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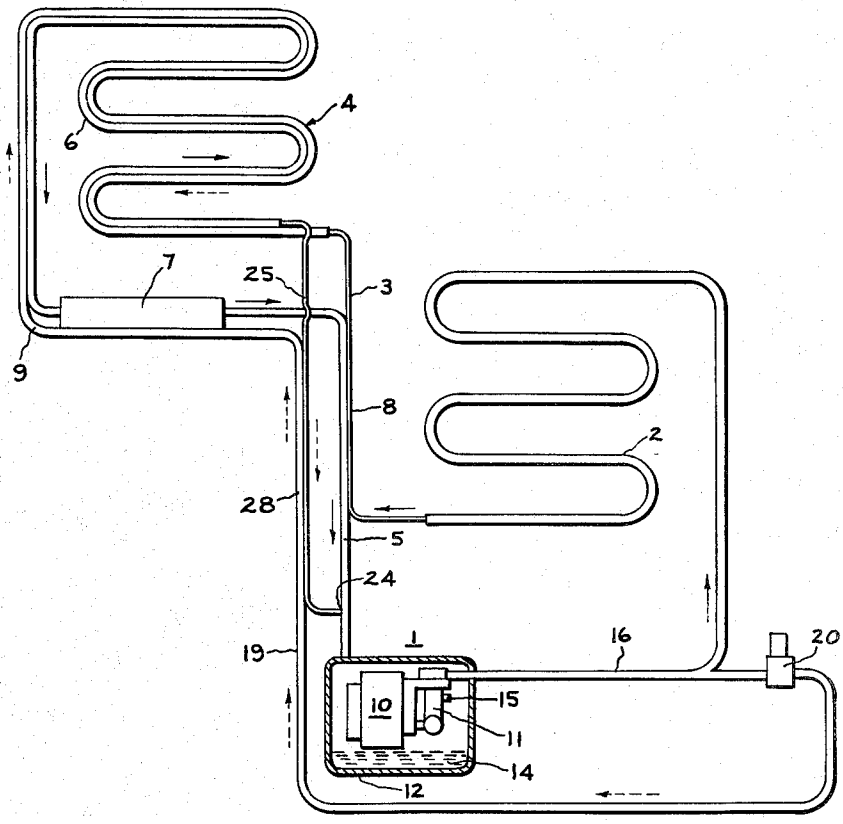

INVENTOR
CLYDE J. NONOMAQUE

BY Walter E. Rule

HIS ATTORNEY

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REFRIGERATING SYSTEM INCLUDING HOT GAS DEFROST MEANS

Clyde J. Nonomaque, Louisville, Ky., assignor to General Electric Company, a corporation of New York

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1 Claim. (Cl. 62—278)

The present invention relates to refrigerating apparatus and is more particularly concerned with a refrigerating system including a hot gas defrost circuit for warming the evaporator component of the system to defrosting temperatures.

In my copending application S.N. 698,462 filed November 25, 1957, now Patent No. 2,928,256 and assigned to the same assignee as the present invention, there is described and claimed a refrigerating system including an auxiliary hot gas defrosting circuit for quickly and effectively defrosting the evaporator component of the refrigerant system by means of hot compressed refrigerant.

The refrigerant system described in my copending application preferably comprises a hermetic compressor, a condenser, a fixed flow restrictor and an evaporator connected to form a series-flow normal refrigerating circuit in which the refrigerant passing through the hermetic casing cools the motor employed for driving the compressor. For the purpose of periodically raising the evaporator to defrost temperatures by means of hot compressed refrigerant from the compressor, there is provided an auxiliary circuit connected between the high and low pressure sides of the normal refrigerating circuit and in parallel with at least that part of the normal refrigerating circuit including the fixed flow restrictor and the evaporator. This auxiliary circuit includes a defrost portion in heat exchange with the evaporator so that upon opening of a normally closed valve in the auxiliary circuit, hot compressed refrigerant will flow through the defrost portion of the auxiliary circuit in heating relation with the evaporator where condensation of refrigerant in the defrosting portion quickly and effectively warms the evaporator to defrosting temperatures. The refrigerant condensed in the defrost portion then passes back to the compressor case where it produces refrigeration and increases the load on the refrigerant cooled compressor motor, causing the input watts to the motor to increase and thereby providing additional energy in the form of heat for defrosting operations.

During the defrost operation of the refrigerating system described in my aforementioned application, the refrigeration taking place in the hermetic casing cools the lubricating oil contained therein and since the solubility of the refrigerant in the oil increases with decreasing temperatures, additional refrigerant is dissolved in the oil during the defrost cycle. In some cases, as with the more oil-soluble refrigerant dichlorodifluoromethane, hereinafter referred to as R–12, a substantial portion of the total refrigerant charge is absorbed into the oil in the compressor case. When the defrost function is terminated and the system is returned to the normal refrigerating operation, the absorbed refrigerant slowly evolves from the oil, the rate of evolution depending upon the rate at which the compressor case returns to normal operating temperatures. While this delay in the liberation of the refrigerant from the oil does not adversely affect the over-all operation of a system which is defrosted only two or three times per day, systems comprising evaporators which require a more frequent defrost, as for example once each hour, may be adversely affected since a recovery delay of only a few minutes will cause such systems to operate at higher average operating temperatures and longer running times.

It is therefore an object of the present invention to provide a refrigerating system including a hot gas auxiliary defrost circuit characterized by a rapid recovery from defrost operation to normal refrigerating operation.

Another object of the present invention is to provide a refrigerating system including a hot gas or auxiliary defrost circuit which is particularly adapted for the frequent defrosting of a low mass evaporator component of the system.

A more specific object of the invention is to provide a defrosting refrigerating system of the above type including a refrigerant component of limited solubility in oil which will quickly return from the defrost circuit to the evaporator during a refrigerating cycle following defrost and means in the hot gas defrost or auxiliary defrost circuit for limiting the flow rate of that refrigerant component to prevent excessive increases in the case pressures and input watts to the compressor motor during defrost operation of the system.

In carrying out the objects of the present invention there is provided a defrostable refrigerating system comprising an evaporator structure including an evaporator passage and a defrost passage in heat exchange with the evaporator passage. For the purpose of supplying refrigerant to the evaporator passage there is provided a hermetic compressor unit including a sealed casing and a compressor and a motor for driving the compressor disposed within the casing. The casing contains a supply of lubricating oil for lubricating the compressor and motor. The system also includes a condenser and a capillary flow restrictor and conduit means connecting the compressor, condenser, capillary flow restrictor, evaporator passage and casing in a series-flow normal refrigerating circuit whereby the compressor withdraws lower pressure refrigerant from the evaporator through the casing and discharges high pressure refrigerant to the condenser. By this arrangement, the motor is cooled by the low pressure refrigerant in the casing. For periodically introducing hot compressed refrigerant into the defrost passage in order to raise the evaporator structure to defrosting temperatures, there is provided an auxiliary circuit including a hot gas conduit connecting the inlet end of the defrost passage to the refrigerating circuit between the compressor and the flow restrictor and a second conduit including a flow restricting means connecting the outlet end of the defrost passage to the refrigerating circuit between the evaporator passage and the compressor. A normally closed valve in the auxiliary circuit controls the flow of compressed refrigerant to that circuit while the flow restricting means between the defrost passage and the compressor restricts the flow of refrigerant to the compressor in order to maintain the refrigerant in the defrost passage at condensing pressure conditions when the valve is opened for defrost operation of the system. To provide a quick recovery of the system from defrost operation to normal refrigerating operation following a defrost period, the system is charged with a refrigerant mixture including a refrigerant component, such as monochlorodifluoromethane hereinafter referred to as R-22 having a relatively low solubility in oil. In order to limit the pressure increases within the compressor case and hence limit the input watts to the motor resulting from the presence of the more volatile and less soluble refrigerant component, means in the form of a heat exchange between the auxiliary circuit conduit leading to the defrost passage and the auxiliary circuit flow restricting means is provided. This heat exchange prevents excessive flow

of condensed refrigerant from the defrost passage to the hermetic casing during defrost operation.

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 refrigerating system embodying the features of the present invention.

With reference to the drawing there is illustrated a preferred embodiment of the invention comprising a hermetic motor-compressor unit 1, a condenser 2, a fixed flow restrictor 3, preferably of the capillary tube type, a cooling or evaporator unit or structure 4 including an evaporator passage 6 and a suction line 5. Preferably, in accordance with the usual practice, the suction line 5 is in heat exchange with a portion of the flow restrictor 3 as indicated by the numeral 8. The evaporator structure 4 is illustrated as a double tube extrusion including the evaporator passage or circuit 6 and a defrost gas passage 9. Also, as part of the evaporator structure there may be provided an accumulator 7 arranged in the usual manner at the outlets end of the evaporator circuit 6.

The motor compressor unit 1 comprises a motor 10 for driving a compressor 11, the two being sealed in a hermetic casing 12. A body of oil 14 is provided in the lower portion of the casing 12 and is circulated within the casing by means of an oil pump (not shown) for lubricating the compressor and motor. The suction line 5 is connected to the case 12 so that the case is part of the low pressure side of the normal refrigerating system and is therefore filled with low pressure refrigerant in cooling contact with the motor 10. The compressor 11 having its inlet 15 communicating with the interior of the case 12 withdraws low pressure refrigerant from the case 12 and discharges high pressure refrigerant directly through a discharge line 16 into the condenser 2. Thus the compressor, condenser, capillary flow restrictor, evaporator passage and hermetic casing are connected in a series-flow refrigerating circuit with the evaporator passage 6, the accumulator 7 and the case 12 forming the low pressure side of the normal refrigerating circuit while the compressor 11 and the condenser 2 comprise the high pressure side.

It will be understood, of course, that in a typical application of a refrigeration system of this type, the evaporator structure 4 is placed in a cabinet (not shown) which is to be cooled while the condenser 2 is placed in the ambient atmosphere. During the normal operation of the refrigeration system thus far described, the refrigerant flow path during the normal refrigeration cycle is that indicated by the solid arrows in Figure 1. The motor compressor unit 1 withdraws vaporized refrigerant from the accumulator 7, or from the evaporator passage 6 if the accumulator as a separate component is not employed, and this withdrawn refrigerant passes through the suction line 5 and flows into the casing 12. Compressed refrigerant discharged in the gaseous state from the compressor flows into the condenser 2 where it is liquified. The liquified refrigerant flows through capillary flow restrictor 3 into the evaporator passage 6 where, at a lower pressure, it is vaporized by the absorption of heat from the cabinet to cool the contents of the cabinet. Any liquid refrigerant not evaporated in the evaporator passage collects in the accumulator 7, the connection between the accumulator 7 and the suction line 5 being such that only gaseous refrigerant is withdrawn from the accumulator through the suction line during normal refrigerating operation of the system.

For the purpose of defrosting the evaporator structure, there is provided an auxiliary defrost circuit which is connected to the normal refrigerating circuit in parallel relationship with the evaporator passage 6, the accumulator 7 and the capillary flow restrictor 3 so that it forms a heating or defrost circuit for circulation of hot compressed refrigerant gas from the compressor through the defrost passage 9 for the purpose of warming the evaporator structure 4 to defrosting temperatures.

In the illustrated embodiment of the invention, the inlet end 19 of this auxiliary circuit is connected to the discharge line 16 leading from the compressor to the condenser 2 and normally closed valve 20 is provided for permitting flow of refrigerant through the auxiliary circuit 18 during defrost. The conduit 19 is connected to the defrost passage 9 which has a portion in heat exchange with the accumulator 7 and another portion in heat exchange with the evaporator passage 6. The outlet end of the defrost passage 9 is connected by a restrictor tube 25 to the suction line 5 as indicated by the numeral 24.

The system as thus far described is constructed in accordance with the teachings of the aforementioned Nonomaque application. Also, in accordance with the teachings of that application, the restrictor tube 25 has a lower flow restriction than the capillary tube 3 but provides sufficient restriction to the flow of refrigerant through that auxiliary circuit to maintain the compressed refrigerant gas in the defrost passage 9 at condensing pressures during defrost operation of the system. When defrosting of the evaporator structure 4 is required, the valve 20 is opened with the result that, due to the pressure differential and temperature conditions existing in the system upon opening of the valve 20, substantially all of the refrigerant withdrawn from the accumulator 7 by the compressor unit 1 flows from the compressor through the auxiliary circuit as indicated by the broken arrows instead of the normal refrigerating circuit. In the defrost passage, which corresponds to the condenser component of a refrigerating circuit, the hot compressed refrigerant condenses; the liberated heat serving to melt the frost accumulated on the evaporator structure 4. This condensed refrigerant then passes through the restrictor 25 and returns as a liquid or liquid-gas mixture to the compressor case 12 which functions as the evaporator on defrost. Also, during defrost operation, refrigerant stored in the evaporator or condenser component of the normal refrigerating circuit is transferred to the defrost circuit. This transfer of most of the refrigerant charge to the defrost circuit and particularly to the compressor case 12, increases the case or low side pressure of the system so that a greater load is placed on the motor causing the input watts to the motor to increase even though the case and motor are cooled to a lower temperature during the defrost cycle. The increased heat output of the motor resulting from the higher input wattage is absorbed by the refrigerant in cooling relationship with the motor and is transferred by the circulating refrigerant to the defrost passage 9 for defrosting of the evaporator structure. When defrosting of the evaporator unit is completed, closing of valve 20 restores the system to normal refrigerating operation wherein any refrigerant dissolved in the oil is liberated as this oil becomes warmer and the case pressure decreases.

Refrigerating systems employing the above-described defrost principle of operation have been found to be most satisfactory for defrosting evaporators of high thermal mass particularly when the defrost operation is initiated only a few, for example, one or two times per day since a few minutes delay in the liberation of dissolved refrigerant does not materially affect the total refrigerating operation of the system.

However, with systems including evaporators which require frequent defrosting so that the accumulation of frost which must be removed during each defrost period is small or with low mass evaporators in which the major portion of the evaporator is quickly warmed to defrosting temperatures, any substantial delay in the return of the system to normal refrigerating operating temperatures is significant and can result in higher average operating temperatures for the system and increased running time. For

example, in the case of household refrigerators cooled by a forced air cooling system in which air is blown over a low mass evaporator that must be kept relatively free of frost collections to facilitate efficient heat removal from the circulating air, frequent defrosting, as for example once per hour, is required for efficient heat transfer between the evaporator and the circulating air. A delay of only a few minutes in the recovery of the system to normal refrigerating operating temperatures decreases the total refrigerating period between defrosts and will thus cause significant increases in the average evaporator temperature and in the total running time for the system.

In accordance with the present invention, the delay in returning the system to normal operation temperatures is substantially decreased by employing as the refrigerant charge for the system a refrigerant mixture containing a minor proportion of a refrigerant more volatile and less oil soluble than the principal constituent of the mixture. Preferably, there is employed a mixture of R–12 and R–22. The presence of small percentages of R–22 has been found to exhibit the ability to return the system to normal temperatures much more rapidly than is possible with R–12 alone. In general, a refrigerant mixture containing about 15% by weight of R–22 and about 85% by weight of R–12 is particularly satisfactory. However, larger proportions of R–22, up to about 35% can be employed in the practice of the present invention.

The principal reason that R–22 in the indicated amounts minimizes the delay in the recovery of the refrigerating operation of the system is due to the fact that R–22 is considerably less soluble in oil than R–12 and also evolves more rapidly from the oil and is returned more quickly to the evaporator as the oil becomes warmer following a defrost cycle thereby producing a much faster return of the system to normal refrigerating temperatures. The presence of the R–22 also results in an increase in capacity of the refrigerating and defrosting systems and this increase can be controlled by the quantity of R–22 added although it is generally desirable to limit the amount of R–22 to a minimum so as not to overload the compressor motor.

It has further been found that while the addition of the more volatile R–22 to the refrigerant charge provides the desirable function of returning the system to normal refrigerating operating temperatures at a much faster rate or in a much shorter time than is possible with the more oil soluble R–12, its presence in the system during the defrost cycle may result in such a rapid increase in the low side or case pressure and hence the input watts to the compressor motor during the defrost cycle that the usual temperature responsive overload protection provided for the compressor motor may trip before the defrost operation is complete. In other words, with the more volatile R–22 present in the system, the pressure changes are much greater than with R–12 alone and these pressure changes are particularly evident as the refrigerant charge is transferred to the compressor case during the initial stages of the defrost cycle following the opening of the valve **20**.

Therefore, in accordance with a further feature of the present invention, the system is so constructed as to control this pressure rise and the corresponding increase in the input motor watts. This is accomplished by heat exchanging the hot gas line **19** with the flow restrictor **25** in the auxiliary or defrost circuit as indicated by the numeral **28** in the accompanying drawing. From a consideration of the system shown in the accompanying drawing, it will be seen that this heat exchange is effective or comes into operation only during the defrost cycle. When the valve **20** is opened, the lesser total restriction of the auxiliary or defrost circuit as compared with the normal or refrigerating circuit, causes the refrigerant to flow through the conduit **19** and into the defrost passage **9** wherein it heats the evaporator or refrigerant passage **6** to defrosting temperatures. At the same time the accumulator **7** is also warmed so that any refrigerant stored therein tends to flow through the suction line **5** into the compressor case **12**. The hot gas condensing in the defrost passage **9** returns as a liquid through the flow restricting means **25** to the compressor case **12**. By providing the heat exchange **28** between the flow restricting means **25** and the hot gas conduit **19**, the cool liquid in the flow restricting means **25** removes a portion of the heat from the gas flowing through the line **19** which slows the temperature and pressure rise in the defrost passage **9** thus in turn slowing the return flow through the flow restricting means **25**. In addition, this slower increase in the temperature of the defrost passage **9** decreases the rate of transfer of accumulated refrigerant in the accumulator **7** to the compressor case. Thus by the heat exchange **28** a rapid increase in the case pressure and an overloading of the compressor motor is avoided.

It will be observed that while the net result of the heat exchange **28** is to decrease the rate of flow of refrigerant through the auxiliary circuit and back to the compressor case **12**, the use of a smaller or more restrictive flow restrictor means **25** in place of the heat exchange **28** to obtain such a decreased flow rate would not be satisfactory. While the use of greater flow restricting means in the auxiliary circuit would decrease the rate of flow to the compressor case, it would also increase the pressure conditions within the defrost passage **9** and also upset the pressure conditions existing during defrost between the auxiliary or defrost circuit and the normal refrigerating circuit which is also open to the compressor or interconnected therewith during defrost operation. This would result in an increase in the amount of refrigerant flowing through the normal circuit during defrost operation of the system and therefore an excessive cooling action in the evaporator passage **6** so that difficulty would be encountered in defrosting all or part of the evaporator structure, particularly the portions thereof near the outlet end of the capillary flow restrictor **3**.

While there has been shown and described a particular embodiment of the present invention, it is to be understood that the the invention is not limited to the particular form and is intended by the appended claim to cover all modifications within the true spirit and scope of the invention.

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

A defrostable refrigerating system comprising an evaporator structure including an evaporator passage and a defrost passage in heat exchange with said evaporator passage, a hermetic compressor unit including a sealed casing and a compressor and a motor for driving said compressor disposed within said casing, said compressor having an inlet port communicating with the interior of said casing, a condenser and a capillary flow restrictor, conduit means connecting said compressor, condenser, capillary flow restrictor, evaporator passage, and casing in closed series-flow refrigerating circuit whereby said compressor withdraws low pressure refrigerant from said casing and discharges high pressure refrigerant to said condenser, a charge of lubricating oil in said case, a refrigerant charge in said system comprising a mixture of dichlorodifluoromethane and up to 35% by weight of monochlorodifluoromethane, said motor and oil being cooled by low pressure refrigerant in said casing, and means for periodically introducing hot compressed refrigerant into said defrost passage to raise said evaporator structure to defrosting temperatures comprising an auxiliary circuit including said defrost passage, a hot gas conduit connecting the inlet end of said defrost passage to said refrigerant circuit between said compressor and said capillary flow restrictor and means including a fixed flow restricting means connecting the outlet end of said auxiliary circuit to said refrigerant circuit between said evaporator passage and said compressor, said auxiliary circuit including a normally closed valve for controlling

the flow of compressed refrigerant through said auxiliary circuit, said flow restricting means restricting the flow of refrigerant to said compressor thereby to maintain refrigerant in said defrost passage at condensing pressure conditions when said valve is open, said auxiliary circuit conduit being in heat exchange with said auxiliary circuit flow restricting means to prevent excessive flow of condensed refrigerant to said casing when said valve is open.

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