Oct. 25, 1938. L. B. M. BUCHANAN 2,133,948

REFRIGERATION APPARATUS

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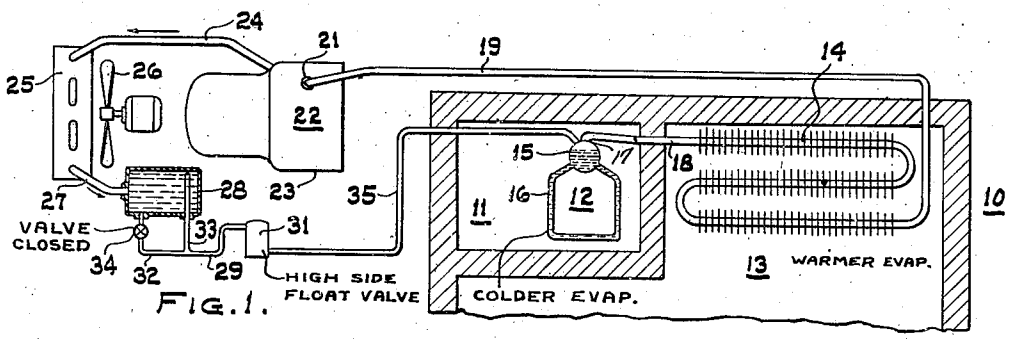


FIG. 1.

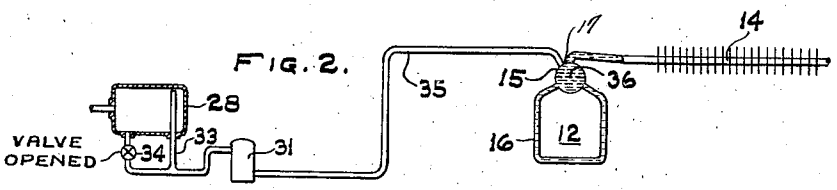


FIG. 2.

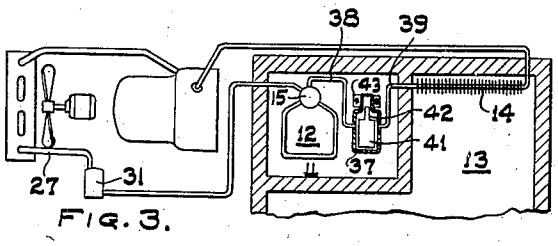


FIG. 3.

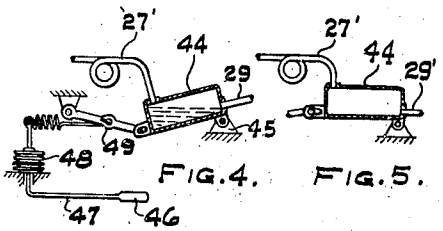


FIG. 4. FIG. 5.

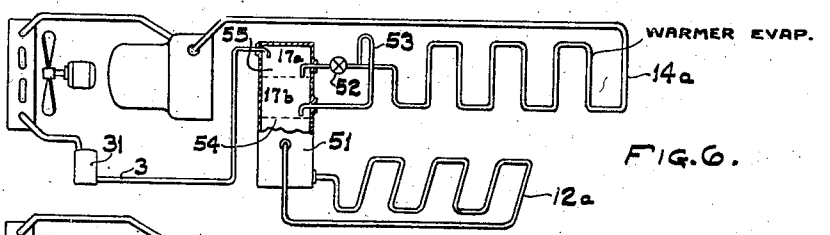


FIG. 6.

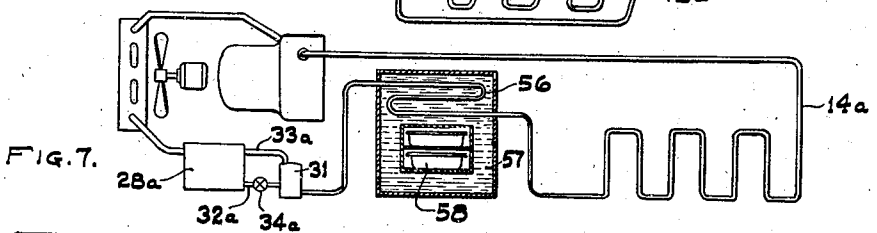


FIG. 7.

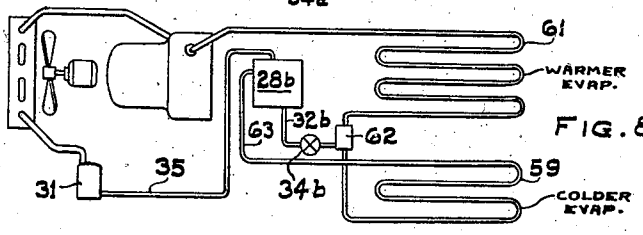


FIG. 8.

INVENTOR
LESLIE B. M. BUCHANAN
BY
ATTORNEY

Oct. 25, 1938. L. B. M. BUCHANAN 2,133,948

REFRIGERATION APPARATUS

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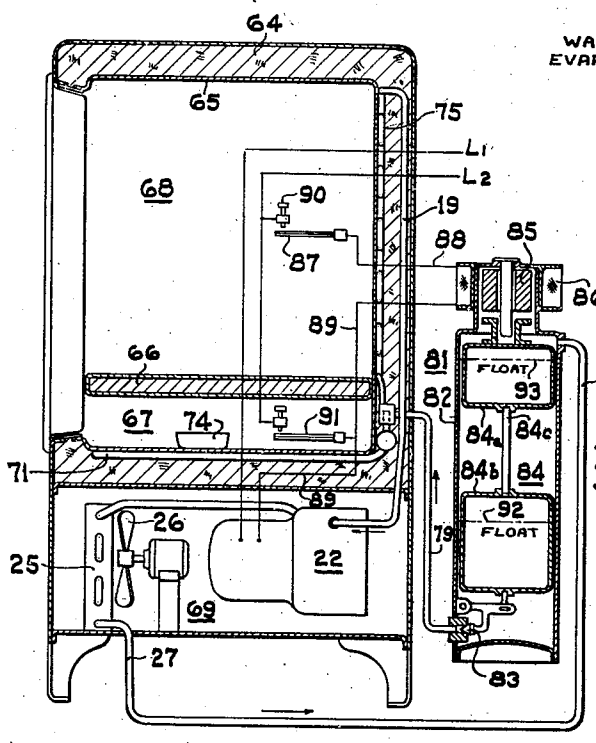
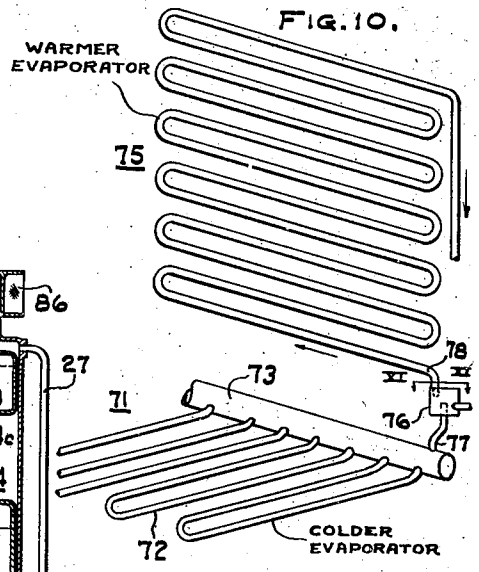


FIG. 9.

FIG. 10.



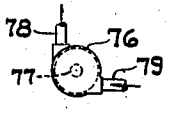


FIG. 11.

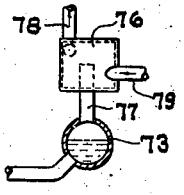


FIG. 12.

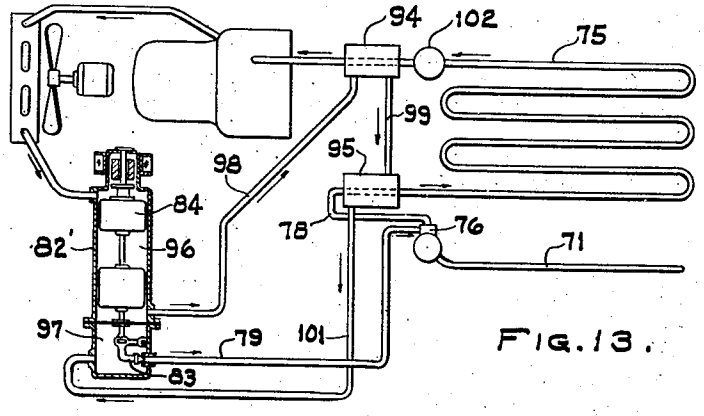


FIG. 13.

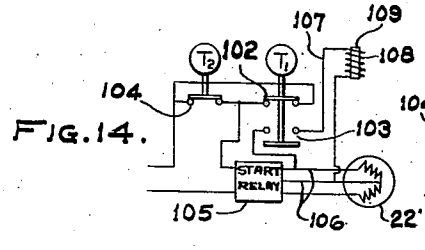


FIG. 14.

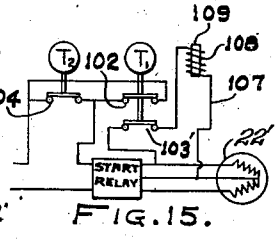


FIG. 15.

INVENTOR
LESLIE B.M. BUCHANAN
BY
ATTORNEY

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UNITED STATES PATENT OFFICE

2,133,948

REFRIGERATION APPARATUS

Leslie B. M. Buchanan, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application April 6, 1935, Serial No. 15,003

20 Claims. (Cl. 62—115)

My invention relates to refrigeration apparatus, more particularly to refrigeration apparatus embodying a plurality of evaporators operating at different temperatures, and it has for an object to provide improved apparatus.

A further object is to provide apparatus of the character set forth having a minimum number of parts, particularly moving parts such as valves.

Another object is to provide such apparatus in which the higher temperature evaporator operates at higher pressure to provide increased efficiency and capacity, and which apparatus has a minimum number of moving parts.

A further object is to prevent condensation of gaseous refrigerant in the lower temperature evaporator when the higher temperature evaporator is in operation at the higher pressure.

Another object is to provide apparatus of the above type in which the mechanism for selecting the evaporator to be refrigerated may be disposed in the high side of the system rather than in the low side, so that it need not be heat insulated to prevent condensation of moisture.

In accordance with my invention, I provide a lower temperature evaporator and a higher temperature evaporator in free communication with each other, so that the pressure therein is always substantially the same. I arrange the evaporators, and the connection between them and the supply of liquid refrigerant, in such manner that liquid refrigerant flows into the low temperature evaporator in preference to the higher temperature evaporator. This may be done, for example, by disposing the connection to the low temperature evaporator, at the point of division, at a lower level than the connection to the higher temperature evaporator. When refrigeration is to be effected in the lower temperature evaporator, liquid refrigerant is supplied only to said lower temperature evaporator, the higher temperature evaporator remaining dry so that evaporation of refrigerant cannot take place therein. The superheating of the vapor in the latter does not affect the low pressure necessary for operation of the lower temperature evaporator. When refrigeration is to be effected in the higher temperature evaporator, the lower temperature evaporator is first substantially filled with liquid refrigerant by reason of the arrangement giving it preference, and then the higher temperature evaporator is supplied with liquid refrigerant to effect evaporation therein. By filling the lower temperature evaporator with liquid refrigerant, condensation of vaporous refrigerant therein, which would otherwise be caused by the higher pressure effected by evaporation in the higher temperature evaporator, is avoided.

In the preferred form of my invention, which is claimed herein and several modifications of which are illustrated in the drawings, the refrigerating system is charged with such quantity of refrigerant as will substantially fill the lower temperature evaporator and supply sufficient liquid refrigerant to the higher temperature evaporator for operation thereof. There is also provided means for retaining, in a part of the refrigerating system other than the higher temperature evaporator, sufficient refrigerant, preferably in liquid form, to prevent the higher temperature evaporator from receiving liquid refrigerant. In this form, refrigeration is provided selectively in the lower temperature or the higher temperature evaporator by retaining or releasing refrigerant in said retaining means. The refrigerant vaporized in the lower temperature evaporator may be conveyed to the compressor through the higher temperature evaporator, thereby superheating the vapor and cooling the evaporator.

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

Fig. 1 is a diagrammatic view of one form of refrigerating system embodying my invention, showing the lower temperature evaporator in operation;

Fig. 2 is a similar partial view showing the higher temperature evaporator in operation;

Fig. 3 is a diagrammatic view of a second embodiment;

Figs. 4 and 5 are detail views of a modified form of retaining means, said figures showing the retaining means in condition for retaining liquid refrigerant and for releasing liquid refrigerant, respectively;

Figs. 6, 7, and 8 are diagrammatic views showing additional embodiments of the invention;

Fig. 9 is a vertical sectional view of a two-temperature refrigerator embodying the preferred form of refrigerating system, the latter being diagrammatically shown in parts;

Fig. 10 is a perspective view of the evaporators of Fig. 9;

Fig. 11 is a plan view of a detail, as seen from the line XI—XI of Fig. 10;

Fig. 12 is a detail sectional view of the connection between the evaporators and the refrigerant supply;

Fig. 13 is a diagrammatic view of another form

of refrigerating system representing a further development of the embodiment of Fig. 9; and

Figs. 14 and 15 show additional forms of control systems for two-temperature refrigerators.

Referring to Fig. 1 in detail, I show a refrigerator 10 having a compartment 11 which is refrigerated to a relatively low temperature by an evaporator 12, and a compartment 13 refrigerated by an evaporator 14 to a temperature which is higher than that maintained in the compartment 11. The temperature in the compartment 11 may be below freezing, in order to freeze ice and maintain frozen articles, while the temperature in the compartment 13 may be above freezing but sufficiently low for the preservation of food. The evaporator 12 is refrigerated or operated, that is, refrigerant therein is evaporated, at a lower temperature and at a lower pressure than the evaporator 14, and is referred to herein as the lower temperature or colder evaporator while the latter is referred to as the higher temperature or warmer evaporator. The evaporators are operated at different times, rather than simultaneously; each evaporator being operated at intervals for sufficient periods of time, preferably under thermostatic control, to maintain the respective temperature in its compartment.

Each evaporator may be of any desired form, either of the flooded type, or of the type known in the art as a dry evaporator, although the latter is not dry in operation but contains a mixture of liquid and vaporous refrigerant. In the present embodiment, the evaporator 12 is of the flooded type, having a header 15 and refrigerant passages 16 extending downwardly from the lower portion of the header. The header is formed with an outlet 17 disposed above the passages 16, preferably at the top of the header, and communicating through a conduit 18 with the warmer evaporator 14. The latter is illustrated in this embodiment as of the dry type, comprising a cross-finned coil, and it preferably has sufficient area of cooling surface to maintain the compartment 13 at the desired temperature with minimum temperature difference, so as to maintain a relatively high humidity of the air in the compartment.

The outlet end of the evaporator 14 is connected through a conduit 19 to the inlet 21 of a compressor 22, which is enclosed, together with its driving motor in a hermetically-sealed casing 23. The compressor and its motor may be of any suitable form known in the art. The outlet of the compressor is connected through a conduit 24 to a condenser 25. The latter may be air-cooled by a motor-driven fan 26. The condenser in turn is connected through a conduit 27 to a chamber 28. A conduit 29, which connects the chamber 28 with a high side float valve 31, has one branch 32 connected to the bottom of the chamber 28 and a second branch 33, the mouth of which communicates with the chamber 28 adjacent the top. A valve 34 is provided for shutting off flow through the conduit 32. The float valve 31 communicates with the header 15 of the evaporator 12 through a conduit 35.

It will be noted that the outlet 17, through which refrigerant is supplied to the evaporator 14, communicates with the header 15 in the upper portion thereof, so that refrigerant admitted to the header 15 from the conduit 35, flows, by gravity, into and fills the passages 16 of the evaporator 12 in preference to the evaporator 14. Liquid refrigerant passes through the outlet 17 into the evaporator 14 only when the evaporator 12 is filled to the level of the outlet 17 in the header 15. A perforated baffle 36 is preferably provided in the header 15, below the conduit 35 and the outlet 17 and above the passages 16, as shown in Figs. 1 and 2, for a purpose hereinafter described.

The refrigerating system is charged with a quantity of refrigerant such that, when the valve 34 is open, there is sufficient liquid refrigerant supplied to the evaporators, as shown in Fig. 2, to fill the evaporator 12 to the level of the outlet 17 and to supply sufficient liquid refrigerant to the evaporator 14 to effect evaporation throughout substantially the full length thereof. The space within the chamber 28 below the mouth of the branch conduit 33 is such as to retain, when the valve 34 is closed, a sufficient quantity of liquid refrigerant, as shown in Fig. 1, so that there will not be sufficient liquid refrigerant delivered to the header 15 to supply the evaporator 14 but only sufficient to provide the evaporator 12 with the quantity needed to effect operation thereof. In the latter case, the liquid level in the header 15 is maintained below the top of the header in order to provide a vapor space to take care of boiling of the liquid. The quantity of liquid refrigerant retained in the chamber 28 represents substantially the quantity of liquid within the evaporator 14 when it is in operation, plus the liquid displaced by vapor in the evaporator 12 when it is in operation.

To effect refrigeration of the compartment 13, operation of the compressor 22 and the fan 26 is started and the valve 34 is opened. This may be effected by a thermostatic control, a form of which will be hereinafter described. All of the condensed refrigerant now passes through the chamber 28 and the float valve 31 to the evaporators, as indicated in Fig. 2. This quantity is now sufficient to fill the evaporator 12 with liquid up to the level of the outlet 17, in this case completely filling the header 15, and to supply the evaporator 14 with a sufficient quantity for effecting evaporation substantially throughout said evaporator. The liquid refrigerant in the evaporator 14 is vaporized by the heat extracted from the compartment 13 and passes through the conduit 19 to the compressor 22, wherein its pressure is increased. It is then conveyed through the conduit 24 to the condenser 25 wherein it is condensed and then discharged to the conduit 27 to be recirculated.

As the temperature of the evaporator 14 is higher than the temperature of the evaporator 12, the pressure in the low side of the system, that is, the portion from the discharge side of the float valve to the inlet of the compressor, is higher than when the evaporator 12 is in operation. This pressure is not sufficiently low to effect evaporation in the evaporator 12, so that the latter remains inactive. In fact, the pressure is sufficiently high so that any vapor entering the evaporator 12 would tend to condense, but this is avoided or largely minimized by filling the evaporator 12 with liquid, which does not give off heat when its pressure is increased as does a vapor. The purpose of the baffle 36 is to guide the refrigerant from the conduit 35 as directly as possible to the outlet 17 with minimum intermingling with the liquid in the evaporator 12. The liquid coming from the conduit 35 is at a higher temperature than that in the evaporator 12, since it is not subjected to as low

a temperature as that effected when the evaporator 12 is in operation. The portion of the conduits 35 and 18 within the compartment 11 and the upper portion of the header 15 may be covered with heat insulating material. The refrigerating action is discontinued when the temperature of the compartment 13 has been reduced to the desired value.

To effect refrigeration of the colder compartment 11, the compressor 22 and the fan 26 are started and the valve 34 is closed, this operation also being preferably effected by a thermostatic control. The condensed refrigerant conveyed through the conduit 27 is retained in the chamber 28 until it reaches the level of the mouth of the branch conduit 33, as indicated in Fig. 1. As the supply of liquid refrigerant to the evaporators is temporarily cut off, continued operation of the compressor effects evaporation of the liquid refrigerant in the evaporator 14 and of that in the top of the header 15. Most of the latter refrigerant is forced into the evaporator 14 and evaporated due to the boiling or evaporation that is effected in the evaporator 12 as the pressure is reduced. Evaporation takes place for the time being in both evaporators, but the amount of liquid in the evaporator 14 is gradually reduced to zero. Thereafter, evaporation takes place only in the evaporator 12, and when the liquid level in the chamber 28 reaches the mouth of the branch conduit 33, liquid refrigerant is supplied therethrough to the evaporator 12. The retaining of the liquid refrigerant in the chamber 28 reduces the effective refrigerant charge to the extent that sufficient liquid refrigerant passes into the header 15 to just supply the evaporator 12.

The refrigerating apparatus now operates in the usual manner of a refrigerating system embodying a flooded evaporator such as shown at 12 except that the refrigerant vaporized in the evaporator 12 and withdrawn through the outlet 17, passes through the evaporator 14. The refrigerant vapor is superheated therein, effecting some cooling of the compartment 13, and then discharged through the conduit 19 to be compressed, condensed, and recirculated.

In Fig. 3, I show a modified form of means for retaining the necessary quantity of refrigerant to reduce the effective charge and permit evaporation in the colder evaporator 12. This means comprises a chamber 37 connected between the evaporators 12 and 14 by conduits 38 and 39, respectively. The conduit 39 is connected to the chamber 37 at a level high enough so that there may be retained in the chamber 37 below said connection the necessary quantity of refrigerant, such as that retained in the chamber 28 of Fig. 1, for effecting operation of the evaporator 12. A plunger 41 is provided in the chamber 37 for displacing liquid and has a core portion 42 adapted to be actuated by a solenoid 43 for raising the plunger 41.

To effect refrigeration of the evaporator 14 of Fig. 3, the plunger 41 is released and allowed to displace the liquid in the bottom of the chamber 37. The level of the liquid is raised so that it flows through the conduit 39 into the evaporator 14. As soon as it enters the latter, the suction pressure is increased and forces some of the liquid through the conduit 38 into the evaporator 12. This is desirable as the evaporator 12 is thus filled with cold liquid. The evaporator 14 is then refrigerated as described in connection with the first embodiment. The conduit 27, in this case, is connected directly to the float valve 31. The full charge of refrigerant is effective so that sufficient liquid refrigerant will be passed through the header 15 to supply the evaporator 14. To effect operation of the evaporator 12, the solenoid 43 is energized to raise the plunger 41. Sufficient liquid refrigerant is now retained in the chamber 37 to starve the evaporator 14, so that only the evaporator 12 receives liquid refrigerant and evaporation is thus effected therein, as will be clear.

In Figs. 4 and 5, I show another form of refrigerant retaining means. This comprises a chamber 44 pivoted to a supporting member 45 in such manner as to be movable between the two positions shown in these figures. This chamber may be interposed in any part of the refrigerating system between the condenser and the evaporator 14; for this example it will be assumed that it is connected between the condenser 25 and the float valve 31 of Fig. 1 by flexible conduits 27' and 29', respectively. When the chamber 44 is tilted downwardly, as shown in Fig. 4, it retains liquid refrigerant to reduce the effective charge, and, when it is raised as shown in Fig. 5, it discharges the liquid refrigerant to the float valve through the conduit 29' so as to increase the effective refrigerant charge.

In Fig. 4, I show a thermostatic means for actuating the refrigerant retaining means, comprising a thermostatic bulb 46 connected by a tube 47 to a bellows 48, and a snap acting toggle link connection 49 of any suitable construction between the bellows and the end of the chamber 44. The thermostatic bulb 46 is disposed in the warmer compartment 13. When the temperature in the compartment 13 increases to a value indicating need for refrigeration, the increased pressure in the bulb 46 transmitted to the bellows 48 causes the latter to raise the chamber 44 through the toggle link 49. The liquid refrigerant retained in the chamber is released so as to supply the evaporator 14 therewith for operation thereof in the manner previously described. When the temperature in the compartment 13 is reduced to the desired value, the bellows 48 contracts to move the chamber 44 downwardly to the position shown in Fig. 4. Refrigerant is retained therein for operation of the colder evaporator 12 as already described. Suitable control mechanism for starting and stopping the compressor and the condenser fan is provided for supplying the refrigeration requirements of both compartments. The thermostatic control of Fig. 4 gives preference to the warm compartment when both compartments require refrigeration.

It may be arranged to give preference to the colder compartment by placing the bulb 46 therein and reversing its direction of operation with respect to the chamber 44; that is, upon increase in temperature in the colder compartment, the chamber 44 would be tilted downwardly as shown in Fig. 4.

In Fig. 6, I show an embodiment of my invention in which a header 51 for the colder evaporator 12a also serves as the refrigerant retaining means. The header 51 is provided with two outlets 17a and 17b, disposed at upper and lower levels between which liquid refrigerant is retained. The outlet 17a is connected to the warmer evaporator 14a through a valve 52 and the outlet 17b is connected thereto through a looped conduit 53 which extends to a higher level before connecting with the evaporator 14a. The low temperature evaporator 12a is shown in the form of a coil, but it is

a flooded evaporator in its operation, both ends being connected to the header 51 below the liquid level therein, though preferably at different levels. Obviously, it may be of any desired form of the flooded type.

When the valve 52 is closed, liquid refrigerant is forced through the outlet 17b to the evaporator 14a until the liquid level is brought down to the outlet 17b, as shown at 54. This is due to the fact that the vaporous refrigerant formed on the discharge side of the float valve 31 collects in the upper portion of the header 51. The system is charged with sufficient refrigerant to supply the evaporator 14a under this condition, and operation thereof is effected in the same manner as already described. To effect operation of the low temperature evaporator 12a, the valve 52 is opened. The vaporous refrigerant in the upper part of the header 51 now passes through the outlet 17a to the evaporator 14a, and liquid refrigerant no longer flows through the conduit 53 but is retained in the header 51 for the reason that there is no longer a sufficient pressure difference to raise the liquid refrigerant to the higher level of the loop in the conduit 53. Any other suitable means may be provided for preventing flow through the conduit 53 at this time. The outlet 17a is disposed at a sufficiently higher level than the outlet 17b to retain the necessary quantity of liquid refrigerant therebetween, so that the evaporator 14a does not receive liquid refrigerant. The outlet 17a may be disposed at the higher liquid level now maintained in the header 51 and shown at 55, so as to draw off the lubricant at the surface of the liquid. However, it may be disposed at a higher level if desired, in which case the lubricant will be removed through the outlet 17b when the evaporator 14a is in operation, particularly in initiating operation thereof after previous operation of the low temperature evaporator 12a.

In Fig. 7, I show an embodiment of my invention in which the low temperature evaporator 56 is of the so-called "dry" type arranged in series ahead of the warmer evaporator 14a. Inasmuch as relatively warm refrigerant passes through the evaporator 56 when the warmer evaporator is in operation, it is disposed in the upper portion of a brine chamber 57, the lower portion of which is adapted to effect the cooling action, such as, freezing of water in the ice trays 58. The retaining means comprises a chamber 28a, substantially similar to the chamber 28 of Fig. 1, and is connected at the bottom to the float valve 31 through a conduit 32a having a valve 34a and adjacent the top through a conduit 33a.

To effect refrigeration in the low temperature evaporator 56, the valve 34a is closed so as to retain a quantity of refrigerant in the chamber 28a. Only sufficient liquid refrigerant passes on to supply the evaporator 56 so that evaporation at low pressure and temperature therein is effected. The evaporator 56 cools the brine in the chamber 57, which brine circulates by convection to the lower portion of the chamber to cool the ice trays 58. The vaporized refrigerant is conveyed through the evaporator 14a and the operation is otherwise the same as already described. When the evaporator 14a is placed in operation by opening the valve 34a, the pressure in the low side of the system is increased due to the higher temperature of the evaporator 14a. Consequently, relatively warm refrigerant passes through the evaporator 56 and heats the brine in the upper portion of the chamber 57. Inasmuch as the warm brine tends to remain at the top of the chamber, this heat is not conducted to the ice trays 58 to any great extent. The arrangement of the evaporator in the upper portion of the brine chamber so as to avoid heating of the ice trays when warm refrigerant is conveyed therethrough is the invention of Graham S. McCloy.

In Fig. 8, I show a further embodiment including a low temperature evaporator 59 of the dry type in series with a warmer evaporator 61, also of the dry type. In this embodiment, provision is made for by-passing the low temperature evaporator when the warmer temperature evaporator 61 is in operation. The retaining means comprises a chamber 28b similar to the chamber 28 of Fig. 1 but disposed between the float valve 31 and the evaporators, being connected to the former by the conduit 35. The bottom of the chamber 28b is connected, through a conduit 32b having a valve 34b, to a connection 62 between the evaporators 59 and 61, which connection is disposed at a level above the evaporator 59. A conduit 63 connects the inlet of the evaporator 59 with the chamber 28b at the upper portion of said chamber. The chamber 28b is disposed at a level as high as or higher than the connection 62.

The operation of this embodiment is as follows. When the valve 34b in the conduit 32b is closed, liquid refrigerant is retained in the chamber 28b until the liquid level reaches the connection with the conduit 63 and then flows through said conduit to the colder evaporator 59. Only sufficient liquid is supplied under this condition to effect evaporation in the colder evaporator 59, the vaporized refrigerant being conducted through the evaporator 61 as in the previous embodiments. To effect refrigeration in the warmer evaporator 61, the valve 34b is opened so as to permit the liquid in the chamber 28b to pass through the conduit 32b to the connection 62. The liquid first completely fills the evaporator 59 and then enters the evaporator 61 to effect evaporation therein. It will be noted that, with this arrangement, the colder evaporator 59 is flooded while the evaporator 61 is in operation, both the connection 62 and the chamber 28b being disposed at higher levels.

Referring to Figs. 9 to 12, I show the embodiment of my invention which is at present preferred. In this embodiment, the cabinet 64 has a food liner 65, the interior of which is divided by a horizontal insulated partition 66 into a lower, relatively cold or freezing chamber 67 and an upper, warmer chamber 68 for preservation of food. This arrangement is described and claimed in the application of Milton Kalischer, Serial No. 751,324, filed November 3, 1934. The cabinet is also formed with a machine compartment 69, in this case shown below the food liner, for containing the refrigerating unit.

The colder compartment 67 is refrigerated by an evaporator 71, comprising a plurality of tubes 72. These tubes are bent into U-shape and the ends thereof connected to a header 73. The tubes are secured to the under surface of the bottom wall portion of the food liner 65. Ice trays 74 may be disposed on the bottom of the food liner to be refrigerated by the evaporator 71. This arrangement is described and claimed in the application of J. H. Ashbaugh, Serial No. 751,309, filed November 3, 1934. The warmer compartment 68 is refrigerated by an evaporator 75, comprising a serpentine coil secured to the back surface of the rear wall portion of the food liner portion 65.

The evaporators 71 and 75 are connected to

each other and to the source of liquid refrigerant through a connecting chamber **76**, which may be of a cylindrical form disposed with its axis extending vertically, as shown in Figs. 10, 11, and 12. This chamber is disposed at a higher level than the header **73** and a short conduit **77** is connected to the top of the header **73** and projects centrally into the chamber **76**, as shown in Figs. 10, 11, and 12.

The inlet end **78** of the warmer evaporator **75** connects with the chamber **76** above the upper end of the conduit **77** and is preferably arranged tangentially as shown in Fig. **11**. A conduit **79**, which is connected to the chamber **76** below the upper end of the conduit **77**, and which is preferably arranged tangentially as shown in Fig. 11, provides communication with a float valve structure **81**.

In the present embodiment, the refrigerant retaining means is incorporated in the float valve structure **81**, which includes a chamber **82** connected to the condenser **25** through the conduit **27**, a valve **83** therein for controlling the flow of refrigerant to the evaporators through the conduit **79**, and a float member **84** for operating the valve **83**. The float member **84** comprises upper and lower float elements **84***a* and **84***b*, which are fixed in vertically-spaced relation by a stem **84***c*. A weight member **85** is also provided within the chamber **82** and adapted either to rest on the float member **84** or to be lifted by a solenoid coil **86**.

I also show, in Fig. 9, one form of control system, which may be applied to the other embodiments as well as to the one in Fig. 9. This system comprises line conductors L_1 and L_2, the former being connected to one terminal of the compressor motor. A thermostat **87**, disposed within the warmer compartment **68**, has one contact connected to the line conductor L_2 and the other contact connected to one terminal of the solenoid **86** through a conductor **88**, while the other terminal of the solenoid is connected through a conductor **89** to the other terminal of the compressor motor. A thermostat **91** is disposed in the cold compartment **67** and connected between the line conductor L_2 and the conductor **89**. Each of the thermostats **87** and **91** may obviously be of any desired type known in the art and for purposes of illustration are shown as comprising bi-metallic strips. Each thermostat is adjustable to provide any desired temperature within the respective compartment. In the illustrated embodiment, each thermostat includes a thumb screw **90**, which forms the stationary contact and which may be adjusted to vary the temperature setting of the thermostat. It is to be understood that any suitable form of starting relay for the compressor-motor may be used, as is fully understood in the art, and that any other usual electrical provisions may be made.

The operation of this embodiment is as follows: Assume that the warmer compartment **68** requires refrigeration while the colder compartment **67** is sufficiently cold, so that the contacts of the thermostat **87** are closed while the contacts of the thermostat **91** are opened. The solenoid **86** and the compressor motor are both energized, the circuit extending from line conductor L_1 through the motor, the conductor **89**, the solenoid **86**, the conductor **88**, and the thermostat **87** to the line conductor L_2. The solenoid **86** lifts the weight **85**, and the motor drives the compressor **22**. The float member **84** being relieved of the weight **85** maintains a lower liquid level indicated at **92**. The refrigerating system is charged with a sufficient quantity of refrigerant, so that, under this condition, there is sufficient liquid refrigerant conveyed through the conduit **79** to the chamber **76** to first completely fill the colder evaporator **71** through the conduit **77**, and then to supply sufficient refrigerant to the warmer evaporator **75** for operation thereof. The tangential arrangement of the conduit **79** creates a rotating movement of the refrigerant in the chamber **76**, thereby tending to avoid any intermingling with the liquid in the conduit **77** and the evaporator **71**. The tangential arrangement of the conduit **78** enables liquid to enter said conduit with minimum disturbance of the rotating movement in the chamber **76**.

The refrigerating system now operates in the usual manner of such apparatus to effect refrigeration of the warmer compartment **68**, the liquid refrigerant in the evaporator **75** being vaporized and withdrawn through the conduit **79** to the compressor **22**, wherein its pressure is increased. It is then condensed in the condenser and returned to the float chamber **82**. Due to the higher temperature maintained in the chamber **68**, evaporation of liquid refrigerant in the evaporator **75** effects a higher pressure in the low side of the system, which higher pressure is imposed on the liquid refrigerant in the evaporator **71**. However, the increased pressure has no effect on the liquid therein, thereby avoiding condensation and heating of the colder chamber **67** which would take place if vapor under the higher pressure were admitted to the evaporator **71**.

Assume now that the temperature in the colder compartment **67** rises to the maximum limit for which the thermostat **91** is set so as to close the contacts thereof for effecting refrigeration of said compartment. The thermostat **91** completes a circuit from line conductor L_1 through the motor, the conductor **89**, and the thermostat **91** to the conductor L_2 to effect operation of the motor. The solenoid **86** is now deenergized and releases the weight **85**, regardless of whether the thermostat **87** is opened or closed, since, if it is closed, the solenoid is shunted by the thermostat **91**. Accordingly, the weight member **85** rests on the float member **84**, so that the liquid level within the float chamber **82** must rise to a higher level, shown at **93**, before the float member will rise to open the valve **83**. There is thus retained in the float chamber **82** an additional quantity of liquid refrigerant filling the space between the float elements **84***a* and **84***b*, which is sufficient to reduce the effective refrigerant charge to the extent that only the colder evaporator **71** will receive liquid refrigerant. The liquid refrigerant remaining in the evaporator **75** from previous operation and that filling the vapor space in the top of the header **73** are first evaporated, as described in connection with Figs. 1 and 2, while condensed refrigerant is retained in the float chamber **82** until the upper level **93** is reached. Further operation of the compressor reduces the suction pressure until evaporation in the evaporator **71** takes place.

The refrigerant system now operates in the usual manner, the refrigerant admitted to the chamber **76** flowing through the conduit **77** into the header **73** to supply the colder evaporator **71**, inasmuch as the upper end of the conduit **77** is at a lower level than the inlet end of the conduit **78**, and there is only sufficient liquid to cause evaporation in the evaporator **71**. The refriger-

ant vaporized in the evaporator 71 passes through the evaporator 75, and being at a lower temperature, extracts some heat therefrom, thereby superheating the vapor. Such superheating, however, does not affect the lower suction pressure now effected. When the temperature in the colder compartment 67 is reduced to the lower limit for which the thermostat 91 is set, the latter opens its contacts. If the contacts of the thermostat 87 are open at this time, operation of the refrigeration system ceases but, if they are closed, the solenoid 86 is energized and the motor continues to operate to effect refrigeration of the warmer compartment in the manner first described.

In the control system of Fig. 9, the thermostat 91 may be referred to as the preferred thermostat, since the compartment associated therewith receives refrigeration in preference to the other when both require refrigeration.

In Fig. 13, I show the application of heat exchange apparatus, for transferring heat from the condensed refrigerant in the high side to the vaporized refrigerant in the low side, applied to the embodiment of Figs. 9 to 12. One heat exchanger 94 is connected between the evaporator 75 and the inlet of the compressor, and a second heat exchanger 95 is connected between the evaporators 71 and 75. The float chamber 82' is divided into an upper space 96 containing the float member 84 and a lower space 97 containing the valve member 83. The condensed refrigerant is conveyed from the upper chamber 96 through a conduit 98 to the heat exchanger 94, and through a conduit 99 to the heat exchanger 95, and then through a conduit 101 to the lower chamber 97. From the latter, it is passed through the valve 83 to the conduit 79 and to the evaporators in the same manner as in Figs. 9 to 12. It will thus be seen that the liquid collecting in a body in the upper chamber 96 is passed in heat exchange relation with the vaporized refrigerant before its pressure is reduced by the valve member 83.

In Fig. 13, I also show a storage chamber 102 connected between the warmer evaporator 75 and the inlet of the compressor. Should evaporation take place in both evaporators at the same time, there may be an excess of liquid returned to the compressor. It is the purpose of the chamber 102 to temporarily retain such liquid to prevent passage thereof to the compressor and possible damage thereto and loss of refrigeration. Operation of both evaporators might take place under certain conditions; for example, if preference were given to the warmer evaporator instead of the colder evaporator and the refrigerator had been shut down for a prolonged period allowing both evaporators to acquire a high temperature, evaporation would take place in both evaporators upon resuming operation of the compressor.

When the evaporator 71 of Fig. 13 is being refrigerated, the cold dense vapor discharged therefrom passes through the heat exchanger 95, in which it absorbs heat from the warmer liquid refrigerant being supplied to the evaporator 71, and in which any liquid particles carried in suspension are vaporized. The cooling of the liquid refrigerant means that a smaller portion thereof is vaporized as its pressure is reduced beyond the valve 83, thereby leaving a greater portion of liquid available for effecting refrigeration in the evaporator 71. Thus, the refrigerating effect represented by the capacity of the cold vapor to absorb sensible heat is returned to the evaporator 71 to be utilized therein. The use of this refrigerating effect in the colder evaporator 71, rather than in the warmer evaporator 75, is advantageous since it reduces the operating time of the colder evaporator, which is at lower pressure and hence less economical, rather than reducing the operating time of the warmer evaporator, which may be effected more economically because it operates at higher pressure. In other words, the return of the refrigerating effect to the colder evaporator results in a greater portion of the operation being effected at the higher economy.

The vapor then passes from the heat exchanger 95 to the evaporator 75, but it does not absorb any appreciable amount of heat therein since its temperature has been raised by the heat exchanger 95. It then passes through the heat exchanger 94, in which it extracts further heat from the liquid being supplied to the evaporator 71 and is further superheated.

When the evaporator 75 is being refrigerated, heat exchange takes place in the heat exchanger 95, but has no effect on the heat balance of the system. The vaporized refrigerant discharged from the evaporator 75, however, absorbs heat from the liquid refrigerant in the heat exchanger 94 and is superheated in the usual manner of such heat exchangers.

In Fig. 14, I show another form of control system which effects energization of an electrical element, such as a coil, when the non-preferred thermostat calls for refrigeration. This control mechanism includes a thermostat T_1 which is disposed in the refrigerator compartment that is to have preference, and a thermostat T_2 disposed in the other compartment. The thermostat T_1 has contacts 102 which are closed and contacts 103 which are opened when the thermostat calls for refrigeration and the thermostat T_2 is provided with contacts 104 which are closed when the same calls for refrigeration. The contacts 102 and 104 are connected in parallel in one side of the line going to a starting relay 105. The starting relay is connected to the compressor motor 22' by the necessary number of conductors, including conductors 106 connected to the running winding of the motor. A circuit 107 extends from one of the conductors 106 through a coil 108 and the contacts 103 to the other conductor 106. A core 109 is actuated by the coil 108. When the control system of Fig. 14 is applied to the apparatus of Fig. 9, the coil 86 and the core 85 constitute the coil 108 and the core 109 of Fig. 14, respectively. When it is applied to one of the embodiments having a valve for determining which evaporator shall operate, the core 109 is connected to the valve in such manner as to effect refrigeration in the preferred evaporator when the coil 108 is not energized, and to effect refrigeration in the non-preferred evaporator when the coil is energized.

The operation of this control mechanism is as follows: Assume that the control system is applied to the apparatus shown in Fig. 1, and that the thermostat T_1 is located in the colder compartment 11 to give the same preference and that the thermostat T_2 is located in the warmer compartment 13. The core 109 is connected to the valve 34 so as to open the valve when the coil 109 is energized. Assuming that the warmer compartment 13 is calling for refrigeration and that the colder compartment 11 is not, the contacts 103 and 104 are closed and the contacts

102 are opened. The closing of the contacts 104 effects energization of the compressor motor 22', and of the conductors 106. The contacts 103 being closed, the circuit 107 is now closed to energize the coil 108, thereby opening the valve 34 to supply refrigerant to the warmer evaporator 14. When the thermostat T_1 in the colder compartment calls for refrigeration, the contacts 102 are closed and the contacts 103 opened. The contacts 102 effect energization of the motor and of the conductors 106, but the contacts 103 prevent energization of the coil 108, regardless of whether the thermostat T_2 is calling for refrigeration. The valve 34 is thus closed to cause refrigeration in the colder evaporator 12. When the refrigeration demand of the colder compartment is satisfied, the contacts 103 are closed to enable the thermostat T_2 to effect refrigeration in the warmer compartment. With this control mechanism, it will be noted that the coil 108 is deenergized to place the apparatus in condition for circulation of refrigerant through the preferred evaporator when neither thermostat is calling for refrigeration. In the apparatus of Figs. 1 and 2, the valve 34 is closed.

In Fig. 15, I show another form of control mechanism comprising thermostats T_1 and T_2 which operate contacts 102 and 104, as in Fig. 14, but in which the thermostat T_1 closes contacts 103' when calling for refrigeration. In this case, the core 109 is arranged or connected to effect operation of the preferred evaporator when the coil 108 is energized, and to effect operation of the other evaporator when the coil is deenergized, since the contacts 103' close the circuit 107 when the preferred thermostat T_1 calls for refrigeration.

The operation of this embodiment is as follows: When the thermostat T_1 calls for refrigeration, the contacts 102 effect energization of the compressor motor 22', and the contacts 103' energize the coil 108 to effect operation of the preferred evaporator regardless of whether the other evaporator requires refrigeration. When the thermostat T_2 calls for refrigeration, the contacts 104 effect energization of the compressor motor 22', but operation of the evaporator associated therewith is effected only when the thermostat T_1 becomes satisfied and opens the contacts 103'. In this embodiment, the apparatus is conditioned for operation of the non-preferred evaporator when neither thermostat calls for refrigeration.

The forms of control mechanism shown in Figs. 9 and 14 are suitable for the apparatus shown in Fig. 9 when the colder compartment is to have preference, and for the apparatus shown in Fig. 3 when the warmer compartment is to have preference, since the coil is energized for operation of the non-preferred evaporator. The control mechanism of Fig. 15 is suitable for the apparatus in Fig. 9 when preference is to be given to the warmer compartment and to the apparatus in Fig. 3 when preference is to be given to the colder compartment, since the coil is energized for operation of the preferred evaporator. Any one of the three forms of control mechanism may be applied to any of the other forms of refrigerating apparatus in which the selection between the evaporators is made by a valve, by merely connecting the core 109 to the valve in the proper relation, as will be readily apparent from the above description.

In each of the above embodiments, the portions of the low side conduits outside the refrigerated compartments are preferably heat-insulated or arranged in some suitable way to avoid or minimize absorption of heat. In the embodiments of the invention shown in Figs. 1, 7, 9, and 13, it will be noted that the refrigerant-retaining means and the valve or other means for selecting the evaporator to be operated are disposed in the high side of the system, so that it is not necessary to heat insulate the same to prevent condensation of moisture.

While the drawings are diagrammatic in many respects in order to clearly show the features of invention, it is to be understood that the apparatus is constructed in accordance with the usual knowledge and skill of the art and may embody any other suitable features.

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. In refrigerating apparatus, the combination of a low temperature and a higher temperature evaporator, means for condensing the refrigerant vaporized in said evaporators, means for conveying refrigerant from the condensing means to said evaporators in such manner that liquid refrigerant flows into the low temperature evaporator in preference to the higher temperature evaporator, and means for selectively producing the effect of increasing the refrigerant charge to the extent of causing liquid refrigerant to fill a substantial portion of the higher temperature evaporator, for effecting refrigeration at relatively high pressure and temperature in the higher temperature evaporator, or producing the effect of decreasing the refrigerant charge to the extent that the higher temperature evaporator receives substantially no liquid refrigerant, for effecting refrigeration at low pressure and temperature in the low temperature evaporator.

2. In refrigerating apparatus, the combination of a low temperature and a higher temperature evaporator, means for condensing the refrigerant vaporized in said evaporators, means including a connection to the higher temperature evaporator and a connection at a lower level to the low temperature evaporator for conveying refrigerant from the condensing means to said evaporators, so that liquid refrigerant flows into the low temperature evaporator in preference to the higher temperature evaporator until a predetermined level is reached and then flows into the higher temperature evaporator, and means for selectively producing the effect of increasing the refrigerant charge to the extent of causing liquid refrigerant to fill a substantial portion of the higher temperature evaporator, for effecting refrigeration at relatively high pressure and temperature in the higher temperature evaporator, or producing the effect of decreasing the refrigerant charge to the extent that the higher temperature evaporator receives substantially no liquid refrigerant, for effecting refrigeration at low pressure and temperature in the low temperature evaporator.

3. A refrigerating system including two evaporators, one of which maintains a lower temperature than the other, said evaporators being so connected and arranged that liquid refrigerant

flows into one evaporator until it is full and then into the other, and means for selectively decreasing or increasing the quantity of liquid refrigerant in said evaporators so that when it is decreased there is liquid being evaporated in said first evaporator while the other is dry and when it is increased said one evaporator is flooded and under sufficient pressure to prevent vaporization therein while liquid overflows into and vaporizes in said other evaporator to effect cooling therein.

4. A refrigerating system comprising a low temperature and a higher temperature evaporator, means for liquefying refrigerant vaporized in said evaporators, means for connecting the evaporators and said liquefying means so that with a predetermined effective charge of refrigerant in the system there is sufficient liquid refrigerant in the low temperature evaporator for effecting refrigeration therein while the higher temperature evaporator is dry and so that with a second and greater predetermined effective charge of refrigerant in the system there is sufficient liquid refrigerant in the higher temperature evaporator for effecting refrigeration therein and the low temperature evaporator is filled with liquid refrigerant to prevent condensation therein, and means for selectively varying the effective charge of refrigerant between said predetermined values.

5. A refrigerating system as specified in claim 4, wherein the last-mentioned means comprises means for selectively retaining in a part of the system other than the higher temperature evaporator a quantity of liquid refrigerant equal to the difference between said predetermined values.

6. A refrigerating system having a high side comprising a compressor and a condenser and a low side comprising a low temperature evaporator and a higher temperature evaporator, means for supplying condensed refrigerant from the condenser to the evaporators, the low temperature evaporator being connected to the refrigerant supply means at a lower level than the higher temperature evaporator so that the former has preference in receiving liquid refrigerant and the latter receives liquid refrigerant only when the low temperature evaporator has its full amount of liquid refrigerant, and means for selectively varying the effective charge of refrigerant in the system so that, in one condition, only the low temperature evaporator receives liquid refrigerant and, in a second condition, both the low temperature and the high temperature evaporator receive liquid refrigerant.

7. A refrigerating system comprising a low temperature and a higher temperature evaporator, means for condensing the refrigerant vaporized in said evaporators, said evaporators and the condensing means being so connected that the low temperature evaporator receives liquid refrigerant in preference to the higher temperature evaporator until it is substantially filled, the system containing a sufficient charge of refrigerant to substantially fill the low temperature evaporator with liquid refrigerant and to supply sufficient liquid refrigerant to the higher temperature evaporator to provide refrigeration therein, and means for selectively retaining in a portion of the system other than the high temperature evaporator a sufficient quantity of liquid refrigerant to cause the higher temperature evaporator to become dry while retaining sufficient liquid refrigerant in the low temperature evaporator to effect refrigeration therein or releasing the same to effect refrigeration in the higher temperature evaporator.

8. The method of operating a refrigerating system having a low temperature and a higher temperature evaporator which comprises supplying liquid refrigerant to the low temperature evaporator and maintaining the higher temperature evaporator dry for effecting refrigeration in the low temperature evaporator, and supplying liquid refrigerant to the higher temperature evaporator and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the low temperature evaporator and at a pressure higher than the pressure corresponding to said temperature of the low temperature evaporator, and at the same time supplying liquid refrigerant to the low temperature evaporator to fill the same for preventing condensation of vaporous refrigerant therein.

9. A refrigerating system comprising a low temperature evaporator and a higher temperature evaporator, said evaporators being so connected that liquid refrigerant flows into the low temperature evaporator in preference to the high temperature evaporator until the former is substantially filled and then flows into the latter, means for removing the refrigerant vaporized in said evaporators and condensing the same, a high side float valve for controlling flow of refrigerant from said condensing means to said evaporators, said float valve including a chamber and a float member therein, and means for selectively imposing additional downward bias on said float member to raise the liquid level within the chamber to a point where the additional liquid refrigerant retained in the float chamber prevents the higher temperature evaporator from receiving liquid refrigerant.

10. In refrigerating apparatus, the combination of a low temperature and a higher temperature evaporator, means for condensing the refrigerant vaporized in said evaporators, and means for selectively supplying liquid refrigerant to the low temperature evaporator and maintaining the higher temperature evaporator dry, for effecting refrigeration at relatively low pressure and temperature, or supplying liquid refrigerant to the higher temperature evaporator and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the low temperature evaporator and at a pressure higher than the pressure corresponding to said temperature of the low temperature evaporator and at the same time causing liquid refrigerant to flow into the low temperature evaporator until the same is substantially filled with liquid refrigerant.

11. Refrigerating apparatus as defined in claim 10, wherein the liquid refrigerant in the low temperature evaporator remains in substantially static condition while refrigeration is effected in the higher temperature evaporator.

12. In refrigerating apparatus, the combination of lower temperature and higher temperature evaporators in free communication with each other so that the pressure therein is the same, means for withdrawing vaporized refrigerant from said evaporators and for condensing the same, and means for selectively supplying liquid refrigerant to the higher temperature evaporator and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the lower temperature evaporator and at a pressure higher than the pressure corresponding to said temperature of the lower temperature evaporator and at the same time supplying liquid refrigerant to the lower tempera-

ture evaporator until it is substantially filled so as to prevent condensation therein, or supplying liquid refrigerant to the lower temperature evaporator while maintaining the higher temperature evaporator substantially dry for effecting refrigeration at lower pressure and temperature in the lower temperature evaporator.

13. In refrigerating apparatus, the combination of a colder and a warmer evaporator operating at different times, means for withdrawing vaporized refrigerant from said evaporators and for condensing the same, means for supplying liquid refrigerant to the warmer evaporator and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the colder evaporator and at a pressure higher than the pressure corresponding to said temperature of the colder evaporator and at the same time preventing condensation of vaporous refrigerant in the colder evaporator, and means for supplying liquid refrigerant to the colder evaporator for operation thereof at lower pressure and at the same time maintaining the warmer evaporator substantially dry.

14. In refrigerating apparatus, the combination of a colder and a warmer evaporator operating at different times, means for withdrawing vaporized refrigerant from said evaporators and for condensing the same, means for supplying liquid refrigerant to the warmer evaporator and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the colder evaporator and at a pressure higher than the pressure corresponding to said temperature of the colder evaporator and for filling the colder evaporator with liquid refrigerant at the same time, and means for supplying liquid refrigerant to the colder evaporator for operation thereof at lower pressure while preventing evaporation of liquid refrigerant in the warmer evaporator.

15. In refrigerating apparatus, the combination of a low temperature and a higher temperature cooling element, and means for selectively circulating cooling medium first through the low temperature cooling element for extracting heat therein and then through the higher temperature cooling element or circulating cooling medium through the higher temperature cooling element for extracting heat therein without extracting any appreciable amount of heat in the low temperature cooling element.

16. A refrigerating system comprising, in combination, a compressor, a condenser, a plurality of evaporators, and means for selectively effecting operation of either evaporator, said last-mentioned means comprising means for selectively reducing the effective refrigerant charge in the system.

17. In refrigerating apparatus, the combination of a compressor, a condenser, a plurality of evaporators, a common expansion device for said evaporators, and means for selectively effecting operation of either evaporator comprising a chamber and means for selectively retaining a quantity of liquid refrigerant in said chamber, the retention of a predetermined quantity of liquid refrigerant in said chamber resulting in depriving one evaporator of liquid refrigerant.

18. In refrigerating apparatus, the combination of a colder and a warmer evaporator, a compressor for withdrawing vaporized refrigerant from the evaporators, a condenser, a device for controlling flow of condensed refrigerant to the evaporators, means for conveying refrigerant from said device to said evaporators, said conveying means and said evaporators being connected and arranged so that the evaporators are in communication and at substantially the same pressure at all times, so that liquid refrigerant flows into the colder evaporator in preference to the warmer evaporator and into the warmer evaporator only after the colder evaporator is substantially filled with liquid refrigerant, so that the liquid refrigerant in the colder evaporator may remain in a substantially static condition when the colder evaporator is filled and liquid refrigerant is supplied to the warmer evaporator, so that refrigerant may flow through the warmer evaporator at all times, and so that operation of the warmer evaporator depends on whether there is sufficient liquid refrigerant to spill over into the warmer evaporator, and means for selectively increasing the flow of liquid refrigerant to an extent causing the same to spill over into the warmer evaporator or reducing the flow thereof to an extent preventing such spilling over and thereby depriving the warmer evaporator of liquid refrigerant.

19. In refrigerating apparatus, the combination of a colder and a warmer evaporator element, and means for selectively circulating refrigerant first through the colder evaporator element and extracting heat therein by evaporation of liquid refrigerant at low pressure and then through the warmer evaporator element or circulating refrigerant through the warmer evaporator element and effecting evaporation of liquid refrigerant therein at a temperature above the temperature of the colder evaporator element and at a pressure higher than the pressure corresponding to said temperature of the colder evaporator element without adding an appreciable amount of heat to the colder evaporator element.

20. In a refrigerating system, the combination of a colder evaporator and a warmer evaporator, means including a compressor and a condenser for effecting evaporation of liquid refrigerant in said evaporators and for supplying liquid refrigerant thereto, means for selectively effecting evaporation of liquid refrigerant in the colder evaporator by supplying liquid refrigerant to the colder evaporator only or in the warmer evaporator by supplying liquid refrigerant to both evaporators, and a connection providing communication between said evaporators at all times, said connection being arranged so that liquid refrigerant flows from said connection to the colder evaporator in preference to the warmer evaporator and thereby serves to prevent flow of liquid refrigerant to the warmer evaporator when said second-mentioned means is adjusted for effecting evaporation of liquid refrigerant in the colder evaporator.

LESLIE B. M. BUCHANAN.