Nov. 18, 1947. S. P. SOLING 2,430,960

REFRIGERATION SYSTEM INCLUDING EVAPORATOR DEFROSTING MEANS

Filed May 29, 1945

Fig. 1

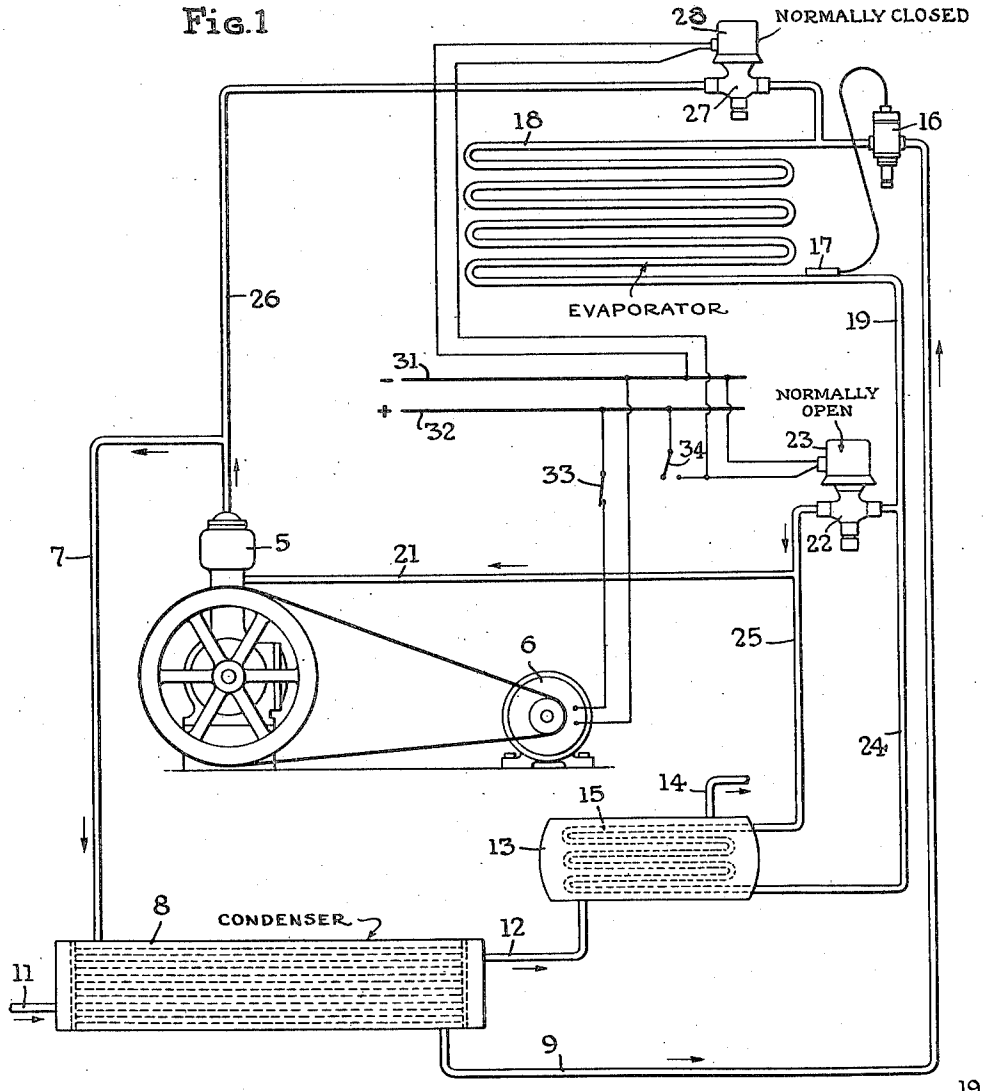


Fig. 2

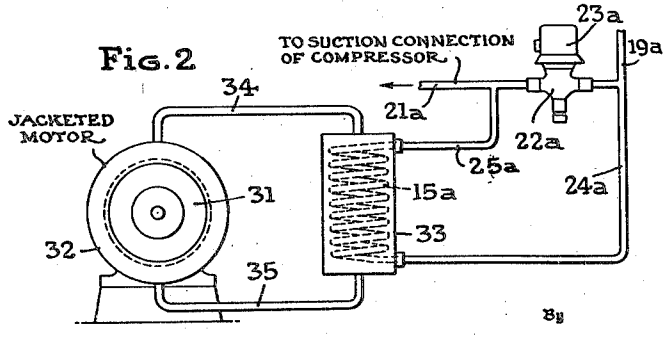
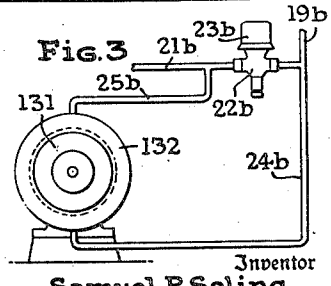


Fig. 3



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Patented Nov. 18, 1947 2,430,960

UNITED STATES PATENT OFFICE

2,430,960

REFRIGERATION SYSTEM INCLUDING EVAPORATOR DEFROSTING MEANS

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Application May 29, 1945, Serial No. 596,523

5 Claims. (Cl. 62—115)

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This invention relates to refrigeration and particularly to means operable periodically to defrost an evaporator which is normally operated at sub-freezing temperatures.

From the early days of mechanical refrigeration it has been common practice to defrost evaporators by what is called "the hot gas method," that is to say by causing the compressor to deliver hot compressed gas to the evaporator. The successful use of this, as heretofore commonly carried out, depends on the presence in the refrigerative circuit of more than one evaporator, or an evaporator capable of subdivision into units which are defrosted one at a time, so that the condenser may continue to function.

In defrosting systems having a single evaporator, recourse has been had usually to some type of heater. These heaters have been of various types and variously located. They are expensive and consume valuable energy.

The present invention is applicable to systems having a single evaporator, resembles and has all the advantages of the conventional hot gas method, and avails of waste heat accumulated externally of the circuit to furnish the heat units needed to thaw the frost.

Generally stated the invention contemplates a heat accumulator which is external to the circuit, and which accumulates heat in substantial quantity but usually at moderate temperature. Such an accumulator may be charged with spent (hot) condenser cooling water, or may be a liquid bath heated by waste heat from the compressor cylinders or from the motor or motors which drive the compressor or other apparatus. Since the accumulator is external to the circuit it does not impair or limit normal performance of the refrigerative circuit.

When defrosting is desired, two connections are temporarily established while the compressor runs, the first being a hot gas connection from the compressor discharge to the vapor space in the evaporator, and the second being made up of a drain connection from the liquid space of the evaporator to a heat exchanger in the heat accumulator, and a suction connection thence to the intake of the compressor.

Thus hot vaporous refrigerant from the compressor melts the frost from the evaporator and is condensed in consequence, drains while in the liquid phase to the exchanger in the accumulator, is there evaporated, and returns in the vapor phase to the compressor.

The reason for using an accumulator is to

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store sufficient heat for one defrosting cycle at the rather low temperatures at which waste heat is commonly available. The higher the temperature at which waste head is available, the smaller is the needed storage capacity. After all, every heat exchanger has some heat storage capacity, so both functions are always present. How they are proportioned is a matter of design, commonly controlled by the maximum temperature at which some part of the apparatus may be operated. For example, the permissible head-pressure limits the temperature of water leaving the condenser. The efficient running temperatures of compressors and of electric and other motors are subject to characteristic limitations and will control in particular cases.

Preferred embodiments of the invention will now be described in order to explain the principles of the invention.

In the drawing:

Fig. 1 is a diagram of a refrigerative circuit with the invention applied so as to recover heat from spent condenser water.

Fig. 2 is a fragmentary view showing how waste heat may be recovered from a motor-compressor unit instead of from spent condenser water.

Fig. 3 is a fragmentary view showing another modification.

Refer first to Fig. 1. The compressor is shown at 5 and is driven by an electric motor 6 through a belt. The high pressure gas line 7 (discharge line) leads to a water-cooled condenser-receiver 8. This is of the shell-and-tube type in which the water flows through the tubes and the refrigerant condenses outside the tubes. Thus the condensed refrigerant flows to the liquid line 9.

The water-supply connection is indicated at 11, and the water-discharge connection at 12. Connection 12 leads to the accumulator shell 13 and the condenser water finally discharges from the shell 13 through the connection 14. Connection 14 may lead to the sewer or to a cooling tower, or to any other disposal means as the designer of the plant may elect. Mounted in the accumulator 13 is a heat-exchange coil 15 whose function will be explained later.

The liquid line 9 leads to an expansion valve 16 which is of the ordinary thermally controlled type having a thermal bulb 17. Expansion valve 16 supplies refrigerant to an evaporator 18 diagrammed as a simple sinuous coil. In normal operation the thermal bulb 17, which is applied

to the suction connection 19, causes the valve 16 to supply refrigerant to the evaporator 18 at such a rate that the off-flowing vapor is always slightly superheated. The evaporator suction line 19 is connected to the compressor suction line 21 through a normally open valve 22. The valve 22 is operated by a solenoid 23. When the solenoid 23 is energized the valve 22 is closed.

The branch 24 of the line 19 leads to one end of the coil 15, whose other end is connected by the line 25 with the compressor suction line 21. When the valve 22 is open, flow will occur through the valve 22 and substantially no flow through the coil 15 will occur because there is substantial resistance to the flow through the coil. This makes it unnecessary to use a three-way valve to insure alternate flow from 19 directly to 21, or from 19 through 15 to 21. To all intents and purposes, the opening and closing of the valve 22 produces strictly selective flow.

A branch line 26 leads from the high-pressure gas line 7 through a normally closed valve 27 to the vapor space in the evaporator 18. The valve 27 is operated by a solenoid 28. The valve opens when the solenoid 28 is energized.

The lines which supply current to the motor 6 and to the solenoids 23 and 28 are shown at 31 and 32. The motor is controlled by a switch 33. The solenoids are controlled by a switch 34 which is independently operable. When the switch 34 is open the valve 22 is open and the valve 27 is closed. When the switch 34 is closed the valve 22 closes and the valve 27 opens.

The switch 34 may be manually operated, or if periodic defrosting is desired it can be operated by a clock. There are various other known expedients in the art for initiating defrosting, and various of these may be used.

Assume that the plant has been in operation, that the evaporator 18 has become frosted, and that it is desired to defrost it. The switch 33 remains closed and the switch 34 is closed. The opening of the valve 27 causes the compressor to deliver hot gas to the vapor space in the evaporator 18. The refrigerant gives up its heat and condenses, and the heat thus released melts the frost off the evaporator. The liquid refrigerant drains from the evaporator, through the line 19, and since the valve 22 is closed, flows through the connection 24 to the heat-exchanger coil 15 and thence, in the vapor phase, through the lines 25 and 21 to the compressor. The warm condenser water in the shell 13 evaporates the liquid refrigerant entering coil 15, so that only vaporous refrigerant is drawn into the compressor.

When the defrosting operation is complete the switch 34 is again opened, restoring the system to its normal refrigerating cycle. If any liquid refrigerant should remain in the coil 15, it will be evaporated and withdrawn by the compressor. In any case, the opening of the valve 22 virtually suspends flow through the coil 15, so that the coil 15 is external to the refrigerative circuit and exercises no disturbing effect thereon. This is an important aspect of the invention.

Fig. 2 is a fragmentary view showing a heat recovery means which may be substituted for the shell 13 and coil 15. In this view parts identical with parts in Fig. 1 are identified by the same reference numerals and the distinguishing letter *a*.

The device indicated at 31 is an enclosed motor-compressor unit, in which a certain amount

of mechanical energy degenerates into heat. In such a unit some of the heat is derived from the motor and some from the compressor. Surrounding unit 31 is a cooling jacket 32 connected in a thermosiphon circuit with shell 33 by the pipes 34, 35. Thus coil 15*a*, the direct analog of coil 15, is subject to heat available at rather low temperature in shell 33.

The motor-compressor unit replaces the motor 6 and compressor 5, but to avoid confusing Fig. 2, connections analogous to 7, 21, 26 of Fig. 1 are not illustrated.

Both Fig. 1 and Fig. 2 show liquid baths which accumulate heat but in some cases this extra heat storage capacity is unnecessary, either because heat is available in adequate quantity or because the motor-compressor itself offers adequate heat storage capacity. In such a case the jacket 32 can be connected to perform the function of coil 15*a* of Fig. 2 as suggested in Fig. 3.

In Fig. 3 parts identical with parts in Figs. 1 and 2 bear the same reference numerals with the letter *b*. The motor-compressor is indicated at 131 and its jacket at 132.

Three embodiments have been illustrated and others are possible. The invention contemplates that waste heat accumulated in adequate quantity at a safe temperature shall be used to supply the heat for defrosting and to protect the compressor against entry of refrigerant in the liquid phase while defrosting proceeds. This waste heat is accumulated outside the refrigerating circuit, which is a feature of marked advantage.

What is claimed is:

1. The combination of a refrigerative plant of the compressor-condenser-evaporator circuit type; a motor for driving the compressor thereof; a heat-exchanger external to said circuit and subject to heat produced by degeneration of mechanical energy supplied through the motor to the plant; and means capable of being made effective while the compressor runs and serving, when effective, to connect the compressor discharge with the evaporator and to connect the compressor suction to withdraw liquid from the evaporator through said heat-exchanger.

2. The combination of a refrigerative plant of the compressor - condenser - evaporator circuit type; means external to said circuit for accumulating waste heat generated as an incident to operation of the plant; and means capable of being made effective while the compressor runs and when effective serving to connect the compressor discharge to the evaporator, and to connect the compressor suction to withdraw liquid from the evaporator through a path which is in heat-exchange relation with said heat accumulating means.

3. The combination of a refrigerative plant of the compressor - condenser - evaporator circuit type; means for accumulating at least a portion of the heat rejected through the condenser; and means capable of being made effective while the compressor runs and when effective serving to connect the compressor discharge to the evaporator and to connect the compressor suction to withdraw liquid from the evaporator through a path which is in heat-exchange relation with said heat accumulating means.

4. The combination of a refrigerative plant of the compressor - condenser - evaporator circuit type; a motor connected to drive the compressor, and of a type which generates waste heat as an incident to its operation; means for accumulat-

ing at least a portion of said waste heat; and means capable of being made effective while the compressor runs and when effective serving to connect the compressor discharge to the evaporator and to connect the compressor suction to withdraw liquid from the evaporator through a path which is in heat-exchange relation with said heat accumulating means.

5. The combination of a refrigerative plant of the compressor - condenser - evaporator circuit type, including a combined motor-compressor unit; a heat exchanger external to the circuit and subject to heat generated by said unit; and means capable of being made effective while the

compressor runs, and when effective serving to connect the compressor discharge to the evaporator and to connect the compressor suction to withdraw liquid from the evaporator through said heat exchanger.

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