United States Patent

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[54] HOT GAS REFRIGERATION DEFROST STRUCTURE AND METHOD

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[52] **U.S. Cl.** **62/81**, 62/151, 62/159, 62/277, 62/278, 62/204

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

[58] **Field of Search** 62/81, 278, 277, 151, 159

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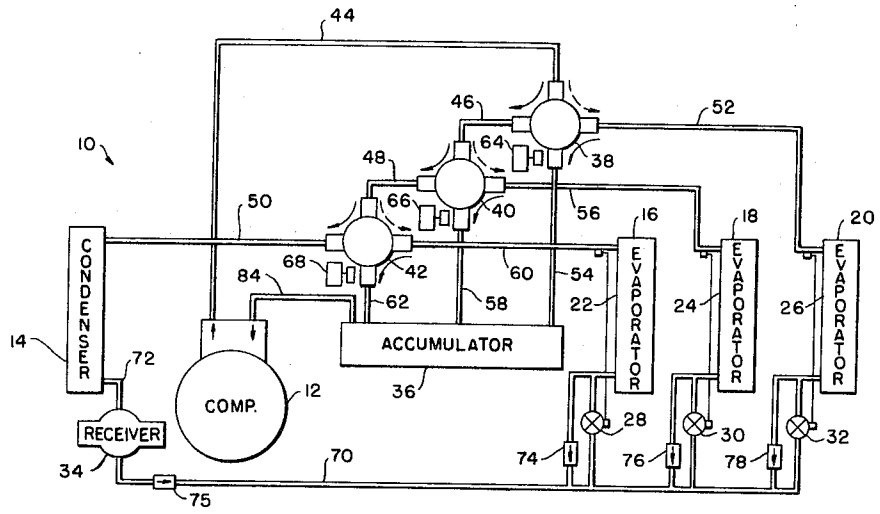
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[57] **ABSTRACT**

A hot gas refrigeration defrost system is disclosed including a compressor and condenser in series with a plurality of series expansion means and evaporators connected in parallel, and a plurality of diverting valves connected between the evaporators and compressor input in parallel and connected in series between the compressor output and condenser. The diverting valves are operable to change the flow of the hot gas from the compressor to one of the evaporators to defrost the one evaporator and are simultaneously operable to isolate the condenser from the compressor output. A check valve is provided in the high side of the refrigeration system between the condenser and evaporators and a check valve is provided around each of the expansion means whereby hot compressor gas passed through an evaporator to defrost the evaporator is bypassed around the associated expansion means, is prevented from returning to the condenser and is passed through the expansion means associated with the remaining evaporators and back to the compressor. An accumulator is provided between the evaporators and compressor to prevent slugs of liquid refrigerant returning to the compressor at the end of the defrost cycle when the cooling cycle is resumed.

20 Claims, 3 Drawing Figures



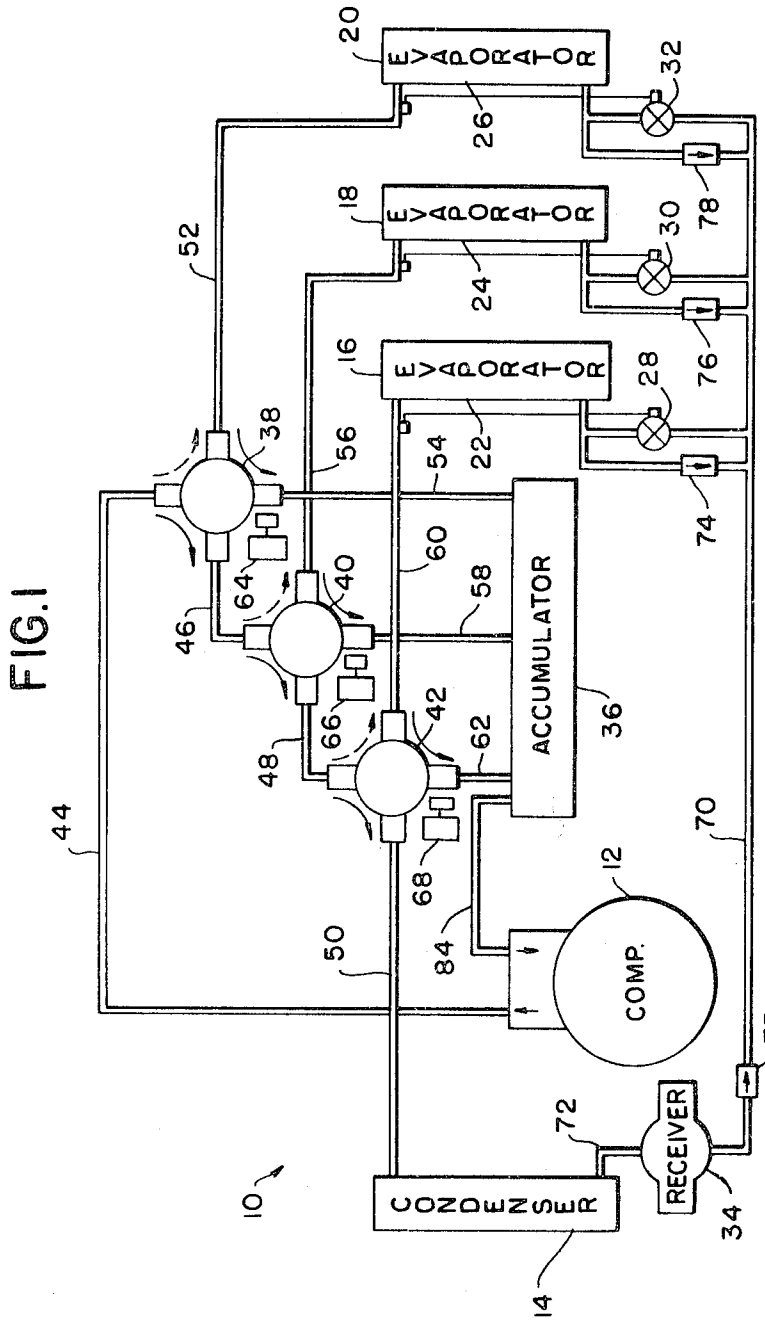


FIG. 1

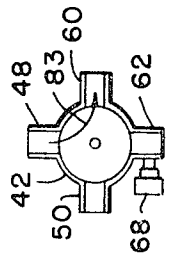


FIG. 3

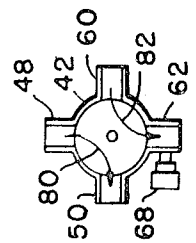


FIG. 2

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HOT GAS REFRIGERATION DEFROST STRUCTURE AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is related to commonly owned U.S. Pat. application, Ser. No. 733,946, filed June 3, 1968, in that the expansion valves in the present system are balanced expansion valves having oversize metering orifices such as the valves disclosed in application, Ser. No. 733,946. These valves control feeding of the evaporator associated therewith during defrost so as to maintain a minimum degree of superheat leaving the evaporator without flooding past the evaporator over a large range of condenser temperature such as ambient extremes during summer and winter with the condenser located outdoors.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to refrigeration and refers more specifically to structure for and a method of hot gas defrosting of a refrigeration system in which hot gas is returned from the compressor in a refrigeration system through one of a plurality of evaporators in the system whereby the one evaporator acts as a condenser for the remaining evaporators in the system during defrosting of the one evaporator and the condenser in the system is isolated therefrom during defrost of the one evaporator.

2. Description of the Prior Art

In the refrigeration systems of the past having an evaporator coil temperature below 25° F., moisture condenses from the air and forms frost on the evaporator coil surface. This frost must be removed at intermittent intervals to maintain proper heat transfer in the refrigeration system.

As is well known in the prior art, hot compressed vapor refrigerant discharged from the compressor has a heat content capable of defrosting the evaporator coil in a refrigeration system. However, satisfactory defrosting with hot compressor gas has in the past been unsatisfactory, particularly if the refrigeration system is using an air cooled condenser located in a cold ambient temperature such as might be experienced in the outdoors in the winter time which results in the reduction of the heat quantity available to the evaporator coil to the point where it is insufficient to properly defrost the evaporator coil.

Further, in the past the cooling of the refrigerant during defrost has reduced its pressure to the point that it has been difficult to introduce the refrigerant into the high side of the refrigeration system and pass the refrigerant on through the normal refrigeration thermostatic expansion valve into the evaporator coil of the cooling cycle.

SUMMARY OF THE INVENTION

In accordance with the present invention, defrosting of a refrigeration system including a plurality of parallel connected expansion valves and evaporators is accomplished by isolating the usual condenser of the refrigeration system during defrost of one or more of the evaporators, passing the compressor outlet hot gases through the evaporators to be defrosted from the normal outlet to the inlet thereof, bypassing the expansion valves associated with the evaporators being defrosted and providing discharge of the evaporators to be defrosted, which during the defrost cycle act as a condenser, to the expansion valves associated with the remaining evaporators, and completing a normal cooling cycle with the remaining evaporators.

In accomplishing such defrosting, diverting valves adapted to be connected in series between the compressor outlet and condenser inlet and each adapted to be connected in parallel between one of the evaporators and the compressor inlet are provided, a check valve is provided to prevent return of fluid from the usual expansion valve inlet to the condenser outlet, and bypass check valves are provided around the expansion valves to permit reverse flow of fluid around the expansion valves.

In addition, an accumulator is provided between the diverting valves and the compressor to prevent large quantities of liquid refrigerant from passing from the evaporators being defrosted directly into the compressor on return of the refrigeration system to a cooling cycle from a defrosting cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of refrigeration structure constructed to perform the hot gas defrost method of the invention.

FIG. 2 is a diagrammatic indication of one diverting valve of the refrigeration system of FIG. 1 connected in a refrigeration cycle.

FIG. 3 is a diagrammatic representation of the one diverting valve of the refrigeration structure in FIG. 1 connected in a defrost cycle.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The refrigeration system **10** illustrated best in FIG. **1** includes a compressor **12** and a condenser **14**, expansion valves **28, 30** and **32** and evaporators **22, 24** and **26** connected in parallel with each other in series with the condenser outlet and compressor inlet in the usual multiple evaporator refrigeration configuration as shown. A receiver **34** is connected between the outlet of the condenser **14** and the expansion valves **28, 30** and **32** and an accumulator **36** is positioned between the evaporators **22, 24** and **26** and the compressor **12**, again to function in the usual manner during a refrigeration cycle of the refrigeration structure **10**.

In addition, the refrigeration structure **10** includes the diverting valves **38, 40** and **42** connected in series between the outlet of compressor **12** and the inlet of condenser **14** through conduits **44, 46, 48** and **50**. The diverting valves **38, 40** and **42** are also connected in parallel between the evaporators **22, 24** and **26** and the accumulator **36**, through conduits **52** and **54**, conduits **56** and **58** and conduits **60** and **62** respectively.

The diverting valves **38, 40** and **42** which are provided with actuating structures **64, 66** and **68** are provided to divert hot gas from the compressor output conduit **44** into the evaporators **22, 24** or **26** selectively on being individually actuated. On diverting the hot gas from the compressor **12** into the evaporators **22, 24** and **26**, the diverting valves **38, 40** and **42** isolate the input end of the condenser **14** from the rest of the refrigeration system **10**.

The output conduit **70** from the receiver **34** through conduit **72** includes a check valve **75** therein which effectively isolates the output end of the condenser **14** from the rest of the refrigeration system **10** with regard to flow backwards through the condenser **14**.

In addition, check valves **74, 76** and **78** are provided around the expansion valves **28, 30** and **32**. Check valves **74, 76** and **78** permit reverse flow of fluid from the evaporators **22, 24** and **26** respectively during defrost of the evaporators **22, 24** or **26**.

Diverting valves **38, 40** and **42** are exactly similar. Therefore, only the diverting valve **42** has been shown in more detail in FIGS. **2** and **3**.

In FIG. **2** the diverting valve which may in fact be a solenoid-actuated spool valve is shown in the position it maintains during a refrigeration cycle when the solenoid actuating structure **68** is deenergized. In such position as shown by the arrow **80**, the compressor discharge line **48** is connected directly to the input conduit **50** of the condenser through diverting valves **38** and **40** and conduits **46** and **48**. At the same time, the evaporator **22** is connected to the suction line **84** of the compressor **12** through the accumulator **36** and conduits **60** and **62** as shown by arrow **82**. Thus, the refrigeration system **10** is connected in a normal refrigeration configuration.

On energizing the actuating mechanism **68** for the diverting valve **42**, and as shown by arrow **83** in FIG. **3**, the conduit **48** is connected directly to the evaporator **22** through valve **42**, while the conduit **62** and the condenser conduit **50** are effectively closed. Thus, when the diverting valve **42** is energized,

the hot gases from the compressor 12 will be passed through the evaporator 22 rather than through the condenser 14 to provide defrosting of the evaporator 22, as will now be considered in the overall operation of the refrigeration system 10.

In operation of the refrigeration system 10 in a refrigerating cycle, all of the diverting valve actuating means 64, 66 and 68 are in the condition illustrated in FIG. 2. Thus, refrigerant gases from the accumulator 36 are compressed in compressor 12 and the hot compressed gases are discharged from the compressor 12 through conduit 44, diverting valve 38, conduit 46, diverting valve 40, conduit 48 diverting valve 42 and conduit 50 to the condenser. The hot gases are condensed in the condenser which may be at a low ambient outside temperature and the condensed gases passed into the receiver 34 through the conduit 72.

The compressed condensed refrigerant from the receiver 34 is then passed through the check valve 75 and conduit 70 to the expansion valves 28, 30 and 32 which as indicated above are balanced expansion valves of the type disclosed in U.S. Pat. application, Ser. No. 733,946, which are operated in accordance with the condition present in the evaporator discharge lines 52, 56 and 60 to provide proper refrigerant flow to the evaporators 22, 24 and 26 over a particularly wide range of pressure differentials thereacross.

On passing of the refrigerant from the receiver 34 through the expansion valves 28, 30 and 32, the refrigerant expands to cool the evaporator coils 22, 24 and 26 and provide the required refrigeration after which the refrigeration gas is passed from the evaporators 22, 24 and 26 to the accumulator 36 through the multiple paths of conduit 52, valve 38 and conduit 54; conduit 56, valve 40 and conduit 58; and conduit 60, valve 42 and conduit 62. The refrigerant is then drawn from the accumulator 36 through conduit 84 by the compressor 12 to complete a refrigerating cycle.

When one or more evaporators 22, 24 and 26, such as the evaporator 22 for example, becomes covered with frost so that the refrigeration provided thereby is inefficient to the point where it is desired to defrost the evaporator 22, the diverting valve associated with the evaporator or evaporators it is desired to defrost is actuated so that it is in the condition illustrated in FIG. 3 by actuating the actuating means associated therewith as for example by actuating the solenoid of actuating means 68.

On placing the diverting valve 42 in the condition illustrated in FIG. 3, the condenser input conduit 50 is isolated and the hot compressor gases are passed from conduit 48 to conduit 60 into the evaporator 22 from the normal discharge end thereof. The hot compressor gases are condensed in the evaporator 22 while the evaporator 22 is defrosted.

Condensed refrigerant from the evaporator 22 is then bypassed around the refrigeration valve 28 through the check valve 74 into the high side of the refrigeration system 10 into conduit 70. The refrigerant in the conduit 70 then passes through the expansion valves 30 and 32 and through the evaporators 24 and 26 back to the accumulator 36 through the diverting valves 38 and 40 which have not been energized to permit return of the refrigerant from the compressor 12 into the accumulator 36 as before.

After defrosting of the evaporator 22 is complete, the diverting valve 42 is returned to the condition illustrated in FIG. 2 to resume a refrigeration cycle. On returning to the refrigeration cycle, the accumulator 36 between the evaporator 22 and the compressor 12 prevents large slugs of liquid refrigerant being passed directly to the compressor 12, since as is well known, this is detrimental to the compressor.

It will be understood that all of the evaporators 22, 24 and 26 cannot be defrosted simultaneously, but that the refrigeration system 10 provides relatively simple, inexpensive and particularly efficient means for defrosting the evaporators 22, 24 and 26 individually or in pairs as the particular system design permits.

While one embodiment of the present invention has been disclosed in detail, it will be understood that other embodiments and modifications of the invention are contemplated. It is therefore the intention to include all the modifications and embodiments of the invention as are defined by the appended claims within the scope of the invention.

What I claim as my invention is:

1. Refrigeration structure including hot gas defrost means comprising a compressor, a condenser, a plurality of evaporators and series connected expansion means therefor connected in parallel with each other and in series between the compressor and condenser and separate valve means connected between the compressor, condenser and each of the evaporators for completely isolating the condenser from the compressor, expansion means and evaporators during defrost of some of the evaporators and for connecting at least one of the evaporators with the discharge of the compressor in a defrost cycle while the other evaporators are connected in a refrigeration cycle through the one of the evaporators.

2. Structure as set forth in claim 1 wherein the means for isolating the condenser and connecting at least one of the evaporators with the discharge of the compressor comprises multiple position diverting valves positioned between each of the evaporators and the condenser and compressor.

3. Structure as set forth in claim 2 wherein the diverting valves are positioned in series between the compressor outlet and condenser and in parallel between the evaporators and compressor inlet.

4. Structure as set forth in claim 1 and further including a check valve positioned between the condenser and parallel expansion means to prevent refrigerant from flowing from the evaporators to the condenser.

5. Structure as set forth in claim 1 and further including a check valve bypass around each of the expansion means for permitting refrigerant flow from one evaporator around the expansion means associated therewith to the other expansion means.

6. Structure as set forth in claim 1 and further including an accumulator in series between the evaporators and the compressor for preventing slugs of liquid refrigerant returning to the compressor on refrigeration cycle change from defrost to refrigerate.

7. Structure as set forth in claim 1 wherein the expansion means are balanced expansion valves having oversized valve orifices.

8. The method of defrosting a refrigeration system including a compressor, a condenser and at least two parallel structures each including an expansion means and an evaporator connected in series which parallel structures are connected in series with the compressor and condenser, comprising completely isolating the condenser from the compressor and parallel structures and passing the output of the compressor through the evaporator of one of the parallel structures to defrost the evaporator of the one parallel structure and back through the expansion means and evaporator of the other parallel structure to the compressor.

9. The method as set forth in claim 8 and further including bypassing the expansion means of the one evaporator with refrigerant condensed therein during defrost and preventing flow of refrigerant bypassed around the one expansion means from flowing into the condenser.

10. The method as set forth in claim 8 and further including controlling the feeding of the other evaporator structure during defrost to maintain a minimum degree of superheat leaving the evaporator without flooding past the evaporator.

11. In refrigeration structure including a compressor, a condenser, and at least two evaporator expansion valve structures connected in parallel with each other and in series with the compressor and condenser in a refrigeration cycle, each of which evaporator expansion valve structures includes a series connected evaporator and expansion valve, means for isolating the condenser from the compressor and evaporator expansion valve structures during defrost of the evaporator of one of the evaporator expansion valve structures, and means for passing refrigerant directly from the compressor through the

one evaporator and around the expansion valve in the one evaporator expansion valve structure through the expansion valve and evaporator in the other evaporator expansion valve structure and back to the compressor during defrost of the one evaporator whereby defrost time of the evaporator in the one evaporator expansion valve structure is substantially independent of the ambient temperature at the condenser.

12. Structure as set forth in claim 11, wherein the means for isolating the condenser during defrost of one of the evaporators includes separate direction valves between each evaporator and the compressor and condenser for providing a series connection between the compressor and condenser through each of the direction valves and a parallel connection between each of the evaporators and the compressor through the separate direction valves in one position thereof, said direction valves closing the series connection between the compressor and condenser and providing a series connection directly between the compressor and the one evaporator in an alternate position thereof, and a check valve between the evaporator expansion valve structures and condenser preventing refrigerant flow from the evaporator expansion valve structures to the condenser.

13. The method of defrosting one evaporator of a refrigeration structure, which refrigeration structure includes a compressor and a condenser connected in series with each other and in series with at least two parallel evaporator expansion valve structures, each of which evaporator expansion valve structures includes an evaporator and an expansion valve in series comprising the step of isolating the condenser from the compressor and evaporator expansion valve structures and passing the output of the condenser from the compressor through one evaporator and subsequently through the expansion valve and evaporator of the other evaporator expansion valve structure back to the compressor during defrost of the one evaporator.

14. Refrigeration structure including hot gas defrost means comprising a compressor, a condenser, and a plurality of evaporator expansion valve structures each including a series connected evaporator and expansion valve, said condenser being connected at its outlet to each of the evaporator expansion valve structures through the expansion valve, a plurality of direction valves connected between the evaporator expansion valve structures, the compressor and condenser providing in one position thereof a series connection therethrough between the compressor outlet and condenser inlet and parallel connections through the separate direction valves for the separate evaporator expansion valve structures to the input of the compressor and each direction valve providing in an alternate position thereof a break in the series connection between the compressor outlet and the condenser and a series connection between the compressor outlet and the evaporator of the associated evaporator expansion valve structure, whereby the condenser is isolated from the refrigeration cycle during defrost of an evaporator so that defrost of the evaporators on an equal time cycle is possible regardless of the temperature at the condenser.

15. Structure as set forth in claim 14 and further including an accumulator positioned between the direction valves and the compressor input for receiving output from the evaporators through the direction valves in parallel and providing a single output to the compressor input.

16. Structure as set forth in claim 15 and further including a check valve positioned between the condenser output and the expansion valves of the evaporator expansion valve structures for preventing refrigerant from returning to the condenser from the evaporators.

17. Structure as set forth in claim 16 and further including bypass valves connected in parallel with the expansion valves in each of the evaporator expansion valve structures for permitting refrigerant flow from the compressor through the one evaporator around the associated expansion valve and to the expansion valves in the other evaporator expansion valve structures for passage therethrough back to the compressor in a refrigeration cycle and for preventing bypassing of refrigerant from the condenser around the expansion valves.

18. Structure as set forth in claim 17, wherein the expansion valves are balanced expansion valves having oversized valve orifices.

19. The method of defrosting a refrigeration system including a compressor and a condenser connected in series with each other and in series with a plurality of parallel connected evaporator expansion valve structures, each including an evaporator and an expansion valve and a separate direction valve associated with each of the parallel evaporator expansion valve structures providing in one position thereof a series connection between the compressor output and condenser input and parallel connections between the separate parallel evaporator expansion valve structures and the compressor input and providing in an alternate position thereof a direct connection between the compressor output and the evaporator of one of the evaporator expansion valve structures, which method comprises placing one of the direction valve structures in the alternate position thereof when it is desired to defrost the evaporator associated therewith to break the series connection between the compressor output and the condenser input, thereby isolating the condenser from the refrigeration system and passing hot refrigerant directly from the compressor through the one evaporator of the evaporator expansion valve structure associated with the particular direction valve to defrost the one evaporator, and bypassing the refrigerant passed through the one evaporator around the expansion valve associated with the one expansion valve to the expansion valve of the other evaporator expansion valve structures and through the evaporators thereof back to the compressor.

20. The method as claimed in claim 19, and further including the step of preventing return of refrigerant from the one evaporator during defrost to the output of the condenser.

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