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REFRIGERATION APPARATUS

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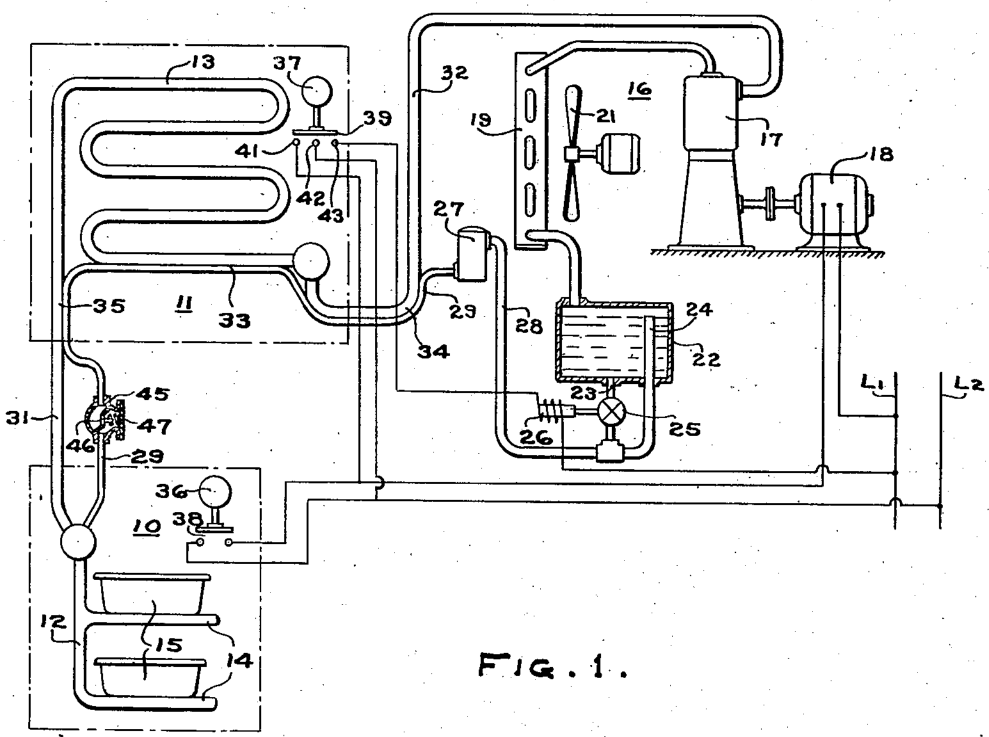

FIG. 1.

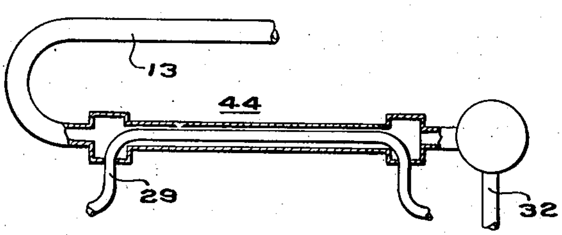

FIG. 2.

WITNESSES:

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REFRIGERATION APPARATUS

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14 Claims. (Cl. 62—3)

My invention relates to refrigeration and has for an object to provide an improved method and apparatus for refrigerating first and second zones of a refrigerator to relatively high and low refrigerating temperatures.

A further object of my invention is to provide an efficient refrigerating machine having relatively high and low temperature cooling elements wherein the periods of time during which the machine operates to refrigerate the low temperature element is reduced by the utilization of refrigeration produced more efficiently at higher temperature.

A still further object of my invention is to abstract heat from the condensed refrigerant supplied to the low temperature element of a refrigerator by subjecting it to the zone cooled by the higher temperature element thereof.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of a two-temperature refrigerating machine arranged in accordance with my invention; and

Fig. 2 is a modified view of a detail employed in the system shown in Fig. 1.

Reference will now be had to Fig. 1 of the drawing wherein the numerals 10 and 11 indicate zones or chambers to be refrigerated at relatively low and high temperatures, respectively. Evaporators 12 and 13 are disposed for cooling the air in the low and high temperature zones 10 and 11, the evaporator 12 preferably including shelf portions 14 for supporting trays 15 in which a fluid to be congealed may be disposed. Refrigerant vaporized in the evaporators 12 and 13 is condensed by a condensing unit, generally indicated at 16 and including a compressor 17, preferably driven by a motor 18, and a condenser 19, cooled in any suitable manner, such as, for example, by a fan 21.

While my invention is applicable to various forms of two temperature refrigerating machines, I have chosen to show it applied to a machine of the type shown and claimed in my copending application, Serial No. 15,003, filed April 6, 1935, and assigned to Westinghouse Electric & Manufacturing Company. The construction and operation of this type of two temperature refrigerator will now be described.

Liquid refrigerant from the condenser 19 flows into a reservoir 22 having outlets 23 and 24 disposed at different levels, the former of which is controlled by a valve 25 operated by a solenoid 26 in such manner that the valve 25 is open when the solenoid 26 is energized and, conversely, it is closed when the solenoid 26 is deenergized. Refrigerant discharged from either outlet 23 or 24 passes to a conventional high side float valve 27 through a conduit 28 and thence to the evaporator 12 through a conduit 29.

The evaporators 12 and 13 are connected by a conduit 31 which conducts vaporized or condensed refrigerant, depending upon which evaporator is active as described hereinafter. Refrigerant vaporized in both evaporators is conducted to the inlet of the compressor 17 by a suction conduit 32 from the evaporator 13. The foregoing defines a two-temperature refrigerating system in which vaporization in either evaporator may be selectively effected by varying the effective charge of refrigerant in the system, or, in other words, by varying the amount of refrigerant stored in the reservoir 22.

When the evaporator 12 is effective for cooling the media in the zone 10, the valve 25 is closed so that refrigerant collects in the reservoir 22 to a depth determined by the outlet 24. The effective charge of refrigerant in the system or the amount of refrigerant circulated is reduced in an amount equivalent to the amount of refrigerant withheld from circulation in the reservoir 22. At this time, the evaporator 12 is substantially filled with liquid refrigerant which flows thereto from the reservoir 22 through the outlet 24, conduit 28, float valve 27 and the conduit 29. Operation of the compressor 17 produces a relatively low pressure in the evaporators 12 and 13 and vaporization of the liquid at low temperature is effected in the evaporator 12. The cold vaporized refrigerant passes through the conduit 31, evaporator 13 and conduit 32 to the compressor.

A small amount of heat may be extracted from the air in the chamber 11 at this time by the gas which is superheated as it passes through the evaporator 13.

Cooling of the chamber 11 is effected by opening the valve 25 whereby the withheld refrigerant in the reservoir 22 is released through the outlet 23 and valve 25 to the conduit 28. Accordingly, the float valve is moved to its full open position to pass the stored refrigerant through the conduit 29 to the evaporator 12. The released refrigerant first fills the evaporator 12 and then flows through the conduit 31 to the evaporator 13. The charge of refrigerant in the system is such that the evaporator 13 is substantially filled when the reservoir 22 is empty or during periods when the full charge is available for circulation.

Admission of liquid refrigerant to the relatively warm evaporator 13 effects rapid vaporization with an increase in pressure over that prevailing when the low temperature evaporator 12 is refrigerated.

Vaporization is effected in the evaporator 13 at relatively high temperature and pressure by the operation of the compressor 17. As the low temperature evaporator 12 is filled with liquid which defines a seal, refrigerant vaporized in the evaporator 13 is prevented from passing to the low temperature evaporator 12 and condensing therein, whereby undesirable heating of the evaporator 12 is prevented. It will be apparent that substantially no vaporization is effected in the evaporator 12 as the temperature thereof is lower than the temperature of vaporization corresponding to the prevailing pressure in the evaporator 12.

It is well understood that more efficient operation of a refrigerating machine is obtained when the evaporator is operated at a high temperature than when it is operated at relatively low temperature, other operating conditions being the same. Accordingly, refrigeration of the higher temperature evaporator of a two temperature refrigerator is effected at higher efficiency than refrigeration of the lower temperature evaporator. I propose to increase the overall efficiency of a two temperature refrigerator by reducing the period of time that the machine operates to effect refrigeration less efficiently at low temperature by utilizing refrigeration which was produced more efficiently at a higher temperature.

In accordance with my invention, the conduit 29 which supplies condensed refrigerant to the evaporators 12 and 13 is subjected directly, or indirectly, to the cooling effect of the higher temperature evaporator 13, whereby heat is abstracted from the condensed refrigerant by the higher temperature evaporator. When refrigerating the lower temperature evaporator 12, an increase in efficiency is obtained as the total heat in the condensed refrigerant admitted thereto is reduced in an amount equivalent to the amount of heat abstracted by the higher temperature evaporator. When refrigerating the higher temperature evaporator 13, the heat imparted thereto by the condensed refrigerant does not represent a loss as it would have to be abstracted anyway. The result of this method of operation is a reduction in the period of time that the compressor operates to refrigerate the low temperature element at relatively low efficiency and an increase in the period of time that it operates to refrigerate the higher temperature evaporator at relatively high efficiency for a given total heat load on the two evaporators. Accordingly, the overall efficiency is substantially increased.

Preferably, the conduit 29 is secured directly to the evaporator 13, as shown at 33, for the transfer of heat from the condensed refrigerant, to the evaporator.

The conduit 29 may be secured in heat transfer relation with the suction conduit 32 as shown at 34 and with the conduit 31, as shown at 35, whereby the efficiency of the system may be increased further. The heat exchanger shown at 34 effects precooling of the liquid prior to its admission to the heat exchanger 33 by transferring heat to the vapor in the suction conduit 32 as superheat. The heat exchanger at 35 functions to further cool the liquid admitted to the evaporator 12 when it is being refrigerated by subjecting the liquid to the cold vapor passing through the conduit 31. The heat exchangers 35, 33, and 34 are connected in series and are arranged for counterflow of the fluids conveyed therethrough.

It is desirable that the refrigerant contained in the conduit 29 be maintained in a liquid state in order that a high rate of heat transfer between it and the evaporator 13 is effected. Accordingly, a device 45, shown by way of example as a pressure actuated valve may be disposed in the conduit 29 adjacent the evaporator 12. The purpose of the device 45 is to maintain the refrigerant in the conduit 29 under sufficient pressure to substantially reduce vaporization of the refrigerant therein. The device 45 preferably includes a valve member 46 which is opened by the pressure of refrigerant in the conduit 29. A spring 47 opposes opening movement of the valve member 46 and determines the pressure of the refrigerant in the conduit 29. The bias of the spring is such that the pressure of the refrigerant in the conduit 29 is maintained at a value somewhat below the pressure of the refrigerant in the condenser 19 and conduit 28 but high enough to preclude the vaporization of any substantial amount of refrigerant in the conduit 29.

Control of the operation of the compressor 17 and of the valve 25 may be effected automatically in accordance with the temperatures to be maintained in the chambers 10 and 11. Accordingly, thermostats 36 and 37 may be disposed so that they are effected by the temperatures to be maintained and arranged for controlling the energization of the motor 17 and solenoid 26. The source of power for the motor 18 and solenoid 26 is represented by line conductors L_1 and L_2. The thermostat 36 opens and closes a switch 38 for deenergizing and energizing the motor 18 in response to predetermined low and high temperatures within the chamber 10. The thermostat 37 includes a movable member 39 for connecting a plurality of contacts 41, 42 and 43 when the temperature in the compartment 11 attains a predetermined value and for disconnecting the contacts when the temperature is depressed to the desired value. The contact 42 is connected to the line conductor L_2 and the contacts 41 and 43 are connected respectively to terminals of the motor 18 and solenoid 26; the opposite terminals of the motor 18 and solenoid 26 being connected to the line conductor L_1. Accordingly, the solenoid 26 and motor 18 are energized by the thermostat 37 when the temperature of the high temperature zone 11 attains a predetermined value and are deenergized thereby when the temperature thereof is depressed to the desired value.

The control disclosed gives preference to the higher temperature compartment as it will be apparent that the valve 25 opens when the thermostat 37 demands cooling. Therefore, the refrigerant in the reservoir is released for vaporization in the high temperature evaporator 13. Other forms of thermostatic control may be employed, if desired, wherein the low temperature compartment is given preference when both compartments require cooling.

Operation

The position of the various elements shown in the drawing indicates that both chambers 10 and

11 are above the temperatures at which their respective thermostats close. Assume a rise in temperature in the low temperature zone 10 to the value at which the thermostat closes the switch 38. Closure of the switch effects energization of the motor 18 which initiates operation of the compressor. As the solenoid 26 is deenergized, the valve 25 is closed so that refrigerant is stored in the reservoir. Therefore, the amount of liquid refrigerant in the low side of the system is reduced and fills the evaporator 12, only.

Condensed refrigerant delivered to the reservoir 22 flows through the outlet 24 into the conduit 28 and float valve 27 and thence through the conduit 29 and device 45 to the evaporator 12. Heat is abstracted from the condensed refrigerant in the conduit 29 by the evaporator 13 and the media cooled thereby, as described heretofore. Vaporization of refrigerant is effected in the low temperature evaporator 12 and the pressure and temperature of the refrigerant therein is progressively decreased by the compressor 17 The refrigerant vaporized in the evaporator 12 passes through the conduit 31, evaporator 13 and conduit 32 to the compressor and is superheated as it abstracts heat from the condensed refrigerant.

Operation of the compressor 17 continues to reduce the pressure and temperature of the refrigerant in the evaporator 12 until the temperature of the media in the chamber 10 is depressed to the relatively low value at which the thermostat 36 opens the switch 38 and terminates operation of the compressor.

Assume the temperature of the chamber 11 rises to the value at which the thermostat 37 moves the bridging member 39 into engagement with its associated contacts 41, 42 and 43. This operation effects operation of the compressor 17 and opening of the valve 25, as described heretofore. Refrigerant stored in the reservoir 22 is discharged through the outlet 23 to the conduit 28 and float valve 27, and thence through conduit 29 and the valve device 45 to the evaporator 12. The addition of the stored refrigerant to the low side of the system causes liquid refrigerant to overflow into the conduit 31 and a substantial portion of the evaporator 13.

The pressure in the entire low side of the system immediately increases as the condensed refrigerant is admitted to the relatively warm evaporator 13 due to rapid evaporation. The compressor operates to progressively depress the pressure and temperature of the refrigerant in the evaporator 13. The heat transmitted to the evaporator 13 by the condensed refrigerant in the present instance represents neither a loss nor gain as this heat must be abstracted from the condensed refrigerant in any event. As the temperature of the chamber is depressed to the desired value the thermostat 37 operates to terminate operation of the compressor 17 and to close the valve 25.

Assume now that the low temperature thermostat 36 closes to initiate operation of the compressor 17. The evaporator 13 is filled substantially with condensed refrigerant from the previous cycle. This refrigerant is first evaporated and is condensed and stored in the reservoir 22. Some refrigeration of the chamber 11 is produced by this operation but the refrigerant is soon evaporated. As the pressure continues to be depressed, evaporation is effected in the low temperature evaporator 12 and continues until the thermostat 36 terminates operation of the compressor 17 as described heretofore.

In Fig. 2, I have shown another form of heat exchanger, generally indicated at 44, for effecting abstraction of heat from the condensed refrigerant. In this form, the liquid conduit 29 is subjected, directly, to the refrigerant in the high temperature evaporator 13. The employment of this form of heat exchanger is particularly desirable when the invention is applied to a two temperature system of the type shown in Fig. 1, as will be apparent from the following.

As described heretofore, the evaporator 12 is filled, substantially with refrigerant when the thermostat 36 initiates operation of the compressor 17 subsequent to previous cycle in which the evaporator 13 was operated. Accordingly, this refrigerant is evaporated with the starting of the compressor and abstracts heat from the media cooled by the evaporator 13 and from the condensed refrigerant in the conduit 29. By employing a heat exchanger of the type shown at 44 in Fig. 2, heat from the condensed refrigerant is more readily abstracted by the refrigerant in the evaporator 13 and less heat is removed from the media in the chamber 11 which, of course, is advantageous as the temperature of the media is depressed less at this time.

In the control disclosed, the warmer compartment 11 is given preference when both the warmer and colder compartments require cooling, although the preference may be reversed, if desired. However, in any event, the operation should be such that the temperature of the warmer compartment would be prevented from rising too high in order to obtain increased efficiency due to the exchange of heat above described.

From the foregoing, it will be apparent that I have provided an efficient two-temperature refrigerator wherein the periods of refrigeration at low temperature and relatively low efficiency are reduced by the utilization of refrigeration produced at higher temperature and high efficiency.

I have shown a type of two-temperature refrigerating system wherein refrigeration of the evaporators is selectively produced by varying the effective charge of refrigerant in the system, but it will be understood that my invention is equally applicable to other forms of two temperature systems whether the operation of the evaporators is selective or not.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. The method of refrigerating relatively high and low temperature evaporators, which comprises selectively effecting evaporation of refrigerant in the high and low temperature evaporators, condensing the vaporous refrigerant and returning it to the evaporators, and transferring heat from the condensed refrigerant at substantially condensing pressure to the high temperature evaporator.

2. The method of refrigerating relatively high and low temperature evaporators, which comprises effecting evaporation of refrigerant in the high and low temperature evaporators, condensing vaporous refrigerant and returning it

to the evaporators, and transferring heat from the condensed refrigerant at substantially condensing pressure to the refrigerant in the high temperature evaporator.

3. The method of refrigerating relatively high and low temperature evaporators, which comprises selectively effecting evaporation of refrigerant in the high and low temperature evaporators, condensing vaporous refrigerant and returning it to the evaporators, and transferring heat from the condensed refrigerant at substantially condensing pressure to the refrigerant in the high temperature evaporator.

4. The method of refrigerating relatively high and low temperature evaporators, which comprises selectively effecting the flow of condensed refrigerant to the high and low temperature evaporators for vaporization therein and reducing the heat content of the condensed refrigerant at substantially condensing pressure by the utilization of refrigeration produced by the evaporation of refrigerant in the higher temperature evaporator.

5. The method of refrigerating relatively high and low temperature zones of a refrigerator which comprises supplying condensed refrigerant for vaporization at relatively low and high temperatures for cooling the low and high temperature zones, respectively, and reducing the heat content of the condensed refrigerant at substantially condensing pressure by utilizing refrigeration produced by the refrigerant vaporized at relatively high temperature.

6. The method of refrigerating relatively low and high temperature evaporating elements, which comprises evaporating refrigerant in the low and high temperature evaporators at relatively low and high pressure, respectively, condensing the evaporated refrigerant, conveying the condensed refrigerant to the evaporators for vaporization, and transferring heat from the condensed refrigerant at substantially condensing pressure to the high temperature evaporator.

7. The method of refrigerating relatively low and high temperature zones of a refrigerator, which comprises evaporating refrigerant at relatively low and high pressures for cooling the low and high temperature zones, respectively, condensing the evaporated refrigerant and resupplying it for evaporation, and transferring heat from the condensed refrigerant at substantially condensing pressure to the zone refrigerated by the evaporation of refrigerant at high temperature.

8. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing refrigerant evaporated in the evaporators, means for conveying condensed refrigerant to the evaporators for vaporization therein, and means for passing the condensed refrigerant at substantially condensing pressure in heat transfer relation with the refrigerant in the high temperature evaporator.

9. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing refrigerant evaporated in the evaporators, means for conveying the condensed refrigerant to the evaporators for vaporization therein, and means for passing the condensed refrigerant at substantially condensing pressure in heat transfer relation with the high temperature evaporator.

10. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing refrigerant evaporated in the evaporators, means for conveying the condensed refrigerant to the high and low temperature evaporators for vaporization therein, and means for transferring heat from the condensed refrigerant at substantially condensing pressure to the high temperature evaporator.

11. In apparatus for refrigerating first and second zones of a refrigerator, the combination of relatively low and high temperature evaporators for respectively cooling the media in the zones, means for condensing at relatively high pressure the refrigerant vaporized in the evaporators, means for conveying the condensed refrigerant to the evaporators, and means for passing the relatively high pressure condensed refrigerant conveyed for vaporization in the low temperature evaporator in heat transfer relation with the media in the zone cooled by the high temperature evaporator.

12. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing refrigerant vaporized in said evaporators, means for conveying the condensed refrigerant to the evaporators in such manner that it flows into the low temperature evaporator until it is full and thence into the high temperature evaporator, means for selectively decreasing or increasing the quantity of liquid refrigerant in the evaporators so that when it is decreased liquid is evaporated in the low temperature evaporator while the high temperature evaporator is substantially dry and, when it is increased, liquid is present in said low temperature evaporator under sufficient pressure to prevent vaporization therein while liquid overflows into the high temperature evaporator and is evaporated therein, and means for transferring heat from the condensed refrigerant to the high temperature evaporator.

13. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing refrigerant vaporized in said evaporators, means for conveying the condensed refrigerant to the evaporators in such manner that it flows into the low temperature evaporator until it is full and thence into the high temperature evaporator, means for selectively decreasing or increasing the quantity of liquid refrigerant in the evaporators so that when it is decreased there is liquid being evaporated in the low temperature evaporator while the high temperature evaporator is dry and, when it is increased, there is liquid present in said low temperature evaporator under sufficient pressure to prevent vaporization therein while liquid overflows into the high temperature evaporator and is evaporated therein, and means for transferring heat from the condensed refrigerant to the refrigerant in the high temperature evaporator.

14. In refrigerating apparatus, the combination of relatively high and low temperature evaporators, means for condensing at relatively high pressure the refrigerant vaporized in said evaporators, means for selectively conveying the condensed refrigerant to the evaporators for vaporization and means for transferring heat from the relatively high pressure condensed refrigerant that is supplied for vaporization in the low temperature evaporator to the high temperature evaporator.

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