

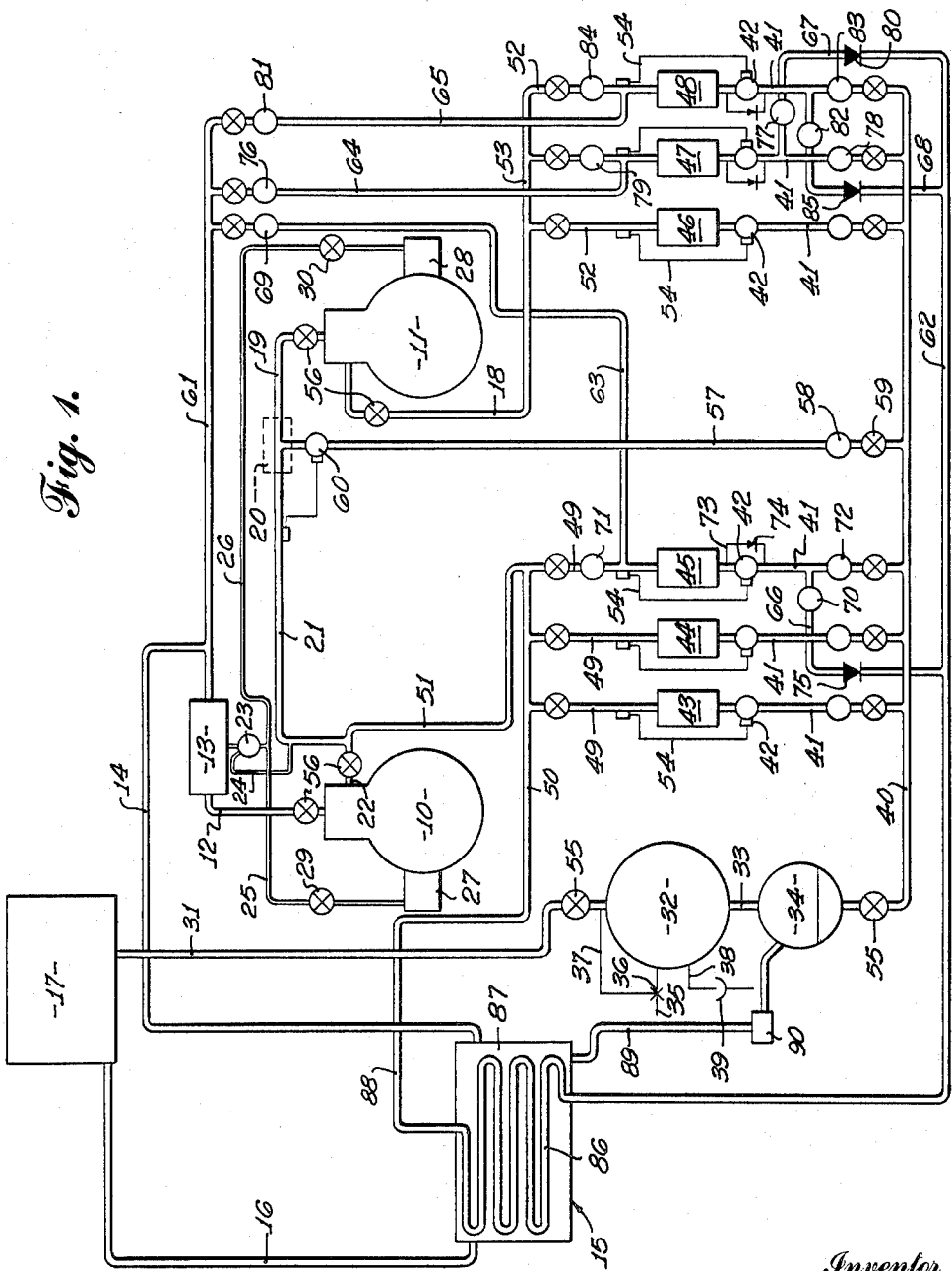
Feb. 15, 1966

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REEVAPORATOR SYSTEM FOR HOT GAS REFRIGERATION
DEFROSTING SYSTEMS

3,234,754

Filed Feb. 18, 1963

3 Sheets-Sheet 1



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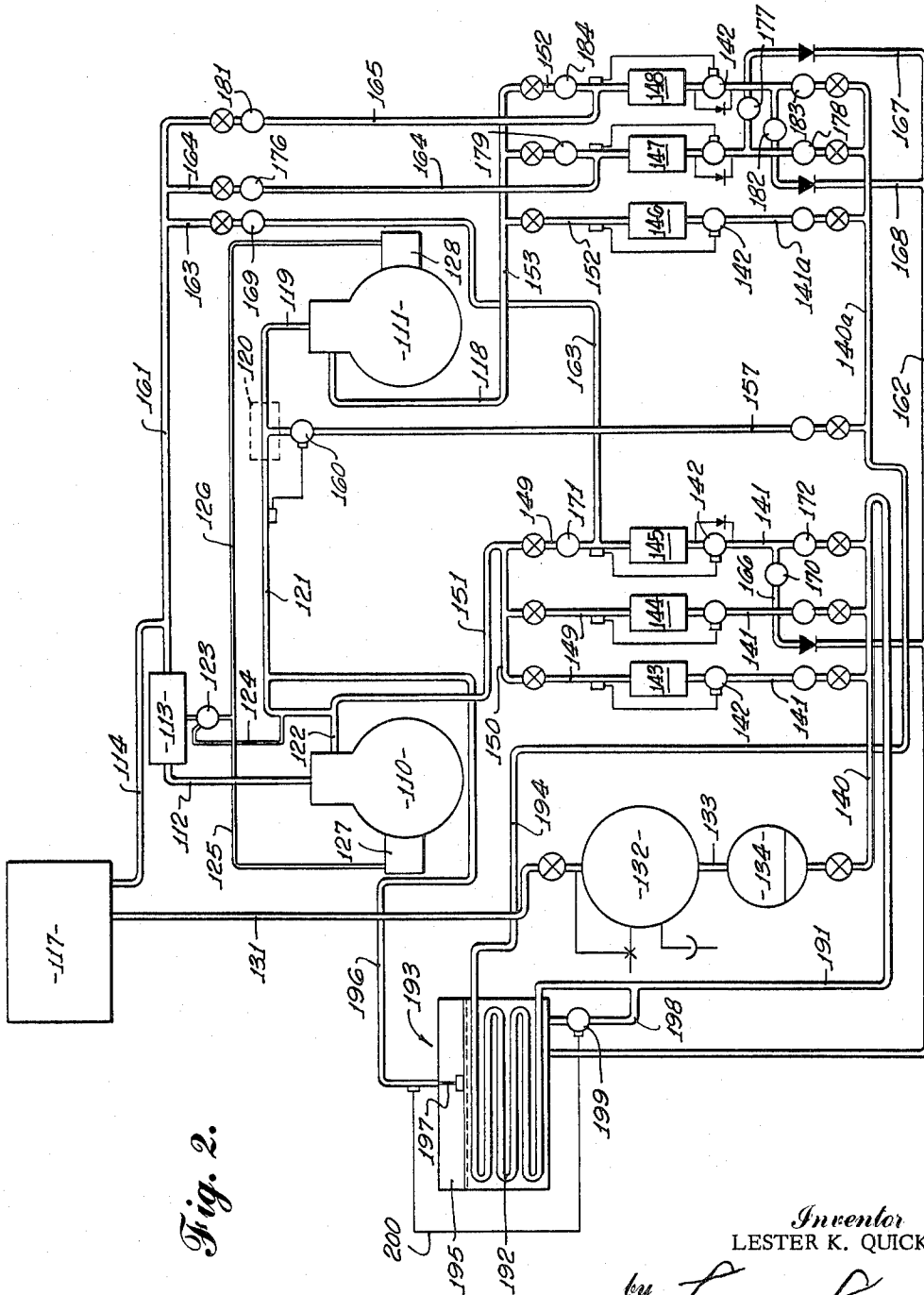


Fig. 2.

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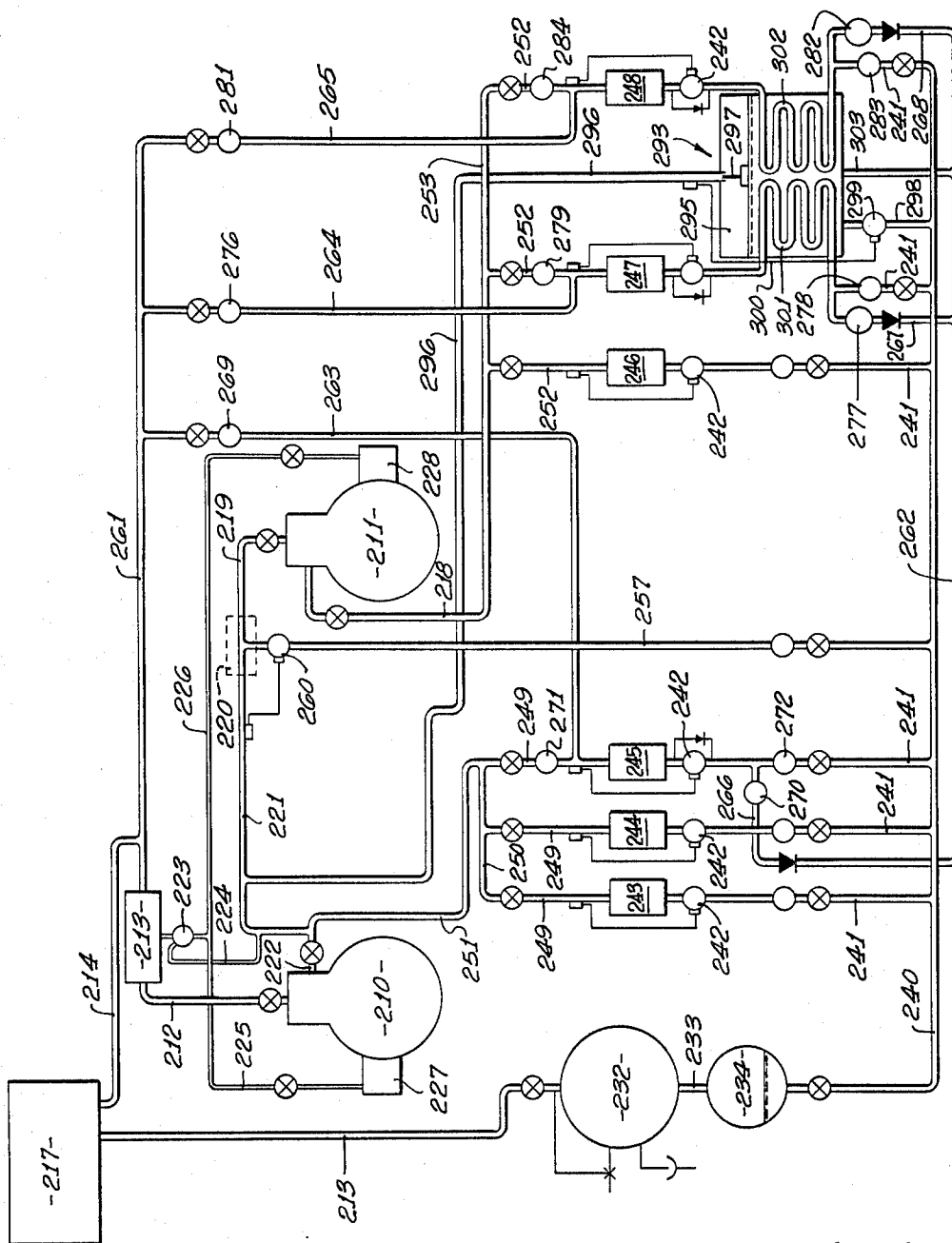


Fig. 3.

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3,234,754

REEVAPORATOR SYSTEM FOR HOT GAS REFRIGERATION DEFROSTING SYSTEMS

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Filed Feb. 18, 1963, Ser. No. 259,189

7 Claims. (Cl. 62-278)

This invention relates to defrosting systems which employ 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, in particular, is directed to a system wherein the refrigerant so used in the defrosting cycle is evaporated to perform a useful function and for reintroduction into the normal refrigeration system cycle.

In the normal refrigeration cycle which is employed in this invention, a refrigerant gas such as ammonia, Freon or the like 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 such as a 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 fixture which periodically 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 of different types which are refrigerated by separate individual refrigeration systems or by a single central refrigeration system supplying compressed-condensed refrigerant to each of the separate evaporator coils positioned in the refrigerated fixtures. Since these evaporator coils and fixtures accumulate frost which must be periodically removed, it is conventional to provide some type of heater, such as an electric heating coil, 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 fixture, it is also relatively expensive both in initial cost of the heaters and in their operation due to the amount of power consumed in accomplishing the defrosting by these individual heaters. Generally, it is highly desirable that the defrosting be relatively rapid in order to avoid raising the temperature of the refrigerated fixture and its contents an objectionable amount.

As is well known the refrigerant leaving a compressor of a refrigeration system is in a hot compressed gaseous state and therefore is capable of supplying the heat necessary to accomplish the defrosting of the evaporator coils in refrigerated fixtures. However, if this hot compressed gaseous refrigerant is used to accomplish the defrosting its pressure and temperature are changed due to the heat given off but the exact amount of such changes may not always be the same for each defrosting cycle or each refrigerated fixture, although, as is well known, for a particular temperature the pressure is known and vice versa. The refrigerant so used must be reintroduced into the normal refrigeration cycle but the variation between the liquid and gaseous state of the refrigerant for different defrosting cycles and the low pressure of this refrigerant prevents its direct reintroduc-

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tion into any portion of the normal refrigeration cycle. For example, this refrigerant cannot be introduced into the intake of the compressor because of the presence of 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 the high pressure side of the refrigeration system.

An intercooler is often provided in refrigeration systems for cooling the compressed-condensed refrigerant to a temperature which enhances the efficiency of the operation of the expansion valves and the evaporator coils. This is particularly true in refrigeration systems having a number of separate evaporator coils and expansion valves for separate refrigerated fixtures which are maintained at different temperatures. Thus, as is well known, for efficient operation the compressed-condensed refrigerant supplied to an evaporator coil associated with a low temperature freezer should be at a lower temperature than the refrigerant supplied to the evaporator coil associated with, for example, a produce display case which is maintained at a higher temperature. An intercooler is generally a type of heat exchanger for cooling the refrigerant supplied to the evaporator coils associated with low temperature refrigerated boxes and cases.

Accordingly, it is a principal object of this invention to provide a novel system for completely evaporating the refrigerant used in a hot gas defrosting arrangement of a refrigeration system so that the refrigerant may be reintroduced into the intake of the refrigeration system compressor and wherein the heat required for evaporating such refrigerant is supplied from a portion of the normal refrigeration cycle.

Another object of this invention is to provide a novel system for employing the hot compressed refrigerant from the refrigeration system compressor to completely evaporate the refrigerant used in defrosting the refrigeration system evaporators.

Still another object of this invention is to provide a novel system for use with a hot gas defrosting system wherein the refrigerant used for defrosting is evaporated in a novel form of intercooler before being reintroduced into the normal refrigeration system.

A further objection of this invention is to provide a novel system for use with a hot gas defrosting system for refrigeration systems wherein the hot gaseous refrigerant used in defrosting is evaporated in a novel form of intercooler for reintroducing that refrigerant back into the refrigeration system, and for cooling the liquid refrigerant being supplied to one or more selected evaporator coils of the refrigeration system by passing such liquid refrigerant through coils in heat exchange relation with the evaporating refrigerant used for defrosting.

Another and more detailed object of this invention is to provide a novel system for use with a hot gas defrosting system of a multiple evaporator refrigeration system wherein the total output of hot compressed gaseous refrigerant from the compressor or compressors is available for passing through one or more of the evaporator coils at one time for defrosting such coils, and the refrigerant used in the defrosting is completely evaporated in a novel form of intercooler, such evaporation serving to cool the compressed-condensed refrigerant supplied to one or more of the refrigeration system evaporators and the evaporated refrigerant being added to the refrigerant introduced into the compressor intake for cooling that refrigerant to improve the operation of the compressor and condenser.

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

FIGURE 1 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.

FIGURE 2 is a diagrammatic illustration similar to FIGURE 1 showing a modified form of my invention employing an intercooler arrangement.

FIGURE 3 is a diagrammatic illustration similar to FIGURE 2 showing a modified form of intercooler arrangement.

Referring now more particularly to FIGURE 1, means are provided for compressing the refrigerant gas and these means may include a commercial temperature compressor 10 and a low temperature compressor 11 in compound relation for supplying hot compressed gaseous refrigerant through conduit 12 to oil separator 13. The refrigerant then passes through conduit 14 to heat exchanger apparatus 15, the function of which will hereinafter be described, and thence through conduit 16 to condenser 17 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. Compressor 11 takes low pressure gaseous refrigerant from conduit 18 and compresses same to an intermediate pressure and temperature which then passes through conduit 19 to the hot gas desuperheater 20 and thence through conduit 21 to the intake 22 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 pumped with the gaseous compressed refrigerant from the compressors. The oil thus separated drains to reservoir 23 where it is retained for redistribution to the compressors as needed. A degassing line 24 connects the upper portion of the oil reservoir 23 to conduit 21 for reducing the pressure within the reservoir 23 to a pressure equal to the intake pressure of compressor 10. This reduction in pressure in reservoir 23 serves to evaporate the refrigerant entrapped within the oil separated in the separator 13 and which was drained to the reservoir 23. This evaporated refrigerant is drawn into the intake 22 of the compressor 10 through the degassing line 24 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 23 to permit only liquid to pass from the separator to the reservoir thus preventing the degassing line 24 from drawing hot compressed refrigerant gas directly from the separator 13. Oil return lines 25 and 26 serve to return the oil from reservoir 23 to the compressors 10 and 11, respectively. Float valve assemblies 27 and 28 are provided with each of the compressors 10 and 11, respectively, and are connected to the oil return lines 25 and 26, respectively, for controlling the return of oil to the compressors to thereby maintain the proper oil level within each compressor. Hand valves 29 and 30 are positioned in conduits 25 and 26, 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 17 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. While condenser 17 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; 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 liquid refrigerant passes from receiver 34 through header 40 to individual conduits 41 and then to individual expansion valves 42 where the refrigerant is expanded and passes to the evaporator coils 43, 44, 45, 46, 47 and 48 associated separately with each of the expansion valves 42 and connected conduits 41. The pressure of the refrigerant is reduced as it passes through the expansion valves and this expanded refrigerant evaporates as it passes through the evaporator coils thereby absorbing heat from each of the refrigerated boxes, display cases or cabinets (not shown) within which one of those evaporator coils is positioned.

A separate outlet conduit 49 is associated with each evaporator coil 43, 44 and 45 for passing the expanded evaporated gas to a header 50 which communicates with a conduit 51 for returning the gaseous refrigerant to the intake 22 of compressor 10, thereby completing the refrigeration cycle. Similarly, a separate outlet conduit 52 is associated with each of the evaporators 46, 47 and 48 for passing the expanded-evaporated refrigerant gas to a header 53 which communicates with conduit 18 for passing the gaseous refrigerant to the intake of compressor 11 and thereby completing the refrigeration cycle. Each of the expansion valves 42 are individually responsive to the pressure and temperature in the outlet conduit 49 or 52 which is associated with the same evaporator coil as that expansion valve through any convenient means such as separate capillary tubes 54 which thereby controls the rate of flow of refrigerant through each expansion valve to the associated evaporator coil. In this arrangement the evaporator coils 46, 47 and 48 connected to the low temperature compressor 11 are preferably associated with low temperature fixtures such as freezer cases and evaporator coils 43, 44 and 45 are preferably associated with fixtures such as produce cases.

A hand valve (illustrated as a circle with crossed diameters, but not numbered) may be positioned in each of the conduits 41, 49 and 52 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 fixture. Hand valves 55 may be provided in conduit 31 and header 40 for manual operation to isolate the auxiliary standby condenser 32 and receiver 34 for maintenance and repair as desired. Also, hand valves 56 may be provided on the intakes and outlets of compressors 10 and 11 to isolate the compressors from the system for maintenance and repair as desired.

A conduit 57 is connected to header 40 for passing liquid refrigerant to the hot gas desuperheater 20. The flow of refrigerant through conduit 57 may be controlled by solenoid valve 58 or manually controlled by hand valve 59. An expansion valve 60 responsive to pressure and temperature sensitive means associated with conduit 21 controls the flow and expansion of the liquid refrigerant to the hot gas desuperheater 20. The refrigerant from conduit 57 is expanded, evaporated and added into the flow of hot compressed refrigerant passing from conduit 19 through the hot gas desuperheater to conduit 21. This addition of expanded evaporated refrigerant to the hot compressed gaseous refrigerant serves to cool the refrigerant gas supplied to the intake 22 of compressor 10 through the conduit 21.

Means are provided for accomplishing the defrosting of the evaporators 45, 47 and 48 and as shown in FIGURE 1, these means may include a hot gas header 61, a condensate header 62, and the heat exchanger apparatus 15. The header 61 is connected to conduit 14

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for tapping off hot compressed gaseous refrigerant supplied by compressor 10 as such hot gas is needed for defrosting the evaporator coils. Conduits 63, 64 and 65 connect the hot gas header 61 to the outlet conduits 49, 52 and 52, respectively, of evaporators 45, 47 and 48, respectively, for supplying hot compressed gaseous refrigerant to those evaporator coils for defrosting. Conduits 66, 67 and 68 connect the inlet conduits 41 associated with evaporators 45, 47 and 48, respectively, to the condensate header 62 for conducting the gaseous and condensed refrigerant used in defrosting those evaporator coils from the coils to the heat exchanger apparatus 15. When it is desired to defrost the evaporator 45 for example, normally closed solenoid valves 69 and 70 are opened and normally opened solenoid valves 71 and 72 are closed so that the hot gaseous refrigerant passes from header 61 through conduit 63, through evaporator coil 45, through a bypass line 73 and thence through conduit 66 to the condensate header 62. The bypass line 73 is provided so that the refrigerant used in defrosting the evaporator coil 45 is not passed through the expansion valve 42 associated with that evaporator coil in a reverse direction during the defrosting cycle. A check valve 74 is provided in bypass line 73 for permitting refrigerant to flow through the bypass line during defrosting of the evaporator coil but prohibiting such flow during the normal refrigeration operation which, if permitted, would render the expansion valve 42 ineffective for controlling the rate of flow of refrigerant to the evaporator coil 45.

A check valve 75 is provided in conduit 66 for permitting refrigerant to flow from the evaporator coil 45 through conduit 66 to header 62 during the defrosting of the evaporator coil 45, but prohibiting the flow of refrigerant from header 62 through conduit 66 in a reverse direction toward the evaporator coil 45. Without the check valve 75 in conduit 66, it would be possible for certain conditions of refrigerant pressure to exist in header 62 and conduit 41 associated with evaporator coil 45 when the defrosting of another evaporator coil is taking place, as hereinafter described, that refrigerant could inadvertently flow from header 62 to the evaporator coil 45 in a quantity which would be undesirable in that particular evaporator coil. This reverse refrigerant flow would not be arrested by normally closed solenoid valve 70 due to the particular construction of the type of solenoid valves generally used in such applications in that a pressure differential across the valve in the wrong direction can cause opening of the valve.

Similarly, normally closed solenoid valves 76 and 77 are provided in conduits 64 and 67, respectively, and normally opened solenoid valves 78 and 79 are provided in conduits 41 and 52, respectively, associated with the evaporator coil 47 for defrosting that evaporator coil by opening solenoid valves 76 and 77 and closing solenoid valves 78 and 79. A check valve 80 is provided in conduit 67 similar to and serving the same function as the check valve 75 provided in conduit 66, as heretofore described. Also, a bypass line and check valve (illustrated but not numbered) are provided and associated with the expansion valve 42 associated with evaporator coil 47 in order to avoid reverse flow of refrigerant through that expansion valve during the defrosting cycle. Likewise, normally closed solenoid valves 81 and 82 are provided in conduits 65 and 68, respectively; normally opened solenoid valves 83 and 84 are provided in conduits 41 and 52, respectively, associated with evaporator coil 48; a check valve 85 is provided in conduit 68; and a bypass line and a check valve (illustrated but not numbered) are provided and associated with expansion valve 42 all for use in a like manner for defrosting the evaporator coil 48. Although I have only shown conduits, valves, bypass lines, and check valves adapted to defrost evaporator coils 45, 47 and 48,

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it is to be understood that similar conduits, valves, bypass lines and check valves are normally provided with evaporator coils 43, 44 and 46 or any other evaporator coils which may be present for similar operation in the defrosting of that particular evaporator coil through the use of the hot gas from header 61.

When the hot compressed gaseous refrigerant passes from header 61 through any one of the evaporator coils, heat is extracted from the gaseous refrigerant to accomplish the melting of the frost present on the coils, and this loss of heat from the refrigerant results in condensation of some 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 the 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 reintroduction 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 62 into conduit 31, the pressure within conduit 31 would normally exceed the pressure within the header 62, thus causing the compressed-condensed refrigerant coming from condenser 17 to flow in a reverse direction through the condensate header 62 thereby defeating the defrosting operation.

In the system of FIGURE 1 the heat exchanger apparatus 15 is provided for completely evaporating the refrigerant used in defrosting the evaporator coils so that such evaporated refrigerant may be introduced into the intake of one of the refrigeration system compressors. The heat exchanger apparatus 15 is comprised of a coil 86 positioned within a tank portion 87. The conduits 14 and 16 for conducting hot compressed refrigerant from compressor 10 to condenser 17 are connected to the tank portion 87 so that all of the hot compressed refrigerant passes the coil 86 in heat exchange relation. The condensate header 62 is connected to one end of coil 86 and a conduit 88 connects the other end of coil 86 to header 50. The refrigerant used in defrosting the evaporator coils passes from condensate header 62 to coil 86 where heat is absorbed from the hot compressed refrigerant to evaporate the refrigerant within coil 86 and that evaporated refrigerant is then drawn through conduit 88, header 50 and conduit 51 into the intake 22 of compressor 10. The hot compressed refrigerant passing through tank portion 87 gives up heat to the refrigerant within coil 86 to cause this evaporation and in so doing it is possible that some of the compressed refrigerant will condense within tank portion 87. In order to prevent an excessive accumulation of this liquid refrigerant in tank portion 87 that could adversely effect the function of evaporating the refrigerant with coil 86, a drain conduit 89 connects the bottom of tank portion 87 to the receiver 34 through a float valve 90. The liquid refrigerant is continually drained from tank portion 87 by gravity through conduit 89 and float valve 90 functions to permit only liquid refrigerant to pass through conduit 89 to receiver 34. Conduit 89 and float valve 90 may be eliminated for simplicity by connecting

conduit 16 to the bottom portion of tank 87 so that any condensed refrigerant that would otherwise accumulate in tank portion 87 will be forced to pass on to condenser 17.

By this arrangement it may be seen that the refrigerant used in defrosting is continually and completely evaporated thereby permitting reintroduction into the normal refrigeration cycle at the intake to a compressor. Since the heat needed for causing this evaporating function is absorbed from the hot compressed refrigerant in the system and such heat would merely be given off by the system condenser anyway, the evaporating function is accomplished without additional operating cost. Moreover, the cooling of the hot compressed refrigerant by the evaporation of the defrosting refrigerant improves the operation of the system condenser by both reducing the temperature of the incoming refrigerant and reducing the volume of refrigerant passing through the condenser by the amount which condenses within the heat exchanger apparatus.

In the modified form of the system of my invention illustrated in FIGURE 2 the overall refrigeration and defrosting system are substantially the same as the systems illustrated in FIGURE 1 and heretofore described with the exception of the apparatus for evaporating the refrigerant used in defrosting the evaporator coils and the functions, manner of operation, and arrangement of such apparatus. Two compounded compressors 110 and 111 are provided for supplying hot compressed refrigerant through conduit 112, oil separator 113 and conduit 114 to the condenser 117. The compressed-condensed refrigerant passes through conduit 131 to auxiliary condenser 132 and then through conduit 133 to receiver 134. The liquid refrigerant passes from receiver 134 through header 140 to individual branch conduits 141 and through conduit 191 to a coil 192 of a heat-exchanger apparatus, generally designated 193, of the type commonly referred to as an intercooler and hereinafter described. The liquid refrigerant passes from coil 192 through conduit 194 to header 140a and then to individual branch conduits 141a. The branch conduits 141 and 141a are connected through expansion valve 142 to the individual evaporator coils 143, 144, 145, 146, 147 and 148 that are positioned in individual refrigerated fixtures (not shown). A separate outlet conduit 149 connects each of the evaporator coils 143, 144 and 145 to a header 150 which is in turn connected to the intake 122 of compressor 110 through a conduit 151. Similarly, each of the evaporators 146, 147 and 148 are connected through a separate outlet conduit 152 to a header 153 which is in turn connected through a conduit 118 to the intake of compressor 111.

In the system of FIGURE 2, as is similar in the system of FIGURE 1, compressor 111 draws refrigerant from conduit 118, compresses the refrigerant to an intermediate pressure and temperature and then passes the refrigerant through conduit 119, through hot gas desuperheater 120 and then through conduit 121 to the intake 122 of compressor 110. A conduit 157 connects liquid header 140a to desuperheater 120 for adding refrigerant to the hot compressed refrigerant from compressor 111 through an expansion valve 160. Means may be provided for returning the oil separated by oil separator 113 to the compressors including a reservoir 123 connected to separator 113, a degassing line 124 connecting the top of reservoir 123 to conduit 121, oil return lines 125 and 126 from reservoir 123 to the compressors 110 and 111, respectively, and float valves 127 and 128 associated with compressors 110 and 111, respectively, for controlling the return of oil.

Means are illustrated in FIGURE 2 for defrosting evaporator coils 145, 147 and 148 in the same manner as the defrosting is accomplished in the system of FIGURE 1. These means may include a hot gas header 161 connected with conduit 114 to discharge conduit 112, a condensate header 162, conduits 163, 164 and 165 connecting hot gas header 161 to the outlet conduits, 149, 75

152 and 152, respectively, associated with evaporator coils 145, 147 and 148, respectively, and conduits 166, 167 and 168 connecting branch conduits 141 associated with evaporator coils 145, 147 and 148, respectively, to the condensate header 162. Normally closed solenoid valves 169, 170, 176, 177, 181 and 182 are provided in conduits 163, 166, 164, 167, 165 and 168, respectively, and normally open solenoid valves 171, 172, 178, 179, 183 and 184 are provided in the inlet branch conduits and outlet conduits associated with evaporator coils 145, 147 and 148. A bypass line with a check valve is provided with each expansion valve 142 and also a check valve is provided in each of the conduits 166, 167 and 168, all as shown. When it is desired to defrost evaporator 145 for example, valves 171 and 172 are closed and valves 169 and 170 are opened to allow the hot compressed refrigerant to pass from header 161 through conduit 163, through coil 145, through the bypass line around expansion valve 142, and then through conduit 166 to condensate header 162. Similarly, for defrosting evaporator coil 147 valves 178 and 179 are closed and valves 176 and 177 are opened, or for defrosting evaporator coil 148 valves 183 and 184 are closed and valves 181 and 182 are opened. During the defrosting of an evaporator coil the heat absorbed from the hot gaseous refrigerant for causing the melting of the ice and frost results in some or all of the refrigerant being condensed.

In order to completely evaporate the refrigerant used in defrosting the evaporator coils so that such evaporated refrigerant can be introduced into the intake of one of the refrigeration system compressors, the intercooler 193 is provided. The condensate header 162 is connected to the tank portion 195, preferably at the bottom, of the intercooler 193 for introducing all of the refrigerant, whether gaseous or liquid, used during the defrosting into the tank portion 195. In order to evaporate the refrigerant within tank portion 195, the heat exchanger coil 192 is positioned within the tank portion 195. As previously described, the warm refrigerant from the receiver 134 passes through header 140 and conduit 191 to the coil 192 and then through conduit 194 to header 140a for use in the evaporator coils 146, 147 and 148. Although the refrigerant thus conducted through coil 192 has been compressed and condensed, it is still relatively warm and will cause heating of the refrigerant present in the tank portion 195 of the intercooler. A conduit 196 is connected to the upper portion of the tank portion 195 and is joined to the conduit 121 leading to the intake 122 of the commercial temperature compressor 110. The continuous suction on the tank portion 195 by the compressor 110 through conduit 196 maintains the pressure within the tank portion 195 relatively low. The combined effect of the consistently low pressure within tank portion 195 and the heating by the warm refrigerant passing through heat exchanger coil 192 causes the liquid refrigerant within the tank portion 195 to "boil away" to a vapour which is drawn through conduit 196 into the intake of compressor 110. In order to prevent the tank portion 195 from completely filling with liquid refrigerant and thereby permitting a slug of liquid refrigerant to be drawn through conduit 196 into the intake of compressor 110 an aspirator assembly 197 is provided in communication with conduit 196 for continually introducing a small quantity of liquid refrigerant into the gaseous refrigerant drawn through conduit 196 when the liquid level in tank portion 195 rises above that shown. Thus, the refrigerant used in defrosting the evaporator coils is continuously and automatically reintroduced back into the normal refrigeration system and cycle.

In boiling away the refrigerant within the tank portion 195 of intercooler 193 heat is absorbed from the refrigerant flowing through the coil 192 to thereby cool that refrigerant for use in evaporator coils 146, 147 and 148. Thus, the normal intercooler function of cooling some of the compressed-condensed refrigerant for use in the evap-

orator coils associated with freezers and low temperature boxes is accomplished as an adjunct to evaporating the refrigerant used in the defrosting cycles. As a result the overall efficiency of the refrigeration system itself is increased while the problem of the reintroduction of the refrigerant used in defrosting is also overcome.

If it is desired that the intercooler 193 function as an intercooler without regard to the available supply of condensed refrigerant used in defrosting the evaporator coils, means may be provided for cooling the coil 192 when there is very little or no liquid refrigerant present in the tank portion 195 that has been added thereto through header 162 as a result of defrosting. As shown in FIGURE 2, these means for cooling the heat exchanger coil 192 may be comprised of a conduit 198 connected between conduit 191 or any other continuous source of compressed-condensed refrigerant and tank portion 195, and an expansion valve 199 positioned in conduit 198 for controlling the flow of refrigerant to the tank portion 195. The expansion valve 199 is responsive through any convenient means such as capillary tube 200, to the temperature of the refrigerant in conduit 196 at a location near the tank portion 195. When the liquid refrigerant is at or above the level shown in tank portion 195, liquid refrigerant will be aspirated into conduit 196 by aspirator assembly 197 and lower the temperature of the refrigerant in conduit 196 a sufficient amount to cause closing of the expansion valve 199 by the capillary tube 200. If the amount of liquid refrigerant present within tank portion 195 is insufficient to cause adequate cooling of the refrigerant flowing through coil 192 such as below the liquid level shown, the temperature within conduit 196 will increase thereby causing opening of the expansion valve 199 by capillary tube 200 to admit additional liquid refrigerant to the tank portion 195 until the liquid level rises to the aspirator assembly 197 whereby refrigerant is again aspirated into conduit 196 thereby causing closing of expansion valve 199.

In the modified form of the system of my invention illustrated in FIGURE 3 the overall refrigeration and defrosting systems are substantially the same as the systems illustrated in FIGURES 1 and 2 as heretofore described with the exception of the apparatus for evaporating the refrigerant used in defrosting the evaporator coils and the functions, manner of operation, and arrangement of such apparatus. The two compounded compressors 210 and 211 are provided for supplying hot compressed refrigerant through conduit 212, oil separator 213 and conduit 214 to the condenser 217. The condensed refrigerant passes from condenser 217 through conduit 231 to auxiliary condenser 232 and then through conduit 233 to receiver 234. The liquid refrigerant passes from receiver 234 through header 240 to individual branch conduits 241 and then through individual expansion valves 242 to the evaporator coils 243, 244, 245, 246, 247 and 248. The branch conduits 241 associated with evaporator coils 247 and 248 are connected to their associated expansion valves 242 through individual heat exchanger coils 301 and 302, respectively, the functions of which will hereinafter be described. A separate outlet conduit 249 connects each of the evaporator coils 243, 244 and 245 to a header 250 which is in turn connected to the intake 222 of compressor 210 through a conduit 251. Similarly, a separate outlet conduit 252 connects each of the evaporators 246, 247 and 248 to a header 253 which is in turn connected through conduit 218 to the intake of compressor 211.

In the system of FIGURE 3, similar to the systems of FIGURES 1 and 2, compressor 211 draws refrigerant from conduit 218, compresses the refrigerant and discharges same through conduit 219, hot gas desuperheater 220 and conduit 221 to the intake 222 of compressor 210. A conduit 257 connects header 240 to desuperheater 220 through expansion valve 260 for adding liquid refrigerant to the hot compressed refrigerant passing from compressor 211 to compressor 210. An oil return system may be pro-

vided having a reservoir 223 for receiving oil from separator 213, a degassing line 224 connecting the reservoir to conduit 221, oil return lines 225 and 226, and float valves 227 and 228 for return of the separated oil to compressors 210 and 211.

The system illustrated in FIGURE 3 is provided with means for defrosting evaporator coils 245, 247 and 248 in a manner substantially the same as heretofore described for defrosting evaporator coils 45, 47 and 48 of the system of FIGURE 1 and evaporator coils 145, 147 and 148 of the system of FIGURE 2. In order to accomplish the defrosting of evaporator coil 245 a conduit 263 connects a hot gas header 261 to the outlet conduit 249 associated with evaporator coil 245, a conduit 266 connects a condensate header 262 to the inlet branch conduit 241 associated with evaporator coil 245, the normally closed solenoid valves 269 and 270 in conduits 263 and 266, respectively, are opened and the normally open solenoid valves 271 and 272 in conduits 249 and 241, respectively, are closed to allow hot gaseous refrigerant to pass from header 261 through the evaporator coil 245 to header 262. Similarly, evaporator coil 247 or 248 may be defrosted by opening solenoid valves 276 and 277 or 281 and 282 positioned in conduits 264, 267, 265 and 268, respectively, and closing solenoid valves 278 and 279 or 283 and 284 positioned in conduits 241 and 252 for allowing hot gaseous refrigerant to pass from header 261 through the appropriate evaporator coil 247 or 248 to condensate header 262. Appropriate bypass lines with check valves may be provided around each expansion valve 242 and check valves may be provided in conduits 266, 267 and 268.

A conduit 303 connects the condensate header 262 to the bottom of the tank portion 295 of a heat exchanger assembly or intercooler 293. Thus the refrigerant, whether liquid or gaseous, in header 262 that has been used in defrosting the evaporator coils now passes into tank portion 295 of intercooler 293. A conduit 296 connects the top of tank portion 295 to conduit 221 which is in turn connected to the intake of compressor 210, as heretofore described, to thereby continually maintain the tank portion 295 at a pressure nearly equal to the intake pressure of compressor 210. The heat exchange coils 301 and 302 connecting evaporator coils 247 and 248, respectively, to the liquid header 240 through conduits 241 are positioned within the tank portion 295.

As previously described with respect to FIGURE 2, the refrigerant leaving the receiver 234 is warm and in passing through coils 301 and 302 will, together with the reduced pressure, cause the refrigerant within tank portion 295 to "boil away" to a vapor and be drawn through conduit 296 to compressor 210. This evaporating refrigerant with tank portion 295 cools the coils 301 and 302 to thereby function as an intercooler. In this arrangement evaporator coils 247 and 248 would preferably be associated with very low temperature fixtures such as freezer cases. Additional heat exchanger coils similar to coils 301 and 302 may be provided in tank portion 295 for similar use with other evaporator coils as desired.

In the system of FIGURE 3 an aspirator assembly 297 may be provided and associated with conduit 296 and tank portion 295 for serving the same function as aspirator assembly 197 heretofore described with regard to FIGURE 2. If it is desired that intercooler 293 function as an intercooler without regard to the availability of liquid refrigerant from the defrosting cycles, means may be provided for adding liquid refrigerant to the intercooler 293 from the normal refrigeration system. As shown in FIGURE 3, these means may comprise a conduit 298 connecting the header 240 to tank portion 295 with an expansion valve 299 positioned in conduit 298 to control the flow of refrigerant to the tank portion 295. Expansion valve 299 is responsive, through capillary tube 300, to the temperature of refrigerant leaving tank

portion 295 through conduit 296 similar in function and operation to expansion valve 199 of the system of FIGURE 2 for maintaining the proper liquid refrigerant level in the tank portion.

Thus it may be seen that I have provided a system and described three specific embodiments whereby the hot compressed 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 in a completely evaporated state. 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 which would amount to an increased cost of operation resulting in reduced efficiency. But rather, I provide a useful heat exchanger arrangement for improved efficiency by either cooling the compressed refrigerant entering the condenser or functioning as an intercooler for increasing the efficiency of operation of certain evaporator coils. In this way the refrigerant used in defrosting the evaporator coils improves overall operation while being placed in a condition appropriate for reintroduction into the normal refrigeration system cycle.

In normal operation, I prefer to defrost only one evaporator coil at a time so that all of the hot compressed gaseous refrigerant in header 61, 161 or 261 is available for passing through that evaporator coil to accomplish the 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 fixture. In installations employing a large number of evaporator coils it is possible to defrost more than one coil at a time due to the larger capacity compressors which would be used in such an installation. The solenoid valves which are associated with the evaporator coils, with the hot gas header 61, 162 or 262 may be all 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 fixture, 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 refrigerated boxes are those usually associated with the drains for carrying off water resulting from the defrosting of the evaporator coils. These electric heaters would obviously be relatively inexpensive when compared to the heaters normally necessary for defrosting the entire evaporator coil and refrigerated box.

Although I have illustrated and described three embodiments of my invention each employing a refrigeration system and defrosting system having two compressors, an air-cooled condenser, and auxially condenser, and six evaporators, it is readily apparent and to be understood that other embodiments are possible and 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 and reevaporating system in combination with a refrigeration system having a compressor, a condenser-receiver means and a plurality of evaporator coils; the combination of: means selectively connecting the evaporator coils to the compressor output for conducting hot compressed gaseous refrigerant for defrosting the selected evaporator coils, heat exchanger means

having first and second portions in heat exchange relation and being isolated from each other, means for connecting the selected evaporator coils to said first portion for conducting the refrigerant used in defrosting to said first portion, means for connecting the second portion to the refrigeration system between said condenser-receiver means and at least one evaporator coil for passing the liquid refrigerant of said refrigeration system through said second portion to vaporize refrigerant in said first portion and to sub-cool said liquid refrigerant, and means connecting said first portion to the compressor intake for drawing refrigerant vapor from said first portion into the compressor intake.

2. In a defrosting and reevaporating system in combination with a refrigeration system employing a compressor, a condenser, and a plurality of evaporator coils, the combination of: means operatively connecting each evaporator coil to the compressor output for conducting hot compressed gaseous refrigerant to each evaporator coil for defrosting each coil, an intercooler having a tank portion and a heat exchange coil positioned in said tank portion, means operatively connecting each evaporator coil to said tank portion for conducting the refrigerant used in defrosting to said tank portion, means operatively connecting said heat exchange coil to the refrigeration system for passing compressed-condensed refrigerant through that said coil to heat and evaporate the refrigerant present in the tank portion and thereby cool the refrigerant in said heat exchange coil, and means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake.

3. In a defrosting and reevaporating system in combination with a refrigeration system employing a compressor, a condenser, and a plurality of evaporator coils, the combination of: first conduit means operatively connecting each evaporator coil to the compressor output for conducting hot compressed gaseous refrigerant to each evaporator coil for defrosting each coil, an intercooler having a tank portion and a heat exchange coil positioned in said tank portion, second conduit means operatively connecting each evaporator coil to said tank portion for conducting the refrigerant used in defrosting to said tank portion, third conduit means operatively connecting said heat exchange coil to the refrigeration system for passing compressed-condensed refrigerant through that said coil to heat and thereby evaporate the refrigerant present in the tank portion and in turn cool the refrigerant present within the heat exchange coil, fourth conduit means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake, and valve means operably associated with each of said first and second conduit means for selectively permitting the flow of hot compressed gaseous refrigerant through any one or more of the evaporator coils at one time.

4. In a defrosting and reevaporating system in combination with a refrigeration system employing a compressor, a condenser, a receiver, and a plurality of refrigerated fixtures of both the high and low temperature type with an evaporator coil associated with each fixture, the combination of: means operatively connecting selected evaporator coils to the compressor output for conducting hot compressed gaseous refrigerant to such evaporator coils for the defrosting thereof, an intercooler having a tank portion and a heat exchange coil positioned in said tank portion, means operatively connecting each said selected evaporator coils to said tank portion for conducting the refrigerant used in defrosting to said tank portion, means operatively connecting the receiver to each of the evaporator coils associated with high temperature fixtures, means operatively connecting the last mentioned said means to said heat exchange coil for passing compressed-condensed refrigerant through

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that said coil to heat and thereby evaporate the refrigerant present in the tank portion and cool the refrigerant in said heat exchange coil, means operatively connecting said heat exchange coil to at least one of the evaporator coils associated with the low temperature refrigerated fixtures for supplying cooled liquid refrigerant to such evaporator coil, and means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake.

5. In a defrosting and reevaporating system in combination with a refrigeration system employing a compressor, a condenser, a receiver, and a plurality of refrigerated fixtures of both the high and low temperature type with an evaporator coil associated with each fixture, the combination of: means operatively connecting each evaporator coil to the compressor output for conducting hot compressed gaseous refrigerant to each evaporator coil for defrosting each coil, an intercooler having a tank portion and a heat exchange coil positioned in said tank portion, means operatively connecting each evaporator coil to said tank portion for conducting the refrigerant used in defrosting to said tank portion, means operatively connecting the receiver to each of the evaporator coils associated with high temperature fixtures, means operatively connecting the last mentioned said means to said heat exchange coil for passing compressed-condensed refrigerant through that said coil to heat and thereby evaporate the refrigerant present in the tank portion and cool the refrigerant in said heat exchange coil, means operatively connecting said heat exchange coil to all of the evaporator coils associated with the low temperature refrigerated fixtures for supplying cooled liquid refrigerant to those evaporator coils, means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake, and means for adding refrigerant to said tank portion when cooling of the refrigerant in said heat exchange coil is inadequate.

6. In a defrosting system in combination with a refrigeration system employing a compressor, a condenser, a receiver, and a plurality of refrigerated fixtures of both the high and low temperature type with an evaporator coil associated with each fixture, the combination of: means operatively connecting each evaporator coil to the compressor output for conducting hot compressed gaseous refrigerant to each evaporator coil for defrosting each coil, an intercooler having a tank portion and at least one heat exchange coil positioned in said tank portion

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tion, means operatively connecting each evaporator coil to said tank portion for conducting the refrigerant used in defrosting to said tank portion, means operatively connecting the receiver to said heat exchange coil, means operatively connecting the heat exchange coil between said receiver and an evaporator coil associated with a low temperature refrigerated fixture, compressed-condensed refrigerant passing from the receiver through said heat exchange coil to heat and thereby evaporate the refrigerant present in the tank portion, and means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake.

7. In a defrosting system in combination with a refrigeration system employing a compressor, a condenser, a receiver, and a plurality of high and low temperature refrigerated fixtures with an evaporator coil associated with each fixture, the combination of: means operatively connecting each evaporator coil to the compressor output for conducting hot compressed gaseous refrigerant to each evaporator coil for defrosting each coil, an intercooler having a tank portion and a plurality of heat exchange coils positioned in said tank portion, means operatively connecting each evaporator coil to said tank portion for conducting the defrosting refrigerant to said tank portion, means operatively connecting each said heat exchange coil to the refrigeration system receiver for passing compressed-condensed refrigerant through said coils to heat and thereby evaporate the refrigerant present in the tank portion and cool the refrigerant in said heat exchange coil, means operatively connecting each said heat exchange coil to an evaporator coil associated with a low temperature refrigerated fixture, means operatively connecting the said tank portion to the compressor intake for drawing the evaporated refrigerant from the tank portion into the compressor intake, and means for adding refrigerant to said tank portion when cooling of the refrigerant in said heat exchange coil is inadequate.

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