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METHOD AND APPARATUS FOR DEFROSTING THE EVAPORATOR OF A REFRIGERATION SYSTEM

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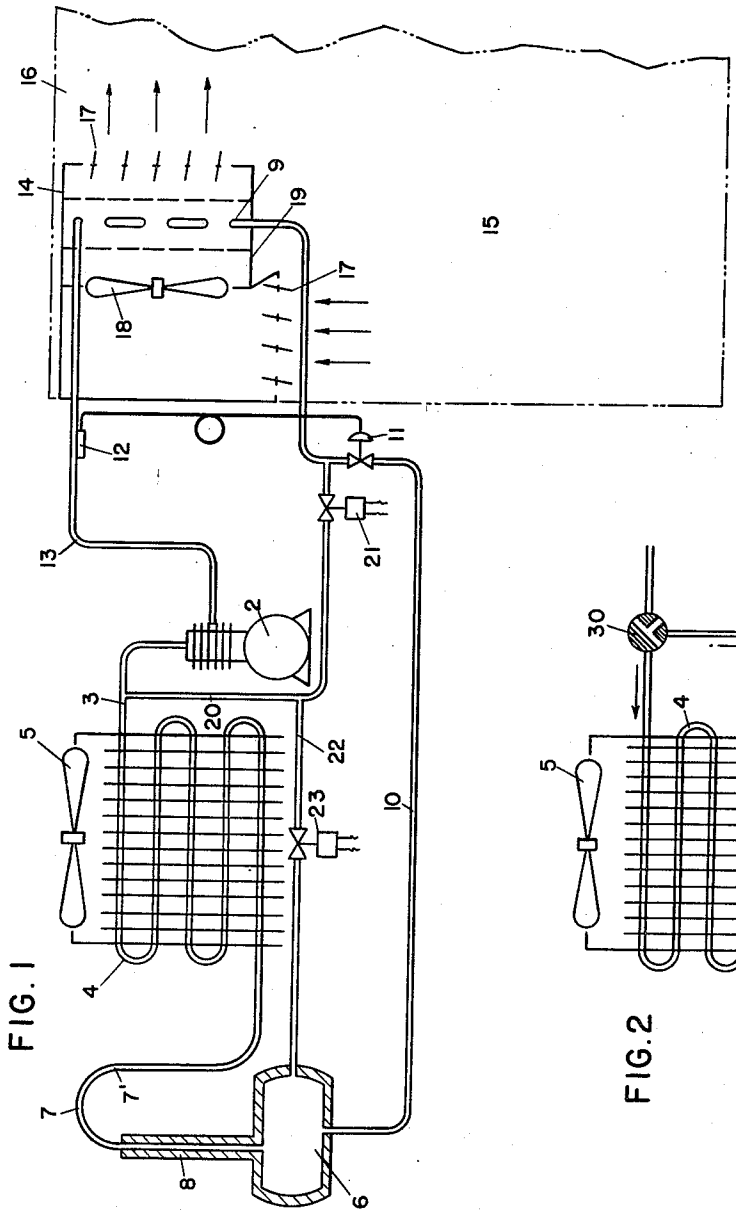


FIG. 1

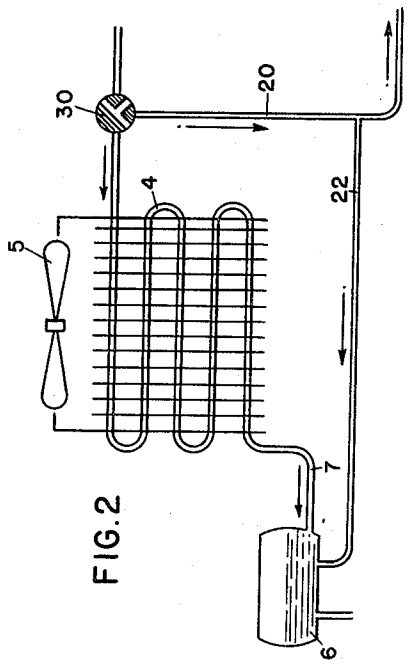


FIG. 2

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METHOD AND APPARATUS FOR DEFROSTING THE EVAPORATOR OF A REFRIGERATION SYSTEM

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15 Claims. (Cl. 62—4)

This invention relates to a method and an apparatus for defrosting the evaporator of a refrigeration system and, more particularly, to a method and an apparatus for defrosting the evaporator of a refrigeration system by employing superheated gaseous refrigerant. The system is particularly adapted for use in transportation such as trailers and trucks in which the evaporator of the refrigeration system is employed for cooling the storage compartment.

The chief object of the present invention is to provide a method and apparatus for defrosting the evaporator of a refrigeration system in which superheated gaseous refrigerant is employed for defrosting, the condenser of the system being inactivated during the defrosting operation preferably by filling the same with liquid refrigerant thereby increasing the compressor discharge pressure and the superheat of the compressed gaseous refrigerant.

An object of the present invention is to provide a method and apparatus for defrosting the evaporator of a refrigeration system by the use of superheated gaseous refrigerant in which liquid refrigerant is supplied to the evaporator simultaneously with the superheated gaseous refrigerant when the superheat of the refrigerant at the exit end of the evaporator increases beyond a predetermined point.

A further object is to provide a method and apparatus for defrosting the evaporator of a refrigeration system in which receiver pressure is equalized with compressor discharge pressure thereby permitting inactivation of the condenser during the defrosting operation with resulting increase in superheat of the compressed gaseous refrigerant. Other objects of the invention will be readily perceived from the following description.

This invention relates to a method of defrosting the evaporator of a refrigeration system in which the steps consist in superheating gaseous refrigerant, supplying superheated refrigerant to the evaporator, placing the superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator to thaw the frost thereby removing at least a portion of the superheat from the gaseous refrigerant and returning gaseous refrigerant only from the evaporator to the compressor.

This invention further relates to a refrigeration system which comprises, in combination, a compressor, a condenser, a discharge line connecting the compressor and the condenser, a receiver, an evaporator, a liquid line connecting the receiver and the evaporator, expansion means placed in the liquid line, a suction line connecting the evaporator and the compressor, a fourth line connecting the discharge line with the refrigerant line at a point between the expansion means and the evaporator, a by-pass line connecting the fourth line and the receiver and means for inactivating the condenser while supplying superheated refrigerant to the evaporator.

The attached drawing illustrates a preferred embodiment of the invention, in which

Figure 1 is a diagrammatic view of a trailer provided with a refrigeration system including the defrosting arrangement of the present invention; and

Figure 2 is a fragmentary diagrammatic view illustrating a modification of the invention.

Referring to the drawing, there is shown a refrigeration system which includes a compressor 2 connected by a discharge line 3 to a condenser 4. Preferably, compressor 2 is driven by an internal combustion engine (not shown). While an internal combustion engine is a preferable prime mover for the compressor of the refrigeration system when the refrigeration system is employed in transportation, it will be appreciated a motor or turbine may be employed for stationary applications. Preferably, the condenser is air cooled by means of fan 5 which passes air through condenser 4 in heat exchange relation with refrigerant therein and through the radiator (not shown) of the cooling system of the internal combustion engine.

Condenser 4 is connected to a receiver 6 by line 7. Preferably, receiver 6 and at least a portion of line 7 is insulated as shown at 8. A loop 7' is formed in line 7 for a purpose hereinafter described.

Receiver 6 is connected to evaporator 9 by liquid line 10. Expansion means 11 such as an expansion valve is placed in liquid line 10, operation of the expansion valve 11 being regulated by means of a bulb 12 placed in contact with the suction line 13 of the refrigeration system.

Evaporator 9 is placed in a casing 14 within the storage compartment 15 of a trailer or truck 16. Suitable dampers 17 are provided in casing 14 to permit air to be drawn within the casing from compartment 15 by a fan 18, fan 18 passing the air through the evaporator 9 to cool the same. The usual drip pan 19 may be provided beneath evaporator 9. Suction line 13 connects the evaporator with the compressor 2 to permit return of gaseous refrigerant from the evaporator to the compressor.

A line 20 connects discharge line 3 with liquid refrigerant line 10 at a point between the expansion valve 11 and evaporator 9. A solenoid valve 21 is placed in line 20 between the discharge line and line 10. Valve 21 is so selected as to provide the desired pressure drop from the compressor to the evaporator during defrosting. A by-pass line 22 connects the receiver with line 20, at a point between discharge line 3 and solenoid valve 21. It will be understood by-pass line 22 may be connected directly to the compressor discharge if desired to assure that no drop in pressure exists between the compressor and the receiver. A second solenoid valve 23 is placed in by-pass 22. Both valves 21 and 23 are normally closed during operation of the refrigeration system for cooling purposes.

It will be appreciated during normal operation of the refrigeration system for cooling purposes frost collects on the exterior surfaces of evaporator 9, thus over a period of time decreasing the efficiency of the evaporator. It is desirable that the frost be removed from the exterior surfaces of the evaporator as quickly and economically as possible in order to resume cooling of the products stored or transported in the storage compartment.

When it is desired to defrost the evaporator of the refrigeration system, both valves 21 and 23 are opened. Opening of valve 23 eliminates any difference in pressure between the compressor discharge pressure and the receiver pressure. Opening of the solenoid valves 21 and 23 permits supply of hot gas to the evaporator and prevents substantial flow of liquid refrigerant from the condenser. Preferably, the evaporator fan is stopped at the time the solenoid valves 21 and 23 are opened while the dampers 17 of casing 14 are closed to prevent gravity flow of air through the evaporator 9.

The condenser 4 is inactivated by filling it with liquid

refrigerant; a trapping loop 7' assures that the condenser is not emptied by forces of gravity. The down leg of the loop 7' is sufficiently large to avoid siphoning liquid refrigerant from the condenser. To minimize condensation of refrigerant under varying outside conditions, preferably receiver 6 and a portion of line 7 (the down leg of loop 7') are insulated. While the condenser fan may be stopped at the same time the evaporator fan is stopped, it will be understood it may be permitted to continue operation since the condenser is inactivated.

If the condenser pressure is lower than the condenser pressure selected for the defrosting cycle on which the restriction of solenoid valve 21 is based, it will be appreciated that the evaporator pressure is also lower than the defrosting cycle pressure selected. Since heat is being supplied to evaporator 9 by the hot gas it will quickly warm the evaporator. With relatively low pressure, the equivalent superheat at bulb 12 will be too high permitting the thermal expansion valve to open and provide liquid refrigerant from the receiver which will be evaporated by the hot gas in the evaporator thereby tending to increase the amount of gaseous refrigerant in the evaporator and increasing the evaporator pressure.

A portion of this vaporized liquid will pass through the compressor and be condensed in the condenser thereby filling the condenser and inactivating it. As the condenser fills with liquid refrigerant the discharge pressure of the compressor rises with a corresponding rise in suction pressure because the compressor is acting to pump a substantially constant volume of refrigerant and the restriction in line 20 (solenoid valve 21) permits a substantial volume of refrigerant to pass to maintain a substantially constant pressure ratio between high and low pressures.

When the discharge pressure has risen to a point at which the suction pressure bears the proper relationship to the selected design temperature to close the thermal expansion valve through bulb 12, the expansion valve 11 is maintained in a closed position so that the entire heating effect of the superheated gaseous refrigerant is available for defrosting.

The superheated gaseous refrigerant passing to the evaporator is placed in heat exchange relation with frost collected on the exterior surfaces of the evaporator thereby thawing the frost from the evaporator and reducing the superheat of the gaseous refrigerant. Only gaseous refrigerant is returned to the compressor through suction line 13.

It will be appreciated some condensation occurs in receiver 6 and in the down leg of loop 7' during the defrosting operation thereby removing gaseous refrigerant from the defrosting portion of the system thus lowering pressure. When the pressure has decreased to a predetermined point expansion valve 11 opens permitting liquid refrigerant to flow from receiver 6 through line 10 to evaporator 9, thus reestablishing the pressure-temperature relationship at which the expansion valve 12 operates.

The restriction of solenoid valve 21 should be so selected that the condensing temperature corresponding to the equilibrium discharge pressure is in excess of the maximum ambient temperature. Otherwise, under the maximum ambient temperature condition, the condenser pressure and therefore the suction pressure will be so high that condensation might occur in the evaporator which is undesirable for liquid refrigerant might return to the compressor with resulting damage to the compressor.

The end of the defrosting cycle may be determined by any suitable means, for example, a timer may be employed or a pressurestat in the suction line for at the end of the defrosting operation the suction temperature will tend to rise and the corresponding suction pressure will also rise under the control of the thermal expansion valve. Normal operation may be resumed by closing the solenoid valves 21 and 23 and actuating the evaporator fan 18 and the condenser fan 5.

In Figure 2 I have shown a modification of the invention. In this modification loop 7' of line 7 is omitted, line 7 entering receiver 6 below the liquid level therein. A three-way valve 30 is employed to close the line going to the condenser 4 and to open by-pass line 22 to the receiver. In other respects the system is the same as shown in Figure 1 and is operated during the defrosting cycle in the same manner.

Under some circumstances, a water cooled condenser may be employed in which case the by-pass line 22 may be omitted. In place of the loop 7', the reservoir can be positioned about the condenser.

It will be appreciated the drain pan 19 and the drain line therefrom are preferably placed in heat exchange relation with the hot gas line 20 to prevent accumulation of ice at these points during the defrosting operation. If the hot gas line were not placed in heat exchange relation with the drain line and the drain pan then ice might accumulate at the exit of the drain pan and might clog the drain line since it is necessary for the drain line to pass through the refrigerated storage space.

While I have described solenoid valve 21 as being provided with a restriction according to design conditions, it will be appreciated that an additional restriction may be provided in hot gas line 20 between solenoid valve 21 and its juncture with liquid line 10.

I have described the present invention employed for defrosting the evaporator of a refrigeration system. It will be understood, however, that the present invention may be employed for heating the storage compartment, if desired, in order to maintain a desired temperature therein.

The present invention provides an inexpensive method and apparatus for defrosting the evaporator of a refrigeration system. The invention assures that superheat of gaseous refrigerant is employed to remove frost from the exterior surfaces of the evaporator; it assures that liquid refrigerant is not condensed in the evaporator during the defrosting cycle eliminating slugging of liquid refrigerant to the compressor with resulting damage to the compressor. The present invention assures that the condenser is substantially inactivated with a resulting increase in the compressor discharge pressure so that sufficient superheat is provided to defrost the evaporator. The present invention also assures that at all times during the defrosting cycle sufficient refrigerant is present in the defrosting arrangement to ensure defrosting of the evaporator.

While I have described a preferred embodiment of the invention, it will be understood the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In the method of defrosting the evaporator of a refrigeration system, the steps which consist in superheating gaseous refrigerant, supplying superheated refrigerant to the evaporator, placing the superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator to thaw the frost thereby removing at least a portion of the superheat from the gaseous refrigerant without substantial condensation of the gaseous refrigerant, and returning gaseous refrigerant only from the evaporator directly to the compressor.

2. A method according to claim 1 which includes the step of supplying liquid refrigerant to the evaporator during the defrosting operation when the superheat of the refrigerant at the exit end of the evaporator increases beyond a predetermined point while continuing the supply of superheated refrigerant.

3. In the method of defrosting the evaporator of a refrigeration system, the steps which consist in inactivating the condenser of the refrigeration system by filling the condenser with liquid refrigerant, superheating gaseous refrigerant, supplying superheated refrigerant to the evaporator, placing superheated refrigerant in heat exchange

relation with frost collected on the exterior surfaces of the evaporator and returning gaseous refrigerant directly from the evaporator to the compressor.

4. A method of defrosting an evaporator of a refrigeration system according to claim 3 in which liquid refrigerant is supplied to the evaporator during the defrosting operation when the super-heat of the refrigerant at the exit end of the evaporator increases beyond a predetermined point while continuing the supply of superheated refrigerant.

5. In the method of defrosting the evaporator of a refrigeration system, the steps which consist in maintaining a predetermined pressure relationship between suction pressure and discharge pressure, superheating gaseous refrigerant, supplying superheated refrigerant to the evaporator, placing the superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator to thaw the frost thereby removing at least a portion of the superheat from the gaseous refrigerant without substantial condensation of the gaseous refrigerant, and returning gaseous refrigerant only from the evaporator directly to the compressor.

6. In the method of defrosting the evaporator of a refrigeration system employed for cooling air, the steps which consist in discontinuing flow of air through the evaporator, superheating gaseous refrigerant, supplying superheated refrigerant to the evaporator, placing superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator to thaw the frost thereby removing at least a portion of the superheat from the gaseous refrigerant without substantial condensation of the gaseous refrigerant, and returning gaseous refrigerant only from the evaporator directly to the compressor.

7. A method according to claim 6 in which liquid refrigerant is supplied to the evaporator during the defrosting operation when the super-heat of the refrigerant at the exit end of the evaporator increases beyond a predetermined point while continuing the supply of superheated refrigerant.

8. A method of defrosting the evaporator of a refrigeration system according to claim 7 in which the condenser of the refrigeration system is inactivated during the defrosting operation by substantially filling the same with liquid refrigerant.

9. In the method of operation of a refrigeration system, the steps which consist in compressing gaseous refrigerant, condensing the gaseous refrigerant, placing the condensate in heat exchange relation with a medium to be cooled thereby evaporating the condensate, returning the gaseous refrigerant to the compressor, then, when it is desired to remove frost from the exterior surfaces of the evaporator, discontinuing passage of medium to be cooled through the evaporator, superheating gaseous refrigerant, supplying superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator to thaw the frost thereby removing at least a portion of the superheat from the gaseous refrigerant without substantial condensation of the gaseous refrigerant, returning gaseous refrigerant only from the evaporator directly to the compressor and, when frost is removed from the exterior surfaces of the evaporator, resuming normal cooling operation.

10. A method of operation of a refrigeration system according to claim 9 which includes the step of supplying liquid refrigerant to the evaporator during the defrosting operation when superheat of refrigerant at the exit end of the evaporator increases beyond a predetermined point while continuing the supply of superheated refrigerant.

11. A method of operation of a refrigeration system according to claim 10 in which, during the defrosting cycle, the condenser of the refrigeration system is inactivated by substantially filling the same with liquid refrigerant.

12. In a refrigeration system, the combination of a compressor, a condenser, a discharge line connecting the compressor and condenser, a receiver, an evaporator, a liquid line connecting the receiver and the evaporator, expansion means placed in the liquid line, a suction line connecting the evaporator and the compressor, a fourth line connecting the discharge line with the liquid line at a point between the expansion means and the evaporator, a by-pass line connecting the fourth line and the receiver, means for inactivating the condenser while supplying superheated refrigerant to the evaporator and means to supply liquid refrigerant to the evaporator simultaneously with the supply of superheated refrigerant to the evaporator upon a predetermined increase in superheat of refrigerant at the exit end of the evaporator.

13. In a defrosting arrangement for the evaporator of a refrigeration system, the combination of a line connecting the discharge line of the system with the liquid line of the system, a by-pass line connecting the first line with the receiver of the system and means for inactivating the condenser by filling the same with liquid refrigerant while supplying superheated refrigerant in heat exchange relation with frost collected on the exterior surfaces of the evaporator.

14. A defrosting arrangement according to claim 13 in which means are provided to supply liquid refrigerant to the evaporator simultaneously with the supply of superheated refrigerant thereto in response to an increase in superheat of refrigerant at the exit end of the evaporator beyond a predetermined point.

15. A defrosting arrangement according to claim 14 in which a solenoid valve is placed in the first line, a second solenoid valve is placed in the by-pass line, said valves being closed during normal operation of the refrigeration system and being opened during the defrosting operation to equalize compressor discharge pressure and receiver pressure and to supply superheated refrigerant to the evaporator.

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