Feb. 15, 1966 L. K. QUICK 3,234,753

HOT GAS REFRIGERATION DEFROSTING SYSTEM

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Fig. 1.

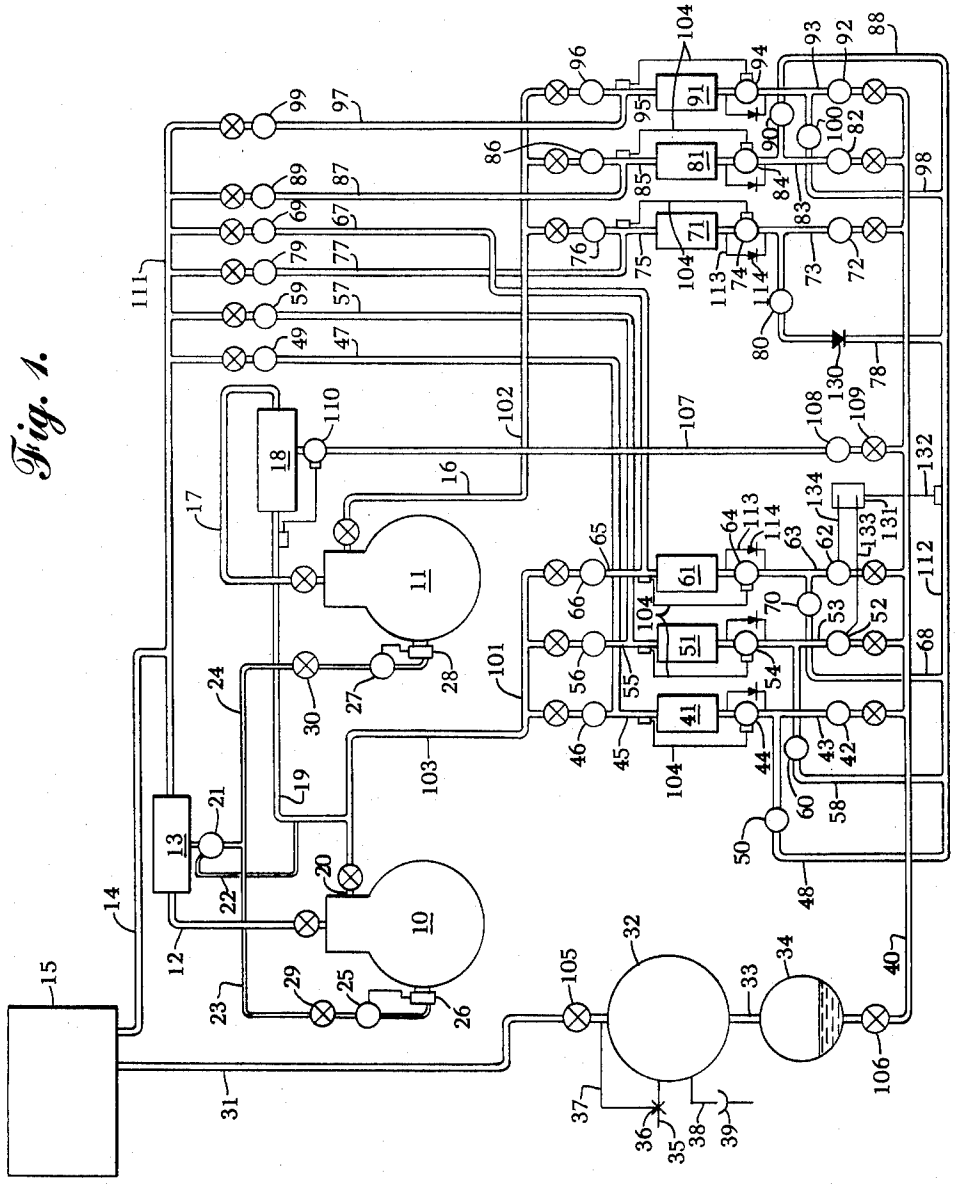
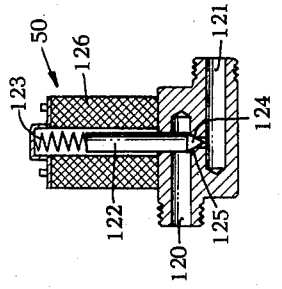


Fig. 2.



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HOT GAS REFRIGERATION DEFROSTING SYSTEM

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This invention relates to a system for defrosting the evaporator coils of a refrigeration system and, in particular, is directed to a defrosting system which employs the hot compressed gaseous refrigerant from the refrigeration system compressor for the source of heat used in defrosting the evaporator coils of the refrigeration system and wherein the refrigerant so used in the defrosting cycle of each evaporator coil is reintroduced into the normal refrigeration cycle by evaporating that refrigerant in one or more other evaporator coils which are being operated in a normal refrigeration manner.

In the normal refrigeration cycle a suitable refrigerant is compressed in a compressor, passes through a condenser where it gives off heat and changes to a liquid state and then is passed through an expansion valve to an evaporator coil to absorb heat and change the refrigerant back to a gaseous state for recompressing in the compressor to complete the refrigeration cycle. The evaporator coil is positioned within a refrigerated fixture, box, display case, or cabinet and the heat absorbed by the refrigerant passing through the coil serves to extract heat from the refrigerated fixture and its contents to maintain the fixture at the desired temperature. As is well known, this extracting of heat from the refrigerated fixture and its contents causes frost to form on the evaporator coil and refrigerated fixture which intermittently must be removed to maintain proper functioning of the evaporator coil and avoid undesirable build-up of frost on the coil or other parts of the refrigerated fixture.

In modern stores, warehouses, and supermarkets it is common to have numerous refrigerated fixtures, boxes, display cases or cabinets which are refrigerated by separate individual refrigeration systems or by a single central refrigeration system supplying liquid refrigerant to each of the separate evaporator coils positioned in the refrigerated fixtures. Since these evaporator coils and refrigerated fixtures accumulate frost which must be removed periodically, it is conventional to provide some type of heater such as an electric heating element which when activated serves to automatically defrost the refrigerated fixture and evaporator coil. Although this periodic defrosting is essential to the proper operation and maintenance of the refrigerated box, electric heaters are also relatively expensive both in initial cost and in operation due to the amount of power consumed in accomplishing the defrosting by these individual heaters. It is highly desirable that the defrosting be relatively rapid in order to avoid raising the temperature of the refrigerated box and its contents an objectionable amount.

As has been well known in the art, hot compressed gaseous refrigerant discharged from the compressor has a heat load capable of defrosting the evaporating coils in refrigerated fixtures. However, in the past a total hot gas defrost was not satisfactory, inasmuch as compressor overloading frequently occurred and the available heat load was generally insufficient to effectively defrost both the evaporators and other fixture parts. Furthermore, the change of refrigerant to liquid phase during defrosting is not always complete, consistent or predictable and problems are created in the re-introduction of the refrigerant into the normal refrigeration cycle. For example, this refrigerant cannot be introduced into the intake of the compressor because of the liquid refrigerant which would damage the compressor. Further, the cooling of this refrigerant which occurs during the defrosting will reduce its pressure so that it cannot be directly introduced into high pressure side of the refrigeration system without the use of special methods.

While it has been found satisfactory to provide additional special apparatus for completely evaporating or completely condensing the refrigerant used for defrosting the evaporator coils and then re-introducing this refrigerant into the refrigeration system at an appropriate point thereof by further special apparatus or methods, this additional apparatus increases the cost and complexity of the entire system. Further, a loss in efficiency may be introduced into the system by the use of these special methods and apparatus.

Accordingly, it is a principal object of this invention to provide a novel system for defrosting the evaporator coils of a refrigeration system wherein the heat required for accomplishing the defrosting is extracted from the hot compressed refrigerant gas discharged from the refrigeration system compressor and the refrigerant so used is reintroduced into the refrigeration system cycle through one or more evaporator coils in a normal refrigerating manner.

Another object of this invention is to provide a defrosting system using the hot gaseous refrigerant discharged from the refrigeration system compressor wherein each evaporator coil is connected to one or more other evaporator coils in a novel manner whereby the refrigerant used in defrosting one evaporator coil is introduced into such other evaporator coils to satisfy, in part, the demand for condensed refrigerant of those coils.

A further and more specific object of this invention is to provide a hot gas defrosting system for a refrigeration system employing numerous separate evaporator coils wherein the flow of liquid refrigerant to any one evaporator coil may be temporarily terminated and hot gaseous refrigerant from the refrigeration system compressor may be circulated through that evaporator coil to accomplish defrosting thereof, and wherein novel means are provided for introducing the refrigerant so used in defrosting into one or more of the other evaporator coils which are operating on a normal refrigerating cycle. A still further and more specific object of this invention is to provide a novel control apparatus for such a system for automatically conditioning at least one evaporator coil to assure the re-introduction of the refrigerant into the system through at least that evaporator coil.

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

In the drawings:

FIGURE 1 of the drawings is a diagrammatic illustration showing the preferred form of my invention as incorporated with a plurality of refrigerated boxes and using two compressors in compounded relationship for increased efficiency, and

FIGURE 2 is a schematic sectional elevation of a type of solenoid valve used in various locations in the system illustrated in FIGURE 1.

As found in a normal refrigeration system, means are provided for compressing the refrigerant gas and, as shown in the drawing, these means may include a standard or normal temperature compressor **10** and a low temperature compressor **11** for supplying hot compressed gaseous refrigerant through conduit **12** to oil separator **13** and thence through conduit **14** to a condenser **15** where the refrigerant is cooled and condensed to a liquid. Although it is not essential to this invention, for increased efficiency, I prefer to use the two compressors **10** and **11** in a multiple evaporator refrigeration system such as illustrated rather than only one compressor. In this arrangement compressor **11** takes low pressure gaseous

refrigerant from conduit 16 and compresses same to an intermediate pressure and temperature, the refrigerant then passes through conduit 17 to a conventional hot gas desuperheater 18 and thence through conduit 19 to the intake 20 of the commercial temperature compressor 10 where it is compressed to a proper temperature and pressure for condensing.

The oil separator 13 serves to remove some of the oil present within the gaseous compressed refrigerant which was absorbed from the oil within the compressors. The oil thus separated drains to reservoir 21 where it is retained for redistribution to the compressors as needed. A degassing line 22 connects the upper portion of the oil reservoir 21 to conduit 19 for reducing the pressure within the reservoir 21 to a pressure equal to the intake pressure of compressor 10. This reduction in pressure in reservoir 21 serves to evaporate the refrigerant entrapped within the oil separated in the separator 13 and which was drained to the reservoir 21. This evaporated refrigerant is drawn into the intake 20 of the compressor 10 through the degassing line 22 thereby minimizing the amount of refrigerant which will be present within the oil returned to the compressors for reuse. A float valve (not shown) is positioned between the oil separator 13 and the oil reservoir 21 to permit only liquid to pass from the separator to the reservoir thus preventing the degassing line 22 from drawing hot compressed refrigerant gas directly from the separator 13. Oil return lines 23 and 24 serve to return the oil from reservoir 21 to the compressors 10 and 11, respectively. Solenoid valve 25 is positioned in the oil return line 23 and is responsive to the float switch 26 associated with compressor 10 for controlling the flow of oil through line 23 to the compressor 10 as needed. Similarly a solenoid valve 27 is positioned in line 24 and a float switch 28 is associated with compressor 11 for controlling the return of oil to that compressor. Hand valves 29 and 30 are positioned in conduits 23 and 24 respectively, for manually stopping the flow of oil to compressors 10 and 11, respectively, as desired. Although this oil separating and return system is not essential to my invention, I prefer to incorporate same for the overall efficiency and automation of the refrigeration system and defrosting system.

The condensed refrigerant from condenser 15 passes through conduit 31 to an auxiliary standby condenser 32 where any uncondensed gaseous refrigerant is condensed before passing through conduit 33 to a refrigerant receiver 34 of the refrigeration system. The condenser 15 is preferably of an air-cooled type for use in conjunction with an air-conditioning system for the building containing the refrigerated boxes and display cases, such as described in my copending application entitled, "Heat Reclaiming System," Serial No. 142,315, filed October 2, 1961; and the condenser 32 is preferably of water-cooled type where the flow of water through the condenser 32 from the water source conduit 35 is controlled by a water valve 36 which is responsive through capillary tube 37 to the inlet pressure of the auxiliary condenser 32. The water used in condenser 32 flows out through line 38 to drain 39.

The compressed-condensed liquid refrigerant passes from receiver 34 to the header liquid 40 for distribution to the various evaporator coils of the refrigerated fixtures. In FIGURE 1 six separate evaporator coils designated 41, 51, 61, 71, 81 and 91 are illustrated although it is to be understood that more or fewer evaporator coils can be employed without departing from my invention and, in fact, in a large supermarket, there are usually twenty to forty such evaporator coils. Each of the evaporator coils 41, 51, 61, 71, 81 and 91 are associated with separate refrigerated boxes, display cases or cabinets which for clarity of illustration are not shown in FIGURE 1. Although an intercooler is not shown in the refrigeration system of FIGURE 1, one may be incorporated in that system and normally the header 40 would be divided between the conduit leading to evaporator 61 and the conduit leading to evaporator 71 for circulating the liquid refrigerant through the intercooler before passing to evaporator coils 71, 81 and 91. In such an installation with an intercooler, evaporator coils 71, 81 and 91 would preferably be positioned in freezer or low temperature boxes and cabinets, as is conventional.

With each of the evaporator coils operating in normal refrigerating manner, the liquid refrigerant passes from header 40 through solenoid valves 42, 52, 62, 72, 82 and 92 to conduits 43, 53, 63, 73, 83 and 93, respectively, and then through each of such conduits to expansion valves 44, 54, 64, 74, 84 and 94, respectively, each of which are associated with the separate evaporator coils 41, 51, 61, 71, 81 and 91, respectively. As the liquid refrigerant present in each of the evaporator coils is evaporated for cooling that coil, the gaseous refrigerant passes from the evaporator coils 41, 51, 61, 71, 81 and 91, through conduits 45, 55, 65, 75, 85 and 95, respectively, and then through normally open solenoid valves 46, 56, 66, 76, 86 and 96, respectively, to headers 101 and 102. The expanded-evaporated refrigerant is drawn from header 102 through conduit 16 to the intake of compressor 11 and the expanded-evaporated refrigerant present in header 101 is drawn through conduit 103 to the intake 20 of compressor 10, thereby completing the refrigeration cycle. Each of the expansion valves 44, 54, 64, 74, 84 and 94 are individually responsive to the temperature of the refrigerant in conduits 45, 55, 65, 75, 85 and 95, respectively, through any convenient means such as separate capillary tubes 104 which thereby control the rate of flow of liquid refrigerant through each expansion valve into the associated evaporator coil. Each of the solenoid valves 42, 52, 62, 72, 82 and 92 are individually sensitive and responsive to the temperature within the refrigerated box, display case or cabinet associated with the respective evaporator coils 41, 51, 61, 71, 81 and 91 through any convenient thermostatic means (not shown). Thus, as is well known to those skilled in the art, the solenoid valves 42, 52, 62, 72, 82 and 92 open and close in response to increases and decreases, respectively, of the temperature within the refrigerated box above or below, respectively, the predetermined desired temperature range. As is also well known to those skilled in the art, the expansion valves 44, 54, 64, 74, 84 and 94 operate as a type of metering valve for reducing the pressure of the liquid refrigerant supplied by the solenoid valves to the pressure within the associated evaporator coil. An increase in temperature in one of the outlet conduits 45, 55, 65, 75, 85 or 95 is the result of a reduction in the quantity of liquid refrigerant present within the associated evaporator coil and thus, through the associated capillary tube 104, the respective expansion valve 44, 54, 64, 74, 84 or 94 is opened to admit additional liquid refrigerant to the associated evaporator coil. Thus, it may be seen that when any one of the refrigerated boxes, display cases or cabinets is at or below the proper predetermined temperature, the associated solenoid valve 42, 52, 62, 72, 82 or 92 will be closed and yet due to the outlet temperature of the associated evaporator coil (which depends on the quantity of liquid refrigerant in that coil), the associated expansion valve may be opened and ready to admit additional liquid refrigerant to that evaporator coil. In such a situation, it may be said that that particular system is "satisfied" in that no additional liquid refrigerant is needed to maintain the refrigerated box, display case or cabinet at the proper temperature.

A hand valve (illustrated as a circle with crossed diameters, but not numbered) is positioned in each of the conduits leading from header 40 to solenoid valves 42, 52, 62, 72, 82 and 92 and also in each of the conduits extending from the solenoid valves 46, 56, 66, 76, 86 and 96 to the headers 101 and 102 for manual operation to isolate any one of the evaporator coils from the rest

of the system for maintenance or repair of that evaporator coil, associated expansion valve or refrigerated box, display case or cabinet. Hand valves 105 and 106 are provided in conduit 31 and header 40, respectively, for manual operation to isolate the auxiliary standby condenser 32 and receiver 34 for maintenance and repair as desired.

A conduit 107 is connected to header 40 for passing liquid refrigerant to the hot gas desuperheater 18. The flow of refrigerant through conduit 107 may be controlled by solenoid valve 108 or manually controlled by hand valve 109. An expansion valve 110 responsive to temperature sensitive means associated with conduit 19 controls the flow and expansion of the liquid refrigerant to the hot gas desuperheater 18 wherein such refrigerant is added to the compressed refrigerant flowing from conduit 17 to conduit 19. Thus, the hot gas desuperheater 18 functions in a manner well known to those skilled in the art to add expanded-evaporated refrigerant to the hot compressed gaseous refrigerant from compressor 11 for cooling the latter refrigerant before delivery of the refrigerant vapor into the suction side of compressor 10.

Hand valves (illustrated as a circle with crossed diameters, but not numbered) may be provided and associated with the suction and discharge sides of each of the compressors 10 and 11 for isolating either of the compressors from the remainder of the refrigeration system for maintenance or repair of that compressor. Further, it will readily appear to those skilled in the art and as disclosed in my aforementioned copending application that by the mere addition of certain valves and conduits a third compressor could be used as a standby for either compressor 10 and compressor 11. It is to be noted that the use of the two or three compressors in the manner illustrated is not essential to my invention, but is preferred for the increased overall efficiency of the refrigeration system.

Means are provided for accomplishing the defrosting of the evaporators 41, 51, 61, 71, 81 and 91 and, as shown in the drawings, these means may include a hot gas header 111, which is connected to conduit 14 for tapping off hot compressed gaseous refrigerant supplied by compressor 10, and a condensate header 112. Conduit 47, 57, 67, 77, 87 and 97 connect the hot gas header 111 to the outlet conduits 45, 55, 65, 75, 85 and 95, respectively, of the evaporators 41, 51, 61, 71, 81 and 91, respectively, for supplying hot compressed gaseous refrigerant to those evaporated coils for defrosting. Conduits 48, 58, 68, 78, 88 and 98 connect the inlet conduits 43, 53, 63, 73, 83 and 93, respectively, associated with the evaporators 41, 51, 61, 71, 81 and 91, respectively, to the condensate header 112 for conducting the gaseous and condensed refrigerant used in defrosting one of those evaporator coils to others of those evaporator coils as hereinafter described. Solenoid valves 49, 59, 69, 79, 89 and 99 are provided in conduits 47, 57, 67, 77, 87 and 97, respectively, and solenoid valves 50, 60, 70, 80, 90 and 100 are provided in conduits 48, 58, 68, 78, 88 and 98, respectively, for controlling the flow of hot compressed gaseous refrigerant to each associated evaporator coil for defrosting that coil and controlling the flow of such refrigerant from that coil to header 112. During the normal refrigeration operation of any of these evaporator coils 41, 51, 61, 71, 81 or 91, the associated solenoid valves 49, 59, 69, 79, 89 and 99, respectively, and 50, 60, 70, 80, 90 and 100, respectively, are normally closed. Further, during normal refrigeration operation of any one of the evaporator coils, the associated solenoid valve 46, 56, 66, 76, 86 or 96 is open and the associated solenoid valve 42, 52, 62, 72, 82 or 92 may be open or closed depending on whether that associated evaporator coil is "satisfied" as heretofore described.

A bypass line 113 is provided and associated with each of the expansion valves 44, 54, 64, 74, 84 and 94 so that the refrigerant used in defrosting the associated evaporator coil is not passed through that expansion valve in a reverse direction during the defrosting cycle. A check valve 114 is provided in each bypass line 113 for permitting refrigerant to flow through the bypass line during defrosting of the associated evaporator coil, but prohibiting such flow during the normal refrigeration operation which, if permitted, would render the associated expansion valve ineffective for controlling the rate of flow of refrigerant to the associated evaporator coil.

When it is desired to defrost evaporator 41, for example, the normally closed solenoid valves 49 and 50 are opened and solenoid valves 42 and 46 are closed so that hot gaseous refrigerant passes from header 111 through conduit 47, through evaporator coil 41, through the bypass line 113, and thence through conduit 48 to the condensate header 112. When the hot compressed gaseous refrigerant passes from header 111 through the evaporator coil 41 or through any one of the other evaporator coils, as will hereinafter be described, heat is extracted from the gaseous refrigerant to accomplish the melting of the frost present on the coils. This loss of heat from the refrigerant generally results in condensation of some, if not all, of the gaseous refrigerant to a liquid state. It is highly undesirable to permit any substantial quantity of condensed refrigerant to enter the intake of a compressor. Even a small amount of liquid refrigerant entering the intake of a compressor will cause objectionable "hammering" of a compressor and the introduction of a large quantity of liquid refrigerant into the intake of the compressor would be likely to cause appreciable damage due to the incompressibility of the liquid refrigerant. It has, therefore, been found impractical to permit the refrigerant used in the defrosting of an evaporator coil to be passed directly to the intake of one of the compressors although this would appear to be a likely solution to the problem of the re-introduction of this refrigerant back into the normal refrigeration cycle. Further, though it would appear to be a ready solution that the refrigerant used in the defrosting of an evaporator coil merely be re-introduced into the refrigeration system at some portion which contains condensed refrigerant, this is not directly possible. As previously indicated, the pressure of the refrigerant used in defrosting an evaporator coil will neither be consistent nor will it usually exceed the pressure of any one point in the refrigeration cycle containing liquid refrigerant at any one particular moment. For example, if it were attempted to introduce the refrigerant used in defrosting from condensate header 112 into conduit 31, the pressure within conduit 31 would normally exceed the pressure within the header 112, thus causing the compressed-condensed refrigerant coming from the condenser 15 to flow in a reverse direction through the condensate header 112 thereby defeating the defrosting operation.

Referring now to Figure 2, the solenoid valve 50 schematically illustrated is typical of the solenoid valves which may be used throughout the system illustrated in Figure 1. When installed in the system the opening 120 of the solenoid valve is normally the inlet opening and opening 121 is normally the outlet opening of the valves. The plunger 122 is spring loaded by spring 123 and has a tapered lower end 124 which seats in a mating tapered seat 125 in the valve body. When the electrical coil 126 is energized, the plunger 122 is raised, as viewed in Figure 2, thereby opening the valve to allow refrigerant to pass from the inlet opening 120 to the outlet opening 121. However, it will be noted that due to this type of construction if the pressure of the refrigerant at outlet opening 121 exceeds the pressure at inlet opening 120, the plunger 122 will be urged upwardly against the force of the spring 123 by this differential refrigerant pressure even though the coil 126 has not been energized. Thus, in effect, this type of solenoid valve when not energized performs similar to a check valve in that fluid may flow from outlet opening 121 to inlet opening 120 upon a suf-

ficient pressure differential, but fluid cannot flow from inlet opening 120 to oulet opening 121 unless the valve is opened by energizing coil 126. Although other types of solenoid valves are available and may be used throughout the refrigeration system of Figure 1, I prefer to use the type shown in FIGURE 2 for the solenoid valves 50, 60, 70, 80, 90 and 100. Further, it will appear to those skilled in the art that if another type of solenoid valve is used for valves 50, 60, 70, 80, 90 and 100 which does not also perform as a "check valve" as described, then the valve so used may be bridged by a bypass line and check valve so that reverse flow (from header 112 toward the evaporator coils) may be accomplished through conduits 48, 58, 68, 78, 88 and 98.

Returning now to the example described above for defrosting evaporator coil 41, wherein solenoid valves 42 and 46 are closed and solenoid valves 49 and 50 are opened to pass hot gaseous refrigerant from header 111 through the evaporator coil, the refrigerant so used in the defrosting passes through conduit 48 to the header 112. While evaporator coil 41 is being defrosted, the evaporator coils 51, 61, 71, 81 and 91 are operating in a normal refrigerating manner. As previously described, an evaporator coil which is operating in a refrigerating manner may be "satisfied" when the associated refrigerated box, display case or cabinet is at or below the proper temperature and when this occurs, the associated inlet solenoid valve 52, 62, 72, 82 or 92 will be closed. In a refrigeration system employing several evaporator coils as shown in FIGURE 1, it would normally be expected that one or two of the evaporator coils would be "satisfied" and obviously in a system employing 20 to 40 separate evaporator coils (such as a supermarket), it would be expected that several of the evaporator coils would be "satisfied."

Now let it be assumed that in the described example for defrosting the evaporator coil 41 that evaporator coils 51 and 81 are satisfied so that the associated inlet solenoid valves 52 and 82 respectively, are closed. The refrigerant used in defrosting evaporator coil 41 will usually be in a liquid state though it may be possible for some gaseous refrigerant to be present particularly toward the end of the defrosting cycle. This refrigerant will be at a relatively intermediate pressure in that its pressure will be less than the pressure of the liquid refrigerant within receiver 34 and header 40, but greater than the intake pressures of the compressors 10 and 11. Since the valves 52 and 82 are closed, the pressures within conduits 53 and 83 will essentially be equal to the intake pressures of the compressors 10 and 11 plus the pressure developed by the head of liquid refrigerant present in evaporator coils 51 and 81 and also plus the small pressure differential required to draw the gaseous refrigerant from conduits 55 and 85 to the intakes of the compressors. Thus, the refrigerant pressure within header 112 and conduits 58 and 88 will exceed the pressures within conduits 53 and 83 so that the refrigerant will flow in a reverse direction through solenoid valves 60 and 90 as previously described. This refrigerant will then be metered into the evaporator coils 51 and 81 through expansion valves 54 and 84, respectively. Since evaporator coils 61, 71 and 91 are operating in a normal refrigerating manner, the solenoid valves 62, 72 and 92, respectively, will be open and the pressures within conduits 63, 73 and 93, respectively will be greater than the pressure within the header 112 and thus there will be no reverse flow of the defrosting refrigerant through solenoid valves 70, 80 and 100.

Since in this example the solenoid valves 52 and 82 are closed, indicating that the refrigerated box, display case or cabinet is at the proper temperature, the additional refrigerant added to evaporator coils 51 and 81 from header 112 will cause additional cooling of the associated refrigerated box, display case or cabinet. The additional cooling will not be very great and thus for most refrigerated boxes, display cases or cabinets, such cooling will not be objectionable. However, in some refrigerated boxes, such as meat coolers, self-service meat cases or possibly dairy produce cases, the desired temperature range is critical at both the upper and lower limits and therefore the additional cooling may be objectionable. Assuming that evaporator 71 is positioned in such a refrigerated box (such as a meat case), a check valve 130 is positioned in conduit 78 so that refrigerant cannot pass from header 112 through conduits 78 to evaporator coil 71 even though that evaporator coil is "satisfied" and solenoid valve 72 is closed. Check valve 130 does not prevent the flow of refrigerant from evaporator coil 71 to header 112 when that evaporator coil is being defrosted.

Evaporator coils 51, 61, 71, 81 and 91 may be individually defrosted in a manner identical to that described for defrosting evaporator coil 41 by closing solenoid valve 52, 62, 72, 82 or 92 and solenoid valve 56, 66, 76, 86 or 96, both respectively, and opening solenoid valve 59, 69, 79, 89 or 99 and solenoid valve 60, 70, 80, 90 or 100, both respectively, to allow hot compresed gaseous refrigerant to pass from header 111 through conduit 57, 67, 77, 87 or 97, respectively, to the associated evaporator coil 51, 61, 71, 81 or 91, respectively, and then through conduit 58, 68, 78, 88 or 98, respectively, to the condensate header 112.

Although it has been assumed that during the defrosting of any one or more evaporator coils there will be one or more other evaporator coils which are "satisfied" so that the refrigerant used in the defrosting would be introduced into these satisfied evaporator coils, this assumption may not always be true. Thus, in a given situation, a particular evaporator coil may be defrosting and the refrigerant used will be flowing into header 112 and yet none of the other evaporator coils are satisfied to provide a pressure differential so that the refrigerant in header 112 will flow to a satisfied evaporator coil as described. In such a situation, the refrigerant pressure within header 112 will increase and if allowed to increase an objectionable amount would in turn resist the flow of refrigerant from the defrosting evaporator coil thereby adversely affecting the defrosting of that coil. Although an accumulator (not shown) could be provided and associated with header 112 so that an objectionable pressure build-up would not occur, I prefer to provide means for adding this refrigerant to one or more of the evaporator coils even though those evaporator coils are not satisfied as is normally required. As shown in FIGURE 1, these means may comprise a switch 131 which is responsive to the pressure within header 112 through capillary tube 132. As the pressure within header 112 increases to a predetermined point thus indicating that no evaporator coil is satisfied or that an inadequate number of evaporator coils are satisfied to handle the refrigerant used in the defrosting of other of the evaporator coils, the switch 131 closes solenoid valves 52 and 62 through any convenient means such as electrical leads 133 and 134, respectively. Valves 52 and 62 are closed by switch 131 even though the thermostatic means within the refrigerated boxes associated with evaporator coils 51 and 61 indicate that valves 52 and 62 should be opened. Thus, if the evaporator coils 51 and 61 are operating on the normal refrigerating cycle, the pressure within the conduits 53 and 63, respectively, will be reduced to a minimum as though evaporator coils 51 and 61 were "satisfied," and the refrigerant used in defrosting will pass through valves 60 and 70, respectively, to those associated evaporator coils. At least two valves such as valves 52 and 62 should be controlled by the switch 131 since at any one time evaporator coil 51 or evaporator coil 61 may be the evaporator coil which is on its defrosting cycle and which is causing the undesirable pressure build-up in header 112.

Thus, it may be seen that I have provided a system whereby the hot compressed gaseous refrigerant supplied by the refrigeration system compressor may be used for defrosting the evaporator coils and the refrigerant so used is introduced back into the refrigeration system through one or more of the evaporator coils not being defrosted which are operating in a normal refrigerating manner but momentarily do not require additional refrigerant. Further, by my arrangement no pumps are needed to reintroduce the refrigerant used in the defrosting back into the refrigeration system, nor is there any need for generating heat or power specifically for evaporating the defrosting refrigerant thereby introducing an inefficiency in the overall system, nor are any special heat exchangers or accumulators necessary for handling the defrosting refrigerant. But rather, I provide an arrangement whereby the refrigerant used in defrosting an evaporator coil is used in its normal manner for refrigerating other evaporator coils, thus increasing the overall efficiency of the refrigeration system since this refrigerant meets, in part, the need for liquid refrigerant in those other evaporator coils which would normally have to be supplied by the refrigeration system compressors, condensers and receiver.

In a normal operation, I prefer to defrost only one evaporator coil at a time so that all of the hot compressed gaseous refrigerant in header 111 is available for passing through that evaporator coil to accomplish defrosting. With this large quantity of available heat, the defrosting can be accomplished rapidly thereby avoiding any objectionable increase in the temperature of the refrigerated box, display case or cabinet. In installations employing a larger number of evaporator coils, it is possible and practical to defrost more than one coil at a time due to the larger capacity compressors which would be used in such an installation. Further, in such an installation, the switch 131 may control more than two solenoid valves in order to assure that there is an adequate number of evaporator coils which appear to be "satisfied" for introducing the defrosting refrigerant into those coils.

The solenoid valves which are associated with the evaporator coils (42, 52, 62, 72, 82, 92, 46, 56, 66, 76, 86 and 96), with the hot gas header 111 (49, 59, 69, 79, 89 and 99) and with the condensate header 112 (50, 60, 70, 80, 90 and 100) may all be controlled by an automatic timing device (not shown) which serves to open and close the appropriate solenoid valves for a predetermined period of time to accomplish the sequential defrosting of the various evaporator coils. The period of time would be determined by considering the type of refrigerated box, its contents, its normal temperature and through defrosting tests. The only electrical heaters which may be needed to accomplish the complete automatic defrosting of the evaporator coils and the refrigerated boxes are those usually associated with the drains for carrying off water resulting from the defrosting. These electrical heaters would obviously be relatively inexpensive compared to the heaters normally necesssary for defrosting the entire evaporator coil and refrigerated box.

Although I have illustrated and described a refrigeration system and defrosting system which employ two compressors, an air-cooled condenser, an auxiliary condenser, and six evaporators, it is readily apparent and to be understood that more or fewer compressors, condensers, and evaporators may be used without departing from my invention as individual installation requirements dictate. Having fully described my invention it is to be understood that I do not wish to be limited to the details herein set forth or to the details illustrated in the drawings, but my invention is of the full scope of the appended claims.

I claim:

1. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, means separate from the normal refrigeration system operably connecting said selected evaporator coil to at least one other evaporator coil for conducting the refrigerant used in defrosting to such other evaporator coil, and valve means associated with each latter said means operable for selectively permitting or preventing the flow of refrigerant from the associated evaporator coil to said other evaporator coil, at least one of said valve means having means for allowing refrigerant flow in the reverse direction from said other evaporator coils to the associated evaporator coil upon differential pressure therebetween.

2. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, a header separate from the normal refrigeration system; and means operably connecting each evaporator coil to said header in by-pass relation with the normal refrigeration connections thereto including valve means operable for selectively preventing and permitting refrigerant flow to said header during normal refrigeration and defrosting, respectively, of the associated evaporator coil and for automatically permitting reverse refrigerant flow from said header to the associated evaporator coil during defrosting of another evaporator coil.

3. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, a header separate from the normal refrigeration system, means operably connecting each evaporator coil to said header for conducting the refrigerant used in defrosting to said header, and valve means associated with each latter said means operable for selectively permitting or preventing the flow of refrigerant from the associated evaporator coil to said header, at least one of said valve means having means for allowing refrigerant flow from said header to the associated evaporator coil upon differential pressure therebetween.

4. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigerating by said compressor and condenser, first means operably connecting each evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant to each evaporator coil and first valve means associated with each said first means; a header separate from the normal refrigeration system; second means operably connecting each evaporator coil to said header for conducting refrigerant from the evaporator coil to said header, and second valve means associated with each said second means; and said first and second means operable for individually permitting the flow of refrigerant from the compressor through each evaporator coil and to said header for defrosting each evaporator coil.

5. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigerating by said compressor and condenser, first means operably connecting each evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant to each evaporator coil and first valve means associated with each said first means; a header separate from the normal refrigeration system; second means operably connecting each evaporator coil to said header for conducting refrigerant from the evaporator coil to said header and second valve means associated with each said second means; and said first and second valve means operable for individually permitting the flow of refrigerant from the compressor through each evaporator coil and to said header for defrosting each evaporator coil, at least one of said second valve means having means allowing refrigerant flow from said header to the associated evaporator coil upon differential pressure therebetween.

6. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: valve means associated wtih each evaporator coil for arresting the flow of refrigerating refrigerant to and from each evaporator coil, first means operably connecting each evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant to each evaporator coil and valve means associated with each said first means; a header separate from the normal refrigeration system; second means operably connecting each evaporator coil to said header for conducting refrigerant from the evaporator coil to said header and valve means associated with each said second means; and the first mentioned valve means selectively operable for arresting the normal flow of refrigerating refrigerant to and from a selected evaporator coil and defrosting that evaporator coil by opening said valve means associated with said first and second means of that selected evaporator coil for permitting the flow of refrigerant from the compressor through said selected evaporator coil and to said header for defrosting said selected evaporator coil.

7. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: valve means associated with each evaporator coil for arresting the flow of refrigerating refrigerant to and from each evaporator coil, first means operably connecting each evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant to each evaporator coil and valve means associated with each said first means; a header separate from the normal refrigeration system; second means operably connecting each evaporator coil to said header for conducting refrigerant from the evaporator coil to said header and valve means associated with each said second means; and the first mentioned valve means selectively operable for arresting the normal flow of refrigerating refrigerant to and from a selected evaporator coil and defrosting that evaporator coil by opening said valve means associated with said first and second means of that selected evaporator coil for permitting the flow of refrigerant from the compressor through said selected evaporator coil and to said header for defrosting said selected evaporator coil, at least one of said second valve means having means allowing refrigerant flow from said header to the associated evaporator coil upon differential pressure therebetween.

8. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigerating by said compressor and condenser, first means operably connecting each evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant to each evaporator coil and first valve means associated with each said first means; a header separate from the normal refrigeration system; second means operably connecting each evaporator coil to said header for conducting refrigerant from the evaporator coil to said header, and second valve means associated with each said second means; said first and second valve means operable for individually permitting the flow of refrigerant from the compressor through each evaporator coil and to said header for defrosting each evaporator coil, at least one of said second valve means having means allowing refrigerant flow from said header to the associated evaporator coil upon differential pressure therebetween; and switch means responsive to an increase in pressure in said header for arresting the flow of refrigerating refrigerant to at least one of the evaporator coils for allowing the refrigerant within said header to flow to that evaporator coil due to such differential pressure.

9. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two evaporator coils having inlet expansion means, the combination of: means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, a heater separate from the normal refrigeration system, means operably connecting each evaporator coil to said header for conducting the refrigerant used in defrosting to said header, said header connected solely to the latter said connecting means, and valve means associated with each latter said connecting means and operable for selectively permitting or preventing the flow of refrigerant from the associated evaporator coil to said header.

10. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two refrigerated fixtures each having an evaporator coil with inlet expansion means, the combination of: valve means associated with each evaporator coil and having temperature responsive means associated with that refrigerated fixture for feeding liquid refrigerant to the inlet expansion means, means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, a header separate from the normal refrigeration system operably connecting each evaporator coil to at least one other evaporator coil between the said temperature responsive valve means and the inlet expansion means of said evaporator coils for conducting the refrigerant used in defrosting said selected evaporator coil to such other evaporator coils, and valve means associated with each latter said connecting means operable for selectively permitting or preventing the flow of refrigerant from the associated evaporator coil to the other evaporator coils.

11. In a defrosting system for use with a refrigeration system employing a compressor, a condenser and at least two refrigerated fixtures each having an evaporator coil with inlet expansion means, the combination of: valve means associated with each evaporator coil and having temperature responsive means associated with that refrigerated fixture for feeding liquid refrigerant to the inlet expansion means, means for selectively isolating each said evaporator coil from the normal refrigeration by said compressor and condenser and operably connecting said selected evaporator coil to the output of the compressor for conducting hot compressed gaseous refrigerant for defrosting said selected evaporator coil, means separate from the normal refrigeration system serving to operably connect each evaporator coil to at least one other evaporator coil between the said temperature re-

sponsive valve means and the inlet expansion means of said evaporator coils for conducting the refrigerant used in defrosting said selected evaporator coil to such other evaporator coils, and valve means associated with each latter said connecting means operable for selectively permitting or preventing the flow of refrigerant from the associated evaporator coil to the other evaporator coils, at least one of the said valve means associated with the latter said connecting means having means for allowing refrigerant flow from the other evaporator coils to that associated evaporator coil upon differential pressure therebetween.

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