The present invention relates to refrigerating apparatus and is more particularly concerned with a refrigerating system including an improved circuit arrangement for the hot gas defrosting of the evaporator component of the system. It is an object of the present invention to provide a new and improved refrigerating system of the hot gas defrost type designed for quick removal of any stored liquid refrigerant from the evaporator during the initial defrost period and thereafter to provide means for increasing the pressure within the evaporator to a pressure closer to that prevailing in the condenser, and maintaining the defrosting process during the entire defrost period. It is a further object of the present invention to provide an improved hot gas defrosting system including refrigerant flow control means adapted during defrost to remove initially refrigerant stored in the evaporator and thereafter automatically and in response to a change in the temperature of the system to provide means for increasing the evaporator pressure so that the latent and sensible heat in the hot compressed refrigerant is available for defrosting purposes.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed in forming a part of this specification.

In carrying out the objects of the present invention there is provided a refrigerating system comprising a hermetic compressor unit including a compressor and a motor for driving the compressor, both being enclosed in a sealed casing. The refrigerating system further comprises a condenser, capillary flow restrictor, an evaporator and an accumulator connected in series-flow relationship with the compressor to form a normal refrigerating circuit in which the compressor normally withdraws low pressure gaseous refrigerant from the accumulator and through the condenser and discharges high pressure refrigerant to the condenser. In order to employ hot gaseous refrigerant from the compressor for periodically warming the evaporator to defrosting temperatures, there is provided a valve-controlled bypass line connecting the compressor discharge to the evaporator inlet whereby gaseous refrigerant flowing through this line bypasses the condenser and restrictor and enters the evaporator with substantially the same heat capacity as the leaves the compressor. Since, during normal operation of the refrigerating system, some liquid refrigerant is stored in the evaporator and particularly the accumulator component thereof, the system is so arranged that during the initial operation of the system on the defrost cycle, this stored liquid refrigerant is caused to flow through the normal suction line from the evaporator. During subsequent portions of the defrost cycle, there is provided, in parallel with the suction line, a defrost return line including a flow restricting means and connecting the bottom portion of the accumulator with the compressor case. A normally open valve in the suction line is provided for the purpose of effecting flow of all of the refrigerant through this defrost return line in response to a change in a system condition following the initiation of the defrost cycle, or more specifically, the removal of the stored liquid refrigerant from the accumulator.

For a better understanding of the invention reference may be had to the accompanying drawing in which the single figure is a diagrammatic illustration of a refrigeration system embodying the hot gas defrost invention of the present arrangement. With reference to the accompanying drawing, there is illustrated a preferred embodiment of the invention comprising the usual components of a refrigerating system including a compressor 1, a condenser 2, a capillary flow restrictor 3, an evaporator 4 and an accumulator 5. The accumulator is connected by means of a suction line 6 with the casing 7 which hermetically encloses the compressor 1 and the motor 8 for driving the compressor. The compressor, condenser, capillary flow restrictor, evaporator, accumulator, suction line, and casing are connected in series-flow relationship to form a normal refrigerating system in which the capillary flow restrictor 3 maintains a pressure differential between the condenser and the evaporator such that refrigerant condenses in the condenser 2 at normal ambient conditions and vaporizes in the evaporator 4 by absorption of heat from a refrigerator cabinet (not shown) to cool the contents of the cabinet. Any liquid refrigerant not evaporated in evaporator 4 collects in the accumulator 5; the connection of the evaporator to the accumulator preferably being at a lower portion thereof while the suction line 6 is connected to the upper portion of the accumulator so that, during normal refrigerating operation of the system, only gaseous refrigerant is withdrawn from the accumulator and through the suction line 6 by the compressor 1. Also in accordance with the usual practice, the suction line 6 is in heat exchange relationship with a portion of the capillary tube restrictor 3 as indicated at 10 whereby condensed refrigerant passing to the evaporator is further cooled by the refrigerant gas flowing through the suction line.

When a refrigerating system of this type is arranged for continuous operation at sub-freezing temperatures, there is a gradual accumulation of frost on the evaporator structure 9 which includes the evaporator tubing 4 and the accumulator 5. This accumulated frost must periodically be removed in order to maintain the system operating at maximum efficiency.

For the purpose of periodically warming the evaporator structure to defrosting temperatures there is provided additional means for bypassing the capillary 3 and conducting the gaseous refrigerant from the compressor into the evaporator inlet. In the illustrated modification of the invention, this portion of the defrost circuit comprises a conduit 12 including a normally closed solenoid-operated valve 13, the conduit 12 being connected at its inlet end to the normal refrigerating circuit between the compressor and the condenser and at its discharge end to the evaporator inlet 14. When the valve 13 is opened, refrigerant from the compressor preferentially flows through the bypass line 12 due to the lower flow restriction offered by this line as compared with the alternate path through the condenser and the capillary flow restrictor 3. This high pressure gaseous refrigerant entering the evaporator 4 causes the stored or accumulated liquid refrigerant in the evaporator and particularly in the accumulator 5 to flow to the compressor case through the suction line 6. Since this circuit, comprising the compressor, the bypass line 12, the evaporator 4, the accumulator 5, the suction line 6 and the casing 7 offers no significant restriction to the
flow of refrigerant, the transfer of stored refrigerant to the compressor case is quickly effected.

There is also provided in accordance with this invention means for restricting the flow of refrigerant to the compressor during the defrost operation in order to increase the pressures within the evaporator and accumulator sufficiently so that the gaseous refrigerant entering the evaporator and accumulator from the compressor will condense therein whereby the heat of condensation is made available for defrosting purposes. The flow rate of the restrictor is designed high enough to prevent the storage of liquid in the evaporator since liquid stored in the evaporator is not available for heating the compressor, thereby increasing the input to the refrigerant cooled motor and compressor unit and hence the amount of heat made available for defrost purposes. For this purpose, there is provided in parallel with the suction line a defrost return line 17 including a flow restricting means 18 and a solenoid controlled valve 16 in the suction line. The defrost return line connects the lower portion of the accumulator 5 with the compressor case or with the suction line 6 at a point between the heat interchange area 10 and the case 7. During normal refrigerating operation of the system and also during the initial defrost period when the valve 16 is in its normally open position, all of the refrigerant from the accumulator flows through the suction line 6, flow through the defrost return line 17 being prevented by the liquid trap 19 provided in the line adjacent the accumulator.

Since a restriction of the refrigerant flow from the accumulator to the compressor case 7 offered by capillary flow restricting means 18 during the defrost cycle will provide the desired condensing pressures within the evaporator structure as well as the desired increased load on the motor 8, the normally opened solenoid valve 16 is so controlled that it will close upon a change in a system condition indicative of the removal of all or substantially all of the stored refrigerant from the accumulator 5. In the illustrated embodiment of the invention, this operation of the valve 16 is effected in response to a changing temperature of a suction line 6 adjacent the compressor case 7 and downstream from the connection of the defrost return line 17 to the suction line.

The electrical control system provided to obtain this action of the valve 16 as well as to control both the normal and defrost operations of the system comprises a pair of supply conductors 20 and 21 for controlling the energization of the compressor motor 8 through a temperature operated switch 22 in the supply lines 21. A temperature sensing device 23 in contact with the plate 9 forming part of the evaporator structure operates the switch 22 so that during normal operation of the system the compressor is energized, for example, when the evaporator structure reaches a predetermined maximum temperature of 0°F, and is de-energized when a temperature of, for example, 20°F is attained. The portion of the electrical control circuit provided for initiating and terminating the operation of the system on the defrost cycle comprises a defrost control switch 28 for periodically energizing solenoid 13a which controls the operation of valve 13; the switch 28 and the solenoid 13a being connected in series to the supply lines 20 and 21 in such a manner that the energization of the solenoid 13a is also under the control of the switch 22. The defrost control switch 28 can be any of the known switch means designed to close periodically as a function of time, number of refrigerator cabinet door openings or the like and to open when the temperature sensed by a temperature sensing element 24 contacting the evaporator structure is a few degrees above freezing, that is, such that the evaporator structure has reached a frost free condition.

It will be seen that this electrical control circuit as thus far described is designed to permit energization of the solenoid 13a to open the valve 13 only when the switch 22 is also closed to energize the compressor motor 8 so that the conditioning of the system for operation on the defrost cycle cannot be initiated unless the compressor is also operating.

In order to delay the operation of the valve 16 until such time that any stored refrigerant within the accumulator has been returned through the suction line 6 to the compressor, there is provided as part of the electrical control system, a temperature sensing switch 30 which in the illustrated embodiment of the invention is arranged so that it senses the temperature of the suction line 6. This switch 30 which controls the energization of the solenoid 16a for operating the valve 16 is designed to remain open for all temperature conditions experienced by the suction line during normal operation of the system and to close when the suction line becomes colder as the result of liquid refrigerant being unloaded from the accumulator 5.

It has been found that the time required for this lowering in the suction line temperature is just long enough for the evaporator and accumulator to unload the stored refrigerant.

Upon the closing of the valve 16 during defrost, all of the refrigerant from the accumulator must return to the accumulator case through the bypass line 17 which includes the flow restricting means 18 so that as the system continues to operate on the defrost cycle the pressures within the evaporator and accumulator continue to rise as a result of the increased temperature of the evaporator as defrosting is accomplished. At the same time the low side or case pressure is rising and these rising pressures cause an increase load on the compressor and therefore a further increase in the amount of defrost heat available due to the fact that the motor for driving the compressor is cooled by the low pressure refrigerant entering the casing 7 and the resultant heat liberated by the refrigerant is transferred to the evaporator.

It will be seen that after valve 16 has closed during the defrost cycle the evaporator and accumulator function as a condenser while the case 7 forms the low pressure or evaporator side of the defrost circuit.

When the defrosting of the evaporator structure is completed as sensed by the sensing device 24, switch 28 is opened thereby de-energizing both the solenoids 13a and 16a to close valves 13 and 16, thus returning the refrigerating system to its normal operation in which the refrigerant from the evaporator passes into the condenser 2. However, since the temperature sensing device 23 which controls the operation of the compressor senses a temperature well above 0°F, the compressor will continue to operate until the temperature of the evaporator structure has reached the predetermined low point at which the compressor is de-energized in a normal refrigerating cycle.

While there has been shown and described a particular embodiment of the present invention it will be seen that the invention is not limited to this particular form. For example, the time delay operation of the valve 16 can be obtained in response to any of a number of changing system conditions initiated by the opening of the valve 13. For instance, switch 28 could be in temperature sensing contact with the inlet to the evaporator in which case it would be designed to complete the circuit and close valve 16 when the inlet to the evaporator attains a predetermined maximum or warmer temperature due to the hot compressed refrigerant flow through the line 12. Other arrangements will also become apparent and it is therefore intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A defrostable refrigerating system comprising a hermetic compressor unit including a compressor and a motor for driving said compressor enclosed within a sealed casing, a condenser, a capillary flow restrictor, an evaporator and an accumulator, conduit means including a suction line between the upper portion of said accumulator and said casing for connecting said compressor, condenser,
capillary flow restrictor, evaporator, accumulator and casing to form a closed series-flow normal refrigerating circuit in which said compressor normally withdraws low pressure gaseous refrigerant from said accumulator and through said casing and discharges high pressure refrigerant to said condenser, said motor being cooled by low pressure refrigerant in said casing, means for circulating hot compressed refrigerant from said compressor through said evaporator for the defrosting thereof comprising a fixed flow restricting means and additional conduit means connecting said compressor, evaporator, accumulator, fixed flow restricting means and casing to form a series-flow defrost circuit for flow of compressed refrigerant from said compressor directly to said evaporator, a first normally closed valve in said defrost circuit between said compressor and said evaporator for preventing circulation of refrigerant through said defrost circuit during normal refrigerating operation of said system, a second normally open valve in said suction line, control means for opening said first valve to effect flow of compressed refrigerant directly from said compressor to said evaporator to increase the pressure therein whereby liquid refrigerant stored in said accumulator is caused to flow to said casing through said suction line and means responsive to a change in a system condition resulting from opening of said first valve to close said second valve.

2. A defrostable refrigerating system comprising a hermetic compressor unit including a compressor and a motor for driving said compressor enclosed within a sealed casing, a condenser, a capillary flow restrictor, an evaporator and an accumulator, conduit means including a suction line between said accumulator and said casing for connecting said compressor, condenser, capillary flow restrictor, evaporator, accumulator, and casing to form a closed series-flow normal refrigerating circuit in which said compressor normally withdraws low pressure gaseous refrigerant from said accumulator and through said casing and discharges high pressure refrigerant to said condenser, means for introducing hot compressed refrigerant from said compressor into said evaporator for the defrosting thereof comprising a fixed flow restricting means and additional conduit means for connecting said compressor, evaporator, accumulator, fixed flow restricting means and casing to form a series-flow defrost circuit for flow of compressed refrigerant from said compressor to said evaporator, a first normally closed valve in said defrost circuit between said compressor and said evaporator for preventing circulation of refrigerant through said defrost circuit during normal refrigerating operation of said system, a second normally open valve in said suction line, control means for opening said first valve to effect flow of compressed refrigerant directly from said compressor to said evaporator to increase the pressure therein whereby liquid refrigerant stored in said accumulator is caused to flow to said case through said suction line and means responsive to a change in the suction line temperature resulting from the flow of liquid refrigerant through said suction line for closing said second valve.

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