pressure is maintained on that evaporator and yet the liquid refrigerated is supplied to all of the evaporators from the common liquid heater **42**.

A bypass line **57** with a check valve **58** is connected from the ultra-low temperature suction line **56** to the discharge side **16** of the ultralow temperature compressor **14** for allowing the bypass of refrigerant upon the failure of compressor **14** or the temporary return of an excessive quantity of refrigerant to compressor **14**. In essence the suction from the ultralow temperature fixtures will then be connected to the suction side **18** of the low temperature compressors **12** and **13** until the malfunction of compressor **14** is corrected or the excess return is reduced.

Referring again to the operation of pressure regulating valve **41** in supplying liquid refrigerant to the header **42**, it is well known in the industry that a pressure reduction of this type in the liquid refrigerant will cause some of the liquid refrigerant to evaporate, commonly called flash gas, to cool the liquid to the saturation temperature for that pressure unless the refrigerant is subcooled to such temperature before the pressure reduction. A common example of the creation of flash gas in every refrigeration system occurs at the expansion valve since the pressure is reduced from the liquid line pressure to the evaporator pressure and the flash gas serves to lower the temperature of the remaining liquid from the liquid line temperature to the evaporator temperature. The quantity of flash gas created will depend on this temperature differential but it is to noted that such flash gas produces no useful work in the evaporator in cooling the refrigerated fixture although the flash gas obviously represents part of the load on the compressor since it must be returned and recompressed. Of course the flash gas also represents part of the volume that must be conducted by the suction conduits and, in its liquid form, part of the liquid that must be conducted by the liquid supply lines, whereby such piping must be sized to accommodate those volumes. However any portion of the flash gas usually produced at the expansion valve that can be eliminated upstream thereof will allow a corresponding reduction in the necessary size of the liquid supply lines and suction lines and, as hereinafter described, such flash gas elimination is accomplished by the system of FIG. **1**.

Immediately downstream of the pressure regulating valve **41** is a separating vessel or chamber **60** connected to the liquid header **42** in a manner for causing the flash gas produced by the pressure reduction to enter the chamber **60**. The chamber **60** contains both gaseous refrigerant and liquid refrigerant as shown. The flash gas collected in chamber **60** is returned through a conduit **61** connected from the top of the chamber to conduit **54** returning to the suction side **21** of standard temperature compressors **10** and **11**. Means are provided for controlling the removal of flash gas through conduit **61** to avoid either the excess accumulation of flash gas in chamber **60** or the inadvertent return of liquid refrigerant to the compressors and, as shown in the drawings, these means may include a float control **62** provided in chamber **60** and connected to and controlling the operation of a valve **63** in conduit **61**. The controlled operation of valve **63** by float control **62** may be either an on-off switching between high and low levels of liquid in the chamber **60** or a modulating control directly related to the level of liquid in chamber **60**. It is to be noted that float control **62** may also serve as an indicator or alarm for the occurrence of a below normal supply of liquid refrigerant, as for example due to the loss of refrigerant through a leak, since chamber **60** will always be partially filled with liquid refrigerant unless there simply is no additional liquid refrigerant available from receiver **28** through conduit **40** and valve **41**. Thus it may be seen that the pressure and temperature reduction of the liquid refrigerant by the regulating valve **41** from the pressure and temperature in receiver **28** to the desired lower level in header **42** is accomplished automatically and continually without employing a subcooler or the like and yet the resultant flash gas is immediately removed and returned directly to the compressors.

In order to accomplish hot gas defrosting of the evaporators in the system of FIG. **1** as thus far described, a variety of arrangements may be used but I have illustrated a still further improvement in my invention of a refrigeration system with hot gas defrosting and this is my preferred arrangement. When it is desired to defrost a given evaporator **44** the associated three-way valve **49** is repositioned from its normal refrigerating connection wherein suction conduit **48** is connected to the suction header (**51**, **52** or **53**) to the position wherein suction conduit **48** is connected to hot gas header **50**. Simultaneously a solenoid valve **64** in conduit **20** is closed thereby eliminating the connection of the discharge sides **19** of low-temperature compressors **12** and **13** to the suction side **21** of standard temperature compressors **10** and **11**. A conduit **65** connects the discharge sides **19** of low temperature compressors **12** and **13** to hot gas header **50** to supply the hot gaseous refrigerant for defrosting from compressors **12** and **13**. A pressure regulating valve **66** is provided in conduit **65** and functions to limit the pressure in conduit **65** so it will not exceed a predetermined constant downstream pressure of a relatively high level related to the temperature of gas desired for accomplishing the defrosting. In order to avoid excessive pressures on the discharge sides of compressors **12** and **13** as might be produced by the pressure regulating of valve **66**, a bypass conduit **67** is connected from the compressor discharge sides **19** to the accumulator and oil separator vessel **23**. A pressure regulating valve **68** of the type for regulating upstream pressure if provided in bypass conduit **67** and is set for a slightly higher pressure than the setting of valve **66** whereby any excess refrigerant not being passed through valve **66** for hot gas defrosting purposes will be discharged through bypass conduit **67** into the vessel **23** thereby entering the normal refrigeration cycle. A check valve **69** is provided in bypass conduit **67** to prevent reverse flow therethrough such as during normal refrigeration operation of the system (when there is no hot gas defrosting being performed) whereby valve **64** would be open and the pressure on the discharge sides **19** of compressors **12** and **13** would be substantially lower than the pressure in vessel **23**.

A desuperheater **70** is provided in association with conduit **65** between pressure regulating valve **66** and the hot gas header **50** for eliminating at least most of the superheat in the gaseous refrigerant whereby the refrigerant will be more nearly its saturation temperature for that pressure thereby avoiding excessive heating of the conduits leading to the evaporators. Desuperheater **70** is shown as a water-cooled

type with the water flow therethrough controlled by valve **71** which is in turn controlled by a temperature responsive sensor **72** associated with the conduit **65** downstream of the desuperheater **70**. In this manner the temperature of the hot gas may be lowered to approximately the saturation temperature for the pressure setting of regulator valve **66**. It will be obvious to those skilled in the art that any form of desuperheater may be used for accomplishing this objective.

The desuperheated gaseous refrigerant passed from hot gas header **50** through the three-way valve or valves **49** associated with the evaporators to be defrosted, then passes in a reverse direction through the suction conduit **48** to the evaporator **44**, and thence through the bypass conduit **46** into the liquid line **43**. A check valve **73** is provided in each liquid line **43** to prevent the flow of the defrosting refrigerant into the liquid header **42**. A branch conduit **74** connects each liquid line **43** to a condensate header **75** for passing the defrosting refrigerant from line **43** to header **75**. Each conduit **74** is provided with a check valve **76** to preclude the reverse flow of refrigerant from header **75** into the liquid line **43** of an evaporator operating in its normal refrigerating cycle which would otherwise occur due to the pressure differentials as will hereinafter appear more fully. A conduit **77** having a pressure regulating valve **78** connects the condensate header **75** to the liquid header **42** immediately downstream of the pressure regulating valve **41** for returning the refrigerant used in defrosting to the refrigerating cycle. Valve **78** functions to maintain a constant upstream pressure (i.e., in header **75**) and such pressure is substantially higher than the pressure in liquid header **42** as regulated by valve **41**. This higher pressure in condensate header **75** precludes the flow of liquid refrigerant into the header **75** from a liquid line **43** during normal refrigerating operation.

It is quite common for significant quantities of gaseous refrigerant to be returned with the defrosting refrigerant after passing through the evaporator being defrosted, particularly in the final stages of defrosting. In various previously conventional systems the reintroduction of this gaseous refrigerant into the liquid refrigerant supply caused substantial malfunctioning of those evaporators operating on their normal refrigerating cycles. Moreover in the present system as the refrigerant passes through regulating valve **78** there is a pressure reduction causing flash gas to pass into header **42** along with the gaseous refrigerant returned from defrosting. However chamber **60** is positioned downstream from the connection of conduit **77** to header **42** whereby such gaseous refrigerant will enter chamber **60** along with the flash gas produced by the pressure reduction by valve **41** and all such gas is separated in chamber **60** and removed through conduit **61** as previously described. Thus the refrigerant actually supplied through lines **43** to evaporators for refrigerating function is essentially free of gaseous refrigerant and is at a reduced temperature and pressure. It is to be noted that in FIG. **1**, of the six separate evaporator systems illustrated, the valves **49** of three of them are positioned for hot gas defrosting of the associated evaporator and, numbering from the left, these are the second, third and sixth valves.

In the installation and operation of a refrigeration system as shown in FIG. **1** a variety of different pressure settings may be selected for the various regulating valves **41**, **66**, **68** and **78**. These settings will depend on a number of factors such as the particular refrigerant selected and the common ambient conditions encountered. For purposes of illustration and without limiting the scope of this invention, the system of FIG. **1** will now be described in connection with typical pressure settings that might be selected when using refrigerant **502**. The pressure regulating valve **41** may be set for **100** p.s.i. with a resultant temperature of the liquid refrigerant in liquid header **42** of approximately 51° F. A desirable setting of hot gas defrosting pressure regulating valve **66** might be 215 p.s.i. whereby the defrosting gaseous refrigerant, after desuperheating by desuperheater **70**, would be slightly over 100° F., perhaps 110° F. to avoid any actual condensing by desuperheater **70**. In turn regulating valve **68** would be set a few pounds higher than valve **66** perhaps 218 p.s.i. Finally regulating valve **78** might be set to maintain **185** p.s.i. pressure in condensate header **75** whereby a pressure differential of about **30** p.s.i. is created between hot gas header **50** and condensate header **75** to cause the flow of defrosting refrigerant through conduit **48** and evaporator **44**, and to be returned through line **43**. This predetermined pressure differential results in predictable and consistent defrosting refrigerant flow through the evaporators whereby an appropriate defrosting time may be selected for each evaporator and a consistent defrosting under all ambient conditions will result. In a supermarket installation of this type, the typical suction pressures on the three levels of compressors for this arrangement might be as follows; 41 p.s.i. on standard temperature compressors **10** and **11**, 12 p.s.i. on low-temperature compressors **12** and **13**, and **0** p.s.i. (gauge) on ultralow temperature compressor **14**. Air-conditioning compressor **15** would normally be set for a suction pressure of around 80 p.s.i. Thus it may be seen that the pressure differential across the expansion valve **45** of a given evaporator **44** will be substantially constant under all operating and ambient conditions which pressure differential will be approximately 59 p.s.i. for standard temperature evaporators, 88 p.s.i. for low-temperature evaporators, and 100 p.s.i. for the ultralow temperature evaporators. As will readily appear to those skilled in the art, this will greatly improve the ability to select and properly set the expansion valves and will improve their operation.

In a central system of the type shown in FIG. **1** and described wherein the compressors are centrally located and yet the evaporators are remotely located, the various headers that have been described will also be centrally located with the compressors. Thus for example the liquid header **42** and flash gas separating chamber **60** will be closely associated with the compressors whereby the removal and return of the flash gas to the compressor suctions is simple and efficient. In contrast, the liquid lines **43** and suction liens **48** will be extremely long for connecting the refrigerated fixtures to the centrally located compressors and headers. Thus due to the aforedescribed reduction in line sizes resulting from elimination of a substantial portion of the flash gas that is normally created at the expansion valve **45**, there is a substantial savings in the cost of the pipes **43** and **48** not heretofore possible. Moreover the recompression of this undesirable flash gas is accomplished by the standard temperature compressor thereby permitting a reduction in the size of the low and ultralow temperature compressors. By providing a constant and relatively low liquid header pressure through the use of regulating valve **41** it is possible to permit the condensing or head pressure to vary over a wide range as dictated by ambient conditions including permitting the pressure to drop to otherwise unacceptably low pressures which produces substantial reduction in the power consumption of the compressors.

Referring now to FIG. **2**, a portion of a refrigeration system is shown that may be substituted for a corresponding portion of the system more fully disclosed in FIG. **1** and to the extend that components of the system of FIG. **2** correspond to or are substitutes for the system of FIG. **1** like numerals in the "100" series will be employed. The compressor **110** has its suction side **121** connected through conduit **154** to the suction header of the evaporators operated by compressor **110**. Also it may be seen that if the system of FIG. **2** were a compound compressor arrangement as is shown in FIG. **1** the suction side **121** and conduit **154** may also be connected to the discharge side of another compressor or compressors such as the low temperature compressors **12** and **13** shown in FIG. **1**. The compressor **110** discharges refrigerant through a conduit **127** to a high side float device **180**. A conduit **127A** is connected from the high side float device **180** to a receiver **128**. The high side float device **180** is a relatively conventional apparatus for allowing only the passage of liquid refrigeration therethrough from its inlet **181** to its outlet **182** and this has been diagrammatically shown by the float arrangement adapted to close the

outlet **182** upon the lowering of the liquid level in device **180**. In normal operation the pressure drop between conduit **127** and receiver **128** occurs across device **180**.

As shown in FIGS. **2** and **3** the receiver **128** is of a unique design which is adapted to enhance the separation of gaseous and liquid refrigerant and yet retain many of the known advantages of a surge type receiver. Receiver **128** includes a cylindrical vessel **183** positioned with its axis horizontal and having a conduit **184** passing horizontally therethrough along the lower portion of the vessel. Conduit **184** is provided with perforations or slots **185** along its length and around its circumference. At least some of the slots **185** are provided along the uppermost portion of conduit **184** to allow flash gas to escape from the conduit as shown by arrow **186**. Additional slots **185** are positioned in the lower portion of conduit **184** to allow liquid refrigerant to enter the conduit as shown by arrows **187**. The inlet end of conduit **184** is connected to conduit **127A** and the outlet end is connected to the main liquid header **142**. The conduit **161** is connected from the upper portion of receiver **128** to the suction side **121** of the compressor for removing flash gas from the receiver **128**. A pressure regulating valve **188** is provided in conduit **161** and serves to maintain a predetermined constant pressure in receiver **128** by controlling the rate of flash gas flow through the valve. By way of comparison with the aforedescribed system of FIG. **1**, valve **188** is set at 100 p.s.i. and will open at any pressure above 100 p.s.i. for passing the flash gas to the compressor thereby maintaining the supply of liquid refrigerant through header **142** at 100 p.s.i., comparable to the manner in which valve **41** of FIG. **1** maintains the liquid line pressure of **100** p.s.i. Thus it will be seen that the combination of high side float device **180** and pressure regulating valve **188**, commonly known as an EPR valve, serve to reduce the pressure from the head pressure in condenser **126** to the constant low liquid line pressure of **100** p.s.i. in header **142**. The flash gas produced in such pressure reduction is separated in receiver **128** and removed through conduit **161**. Conduit **177** is connected to conduit **127A** between the high side float device **180** and receiver **128** to return the refrigerant used in defrosting the evaporators to this point in the systems, similar to the function of aforedescribed conduit **77**. A pressure regulating valve **178** maintains a constant upstream pressure in conduit **177** which, in comparison with the aforedescribed system of FIG. **1**, would be 185 p.s.i. It may be seen that the flash gas created by the pressure reduction through valve **178** plus the gaseous refrigerant being returned from the fixtures being defrosted is carried into receiver **128**, is separated therein, and then removed through conduit **161**. Thus the receiver **128** also serves as a gas separating chamber comparable to aforedescribed chamber **60**. It is to be noted that if an air conditioning system is included in the system of FIG. **2** the liquid refrigerant will be supplied through a conduit **130** from the vessel of the high side float device **180** whereby the liquid pressure will be sufficiently high to supply the air conditioning evaporator.

Among the advantageous difference between the system of FIG. **2** and the previously described system of FIG. **1** obviously is the elimination of one vessel, that is, the receiver **128** of FIG. **2** replaces both the receiver **28** and the separating chamber **60** of the FIG. **1** system. Moreover the flash gas removal is greatly simplified in that the regulating valve **188** supplants the float control **62** and valve **63** in the system of FIG. **1**. In turn this flash gas removal arrangement of FIG. **2** is more dependable and less likely to allow any liquid refrigerant to flow back to the compressor suction in that the receiver **128** is normally of a sufficient size to contain the entire refrigerant charge of the system therefore liquid refrigerant would not reach the outlet to conduit **161**. Another advantageous result in the system of FIG. **2** is the creation of an automatic condenser flooding control since creation of an automatic condenser flooding control since receiver **128** is a modified surge type receiver whereby flooding will occur whenever the condenser pressure drops below the pressure setting of valve **188**, 100 p.s.i. in our example.

Referring now to FIG. **4**, another modified form of the system of this invention is illustrated in greatly simplified form. Again insofar as the components of this system correspond to components of the systems of FIGS. **1** and **2** numerals in the "200" series will be employed. Compressor **210** has its discharge side **222** connected to the condenser **226** which in turn is connected through conduit **227** to the receiver **228** which is illustrated as a surge-type receiver. A liquid refrigerant line **240** has a solenoid valve **289** therein which is in a normally open position during refrigerating operation of the system. The liquid line **240** is connected to a liquid header **242** of enlarged diameter with the liquid line **240** actually extending within a substantial portion o the length of the header **242**. Within header **242** line **240** is provided with apertures **290** whereby the refrigerant passing therethrough into header **242** is separated into gaseous and liquid refrigerant without creating excessive turbulence in header **242**. Thus header **242** in combination with the apertured portion of line **240** comprise a separating vessel or chamber similar to chamber **60** in the system of FIG. **1**. Liquid refrigerant lines **243** connect the bottom of header **242** to the evaporators **244** through the expansion valves **245** in the manner heretofore described. Suction lines **248** are connected to three-way valves **249** for selectively connecting the suction lines to either the suction header **251** or the hot gas header **250**. The hot gas header **250** is connected through a conduit **265** to the top of receiver **228** for supplying hot gaseous refrigerant for defrosting which gaseous refrigerant will be at the condensing or head pressure and at substantially saturation temperature. As shown in FIG. **4** the right-hand three-way valve **249** is positioned for supplying hot gas to the right-hand evaporator **244** for defrosting and the resultant defrosting refrigerant returns through line **243** to the liquid header **242** where any resultant gaseous refrigerant will rise to the top of the header. In order to provide a pressure differential incentive for the return of defrosting refrigerant to header **242** the solenoid valve **289** in liquid refrigerant supply line **240** is closed whereby the liquid refrigerant must flow through a bypass line **291**. A pressure reducing valve **292** is positioned in line **291** for producing a predetermined pressure differential thereacross, as for example about 30 p.s.i. Thus during defrosting the pressure in liquid header **242** will be around 30 p.s.i. less than the pressure in receiver **228** which constitutes the pressure of the hot gaseous defrosting refrigerant. Any flash gas created by the pressure drop across valve **292** will be separated in header **242**. A float switch **262** is positioned in one end of header **242** for sensing the liquid level in the header and controls a valve **263** positioned in a suction line **261** connected to the upper portion of header **242**. Suction line **261** is connected through an accumulator vessel **293** to the suction side **221** of compressor **210** to avoid passing any liquid refrigerant from line **261** directly to the intake if the compressor. The float switch **262** opens and closes valve **263** in response to the liquid level in header **242** to maintain an adequate quantity of liquid refrigerant therein for supplying the evaporators and yet precluding liquid refrigerant from flowing back through suction line **261**. Float switch **262** and valve **263** may be of either an on-off type or modulating between open and closed positions for controlling the liquid level in the header. An adjustable throttling valve **294** may be provided in suction line **261** for further control of the flow therethrough.

Referring to FIG. **5**, another modified form of the system of this invention if illustrated in simplified form similar to the illustration of FIG. **4**. Again similar components in this system of FIG. **5** will be given numerals in the "300" series corresponding to the previous numerals. The compressor **310** has its discharge **322** connected to condenser **326** and thence through conduit **327** to receiver **328**. Liquid line **340** is connected to liquid header **342** which in turn is connected through liquid lines **343** to the evaporators **344**. A suction line **348** is connected from each evaporator **344** through a three-way valve **349** to both the suction header **351** and hot gas header **350**. In this system the hot gas header is illustrated as

being connected directly to the compressor discharge **322**. When defrosting of an evaporator is desired the three-way valve **349** is repositioned to connect the hot gas header **350** to the suction line **348** as shown by the right-hand valve **349**. Simultaneously a solenoid valve **395** in liquid supply line **343** from liquid header **342** is closed and a second solenoid valve **396** in branch conduit **374** is opened for conducting the defrosting refrigerant to condensate header **375**. Under normal refrigerating operation of an evaporator **344** the valve **395** is open and valve **396** is closed. The defrosting refrigerant passes from condensate header **375** through conduit **377** and check valve **397** to a separating vessel or chamber **360** where the liquid and gaseous phases of the refrigerant are separated. The top portion of chamber **360** is connected through a suction line **361** to the suction side **321** of the compressor **310** and a pressure reducing valve **392** is positioned in conduit **361** for controlling the flow therethrough. Valve **392** is set to maintain a predetermined pressure differential between the discharge side **322** of the compressor and the condensate header **375** such as around a **30** p.s.i. differential, whereby an incentive is produced to cause the flow of the defrosting refrigerant through the evaporator to the condensate header. Means are provided for sensing and controlling the liquid level in chamber **360** between maximum and minimum limits and as shown in the drawings these means may include upper and lower float switches **398** and **399**. During the defrosting of one or more evaporators, as the liquid level in chamber **360** rises to the maximum desired level as sensed by float switch **398** a solenoid valve **400** in suction line **361** is closed, a solenoid valve **401** is opened in a high pressure line **401** between the compressor discharge side **322** and chamber **360**, and a third solenoid valve **403** positioned in liquid supply line **340** is closed. A drain line **404** is connected from chamber **360** to liquid line **340** downstream from the location of valve **403** whereby the increased pressure in chamber **360** through line **402** will cause the accumulated liquid refrigerant in the chamber **360** to become the normal liquid refrigerant supply in line **340**. When the predetermined minimum level of liquid refrigerant in chamber **360** is reached as sensed by float switch **399**, valves **400** and **403** are returned to their open positions and valve **401** is closed. A check valve **405** in drain line **404** prevents the flow of liquid refrigerant from liquid line **340** into chamber **360**. Thus a predetermined pressure differential is again provided as incentive for the flow of hot gas defrosting refrigerant through the evaporators and of the returning defrosting refrigerant to chamber **360** where the gaseous phase is removed and returned to the compressor suction while only the liquid phase is returned to the liquid refrigerant supply for the evaporators.

Having fully described my invention in connection with selected embodiments and arrangements by way of example, it is to be understood that my invention is not limited to such specific embodiments and arrangements as disclosed but rather is of the full scope of the appended claims.

I claim:

1. A refrigeration system having multiple refrigerated fixtures with hot gas type defrosting of such fixtures, comprising, compressor means for compressing refrigerant and having low pressure suction and high pressure discharge sides, condenser-receiver means for condensing the compressed refrigerant and supplying liquid refrigerant, a plurality of evaporators associated with the refrigerated fixtures and having means normally connecting said evaporators in parallel between said condenser-receiver means and said suction side of the compressor means with means for evaporating the refrigerant and cooling said fixtures, a chamber means for separating liquid and gaseous refrigerant, valve and conduit means connecting at least one of said evaporators between the high pressure side of the system and said chamber means and operable for selectively supplying hot gaseous refrigerant to said evaporator for defrosting and for conducting the resultant liquid and gaseous refrigerant directly to said chamber means for separating the phases, said chamber means being in communication with said means normally connecting said condenser-receiver means and said evaporators for returning the resultant liquid refrigerant phase produced by defrosting from said chamber means into the liquid refrigerant supply for said evaporators, and means restrictively connecting said chamber means to the suction side of said compressor means for controllably returning the separated gaseous refrigerant from said chamber means to said compressor means.

2. The system of claim **1** wherein said means restrictively connecting said chamber means and compressor suction side includes valve means operably responsive to the presence of excess gaseous refrigerant in said chamber for controlling the communication with said compressor suction side.

3. The system of claim **2** wherein said valve means has means for controlling the pressure in said chamber means whereby the excess gaseous refrigerant is controllably removed.

4. The system of claim **1** wherein a float control means is positioned in said chamber and responsive to the liquid level therein and said means restrictively connecting said chamber means and compressor suction side includes a valve means controlled by said float control means.

5. The system of claim **1** wherein a single vessel includes both said chamber means and the refrigerant retaining receiver portion of the condenser-receiver of the system.

6. The system of claim **5** wherein said vessel is comprised of an elongated cylinder positioned horizontally, and a perforated conduit extends along the bottom of the cylinder with such perforations admitting liquid refrigerant and allowing exit of gaseous refrigerant into the vessel, said conduit having ends comprising the inlet and outlet of the refrigerant receiver formed by the vessel.

7. The system of claim **1** wherein means are provided for reducing the pressure of the liquid refrigerant supply before conducting such refrigerant to the evaporators, said chamber means being in direct communication with such reduced pressure liquid refrigerant supply between said pressure reducing means and the evaporators for receiving and separating flash gas formed in such pressure reduction, said flash gas also being removed from said chamber means by said restrictive connecting means to said compressor suction side.

8. The system of claim **7** wherein pressure reducing means produces a predetermined low pressure having a saturation temperature below normal room temperature in said liquid refrigerant supply and a predetermined pressure differential across said evaporators unrelated to the system head pressure.

9. The system of claim **7** wherein said compressor means, condenser-receiver means and chamber means are all centrally located together and said evaporators and fixtures are remotely located with connecting conduits between such locations, said conduits being of reduced size comparable to the reduced refrigerant conducted by reason of eliminating said flash gas.

10. The system of claim **1** wherein said valve and conduit means includes two pressure regulating valve means operable for controlling maximum and minimum pressures for supplying said hot gaseous refrigerant for defrosting within a small predetermined pressure range under all ambient and operating conditions for controlled defrosting.

11. The system of claim **10** wherein said valve and conduit means includes another pressure regulating valve means for producing a predetermined back pressure on the refrigerant returning from defrosting.

12. The system of claim **11** wherein said other pressure regulating valve means causes a pressure reduction in the defrosting refrigerant before entering said chamber means and any resultant flash gas is separated in said chamber means.

13. The system of claim **1** wherein means are provided in said chamber means for sensing maximum and minimum desired liquid levels in said chamber means, valve controlled means connecting said chamber means to the compressor means discharge side, valve means in said means normally connecting said condenser-receiver to said evaporators up-

stream of the communication with said chamber means, and said sensing means operating said valve controlled means and said valve means to periodically close said valve means and open said valve controlled means upon sensing said maximum level to supply the liquid refrigerant for the evaporators from said chamber means and to reopen said valve means and close said valve controlled means upon sensing said minimum level.

14. The system of claim 13 wherein said restrictive connecting means includes a valve and pressure reducing valve means normally maintaining a pressure differential between said chamber means and normal liquid refrigerant supply, said chamber means having check valve means preventing reverse flow of refrigerant from the liquid refrigerant supply means, and said sensing means also operates said valve in said restrictive connecting means to the same positions as said valve means in said liquid supply.

15. A refrigeration system having multiple refrigerated fixtures with hot gas type defrosting of such fixtures, comprising, compressor means for compressing refrigerant and having low pressure suction and high pressure discharge sides, condenser-receiver means for condensing the compressed refrigerant and supplying liquid refrigerant, a plurality of evaporators associated with the refrigerated fixtures and having means normally connecting said evaporators in parallel between said condenser-receiver means and said suction side of the compressor means with means for evaporating the refrigerant and cooling said fixtures, a chamber means for separating liquid and gaseous refrigerant, valve and conduit means connecting at least one of said evaporators to the high pressure side of the system to supply hot gaseous refrigerant to said evaporator for defrosting and for conducting the resultant refrigerant condensate to said chamber means, said chamber means being in communication with said means normally connecting said condenser-receiver means to said evaporators for returning liquid condensate refrigerant from defrosting into the liquid refrigerant supply for said evaporators, means restrictively connecting said chamber means to the suction side of said compressor for controllably returning gaseous refrigerant from said chamber means to said compressor means, and valve means for affirmatively producing a reduced pressure in said chamber means relative to the pressure of said hot gaseous defrosting refrigerant for producing a pressure differential to cause the defrosting refrigerant to flow through the evaporators into said chamber means.

16. The refrigeration system of claim 15, wherein said valve means produces a predetermined and relatively low pressure in the liquid refrigerant supply.

17. The refrigeration system of claim 15, wherein said valve means produces a predetermined pressure drop in said liquid refrigerant supply between said condenser-receiver and the location of communication of said chamber means.

18. The refrigeration system of claim 15, wherein said valve means produces a predetermined pressure differential between said compressor discharge side and said chamber means and the absolute pressures vary with discharge side pressure variations.

19. The refrigeration system of claim 15, wherein said valve means also affirmatively produces a like reduced pressure in said liquid refrigerant supply upstream of the location of said chamber means, and flash gas created by said liquid refrigerant pressure reduction is separated in said chamber means and also removed by said restrictive connecting means in a controlled manner to said compressor.

20. In a closed cycle refrigeration system employing a compressor, condenser and receiver for supplying liquid refrigerant and multiple evaporators for multiple refrigerated fixtures wherein hot gas defrosting of such fixtures is provided, the improvement comprising, a vessel having chamber means for separating liquid and gaseous refrigerant, valve and conduit means connecting said evaporators to said vessel for selectively connecting it at least one of sad evaporators between the high pressure side of the system and said vessel to supply hot gaseous refrigerant to said evaporator for defrosting and for conducting the resultant liquid and gaseous refrigerant directly to said chamber means for separating the phases, said vessel having means in communication with the normal supply of liquid refrigerant to said evaporators for returning the liquid refrigerant resulting from defrosting into the liquid refrigerant supply for said evaporators, and means restrictively connecting said chamber means to the suction side of said compressor for controllably returning gaseous refrigerant from said chamber means to said compressor means.

21. The refrigeration system improvement of claim 20 wherein a regulating valve means is provided in communication with said chamber means and affirmatively produces a pressure differential between said chamber means and the supply of hot gaseous defrosting refrigerant to cause the defrosting refrigerant to flow through the evaporators to said chamber means.

22. The refrigeration system improvement of claim 20 wherein float control means are provided in said chamber means for maintaining a desired liquid level in said chamber means.

23. The refrigeration system improvement of claim 20 wherein pressure regulating valve means are provided for controlling to three predetermined pressure levels the liquid refrigerant supply, the hot gaseous defrosting refrigerant supply and the resultant refrigerant condensate returning from defrosting.

24. The refrigeration system improvement of claim 21 wherein valve and conduit means also serve to activate said regulating valve means only during the defrosting of an evaporator.

25. The refrigeration system improvement of claim 20 wherein pressure regulating valve means are provided for producing a predetermined and constant low pressure in both the normal supply of liquid refrigerant and said vessel, and the refrigerant at said constant low pressure has a saturation temperature below the normal room temperature.

26. The refrigeration system improvement of claim 20 wherein two pressure regulating valve means are provided for maintaining the pressure of said hot gaseous refrigerant within a small predetermined range under all ambient and operating conditions.

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