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REFRIGERATING APPARATUS AND METHOD

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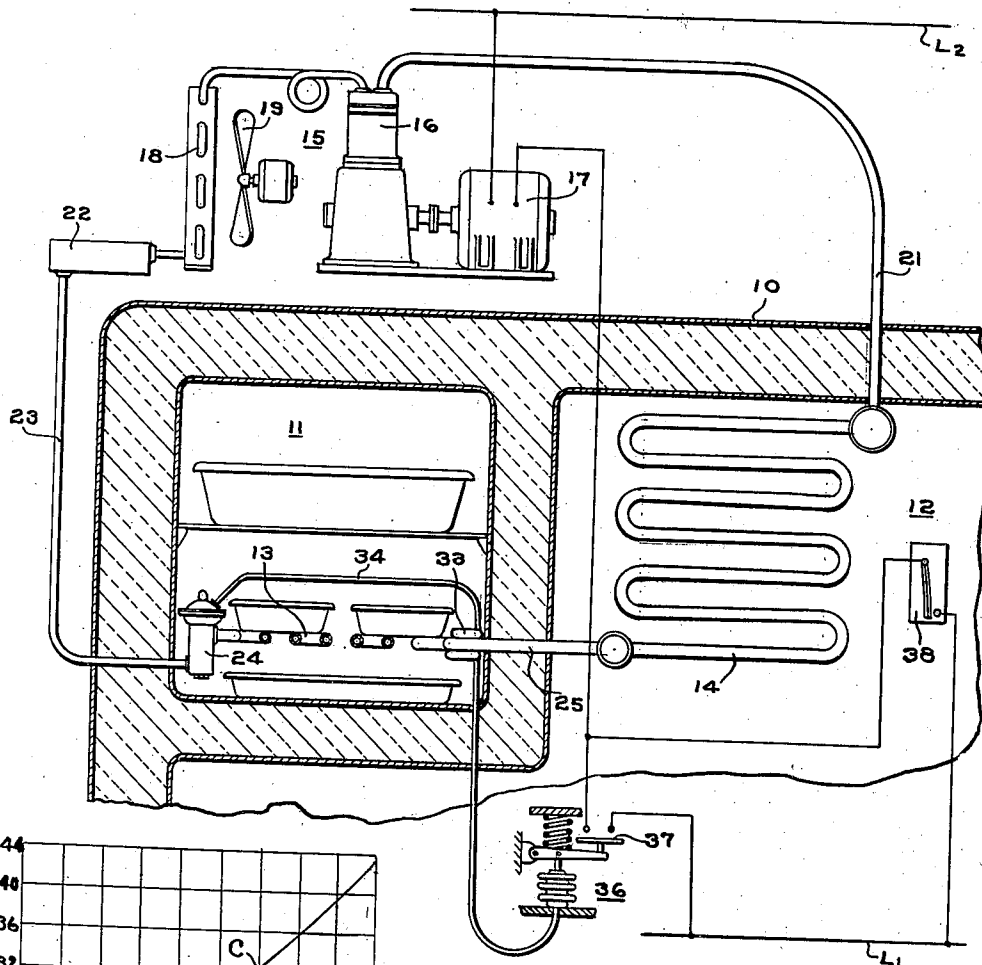


FIG. 1.

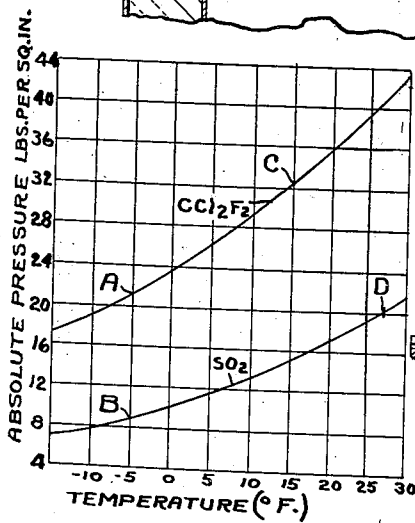


FIG. 3.

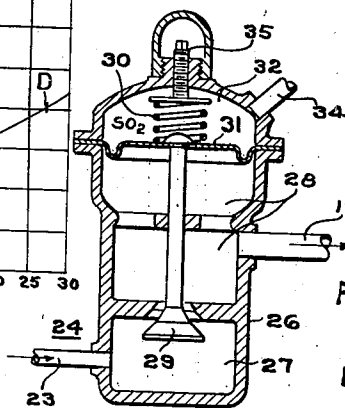


FIG. 2.

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REFRIGERATING APPARATUS AND METHOD

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10 Claims. (Cl. 62-4)

My invention relates to refrigeration and has for an object to provide an improved method and apparatus for controlling the operation of a refrigerating element.

A further object of my invention is to provide an improved method and apparatus for controlling the effective cooling area of an evaporator structure.

A still further object of the invention is to provide an improved two temperature refrigerator which is inexpensive to produce.

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 refrigerator embodying my improved apparatus;

Fig. 2 is a diagrammatic sectional view of a detail employed in the apparatus shown in Fig. 1; and

Fig. 3 is a diagram showing the pressure-temperature characteristics of two volatile fluids which may be employed in my improved apparatus.

Reference will now be had to the drawing wherein I have shown my invention applied to apparatus including a cabinet structure 10 having relatively low and high temperature cooling chambers 11 and 12 formed therein and cooled by respective evaporator elements 13 and 14. The evaporator 13 receives refrigerant in preference to the evaporator 14 and the two may be connected in series, as shown, for the flow of refrigerant.

A refrigerant condensing unit 15 circulates refrigerant through the evaporators 13 and 14 and includes a compressor 16 driven by a motor 17, and a condenser 18, the latter being cooled in any suitable manner such as, for example, by a motor driven fan 19. Vaporous refrigerant is withdrawn from the evaporator 14 by the compressor 16 through a conduit 21 and is compressed to a relatively high pressure in the condenser 18 wherein it is cooled and condensed. The condensed refrigerant is delivered to a reservoir 22 that is connected to the evaporator 13 by a conduit 23. An expansion device 24 is disposed in the conduit 23 for reducing the pressure of the refrigerant whereby it may be vaporized at relatively low temperature.

The foregoing apparatus operates on the well-known compressor-condenser-expander refrigerating cycle. When the chamber 11 is to be

cooled, vaporization of refrigerant is effected in the evaporator 13 only and the vapor passes through a connection 25 to the evaporator 14 and thence through conduit 21 to the compressor 16. At this time, the device 24 controls the admission of condensed refrigerant so that only gaseous refrigerant is discharged to the evaporator 14.

Refrigeration of the chamber 12 is effected by evaporating refrigerant in the evaporator 14, at which time the evaporator 13 is filled with liquid refrigerant. The device 24 admits refrigerant in quantities sufficient to effect overflow of condensed refrigerant into the evaporator 14 through the connection 25. Refrigerant may be vaporized in both evaporators 13 and 14 at this time, but it is principally vaporized in the evaporator 14 due to the higher temperature thereof.

The means for effecting the foregoing operation will now be described. Reference will be had to the device 24 that is shown enlarged in section in Fig. 2. While other forms of expansion devices may be employed in accordance with my invention, I prefer to construct the device 24 similar to a conventional thermostatic expansion valve, but operating differently therefrom. The device 24 includes a casing 26 having chambers 27 and 28 formed therein, which communicate, respectively, with the liquid conduit 23 and the evaporator 13. A valve 29 controls communication between the chambers 27 and 28 and is actuated by a diaphragm 31 that is subjected to the pressure of the refrigerant in the chamber 28 and evaporator 13.

The casing 26 preferably defines a chamber 32 above the diaphragm 31 that communicates with a container or bulb 33 by means of a conduit 34. The bulb 33 contains a volatile fluid and is secured in heat exchange relation with the connection 25. The pressure of the volatile fluid in the bulb 33, conduit 34 and chamber 32 is a function of the temperature of the refrigerant within the connecting conduit 25 and is impressed on the upper side of the diaphragm 31. Accordingly, the pressure corresponding to the saturated temperature of the refrigerant in the evaporator 13 biases the valve 29 in closing direction and the pressure in the chamber 32, which varies with the temperature of the refrigerant discharged through the connecting conduit 25, biases the valve 29 in valve opening direction. An adjustable spring 30, biasing the valve in valve opening direction, may be employed for adjusting purposes to be referred to hereinafter. I have disclosed the device 24 diagrammatically for the sake of clearness and it will be understood that, in practice, refinements

not necessary for the purpose of illustration would be employed. For example, the device 24 would be so constructed that transfer of heat between the chambers 28 and 32 is minimized.

5 In accordance with my invention, I employ fluid in the bulb 33 which has different temperature pressure characteristics than the characteristics of the refrigerant employed, in that the pressure of the fluid varies less with a given change in
10 temperature than the pressure of the refrigerant. As an example, sulphur dioxide (SO_2) may be provided in the bulb 33 when dichlorodifluoromethane (CCl_2F_2) is employed as the refrigerant in the system. The curves shown in Fig. 3 dis-
15 close, approximately, the pressure-temperature characteristics of these fluids.

A valve of the character described in the foregoing controls the superheat in the vapor discharged from the evaporator 13 in such manner
20 that the superheat is relatively high when the pressure and saturated temperature of the refrigerant is high and progressively decreases the amount of superheat in the vapor as the pressure and saturated temperature is reduced.

25 Accordingly, the evaporator 13 contains a relatively small amount of liquid when the temperature of vaporization is high, which liquid is vaporized and superheated before passing through the conduit 25 to the evaporator 14. When the tem-
30 perature of vaporization in the evaporator 13 is depressed to a predetermined value, the superheat is reduced to zero and the evaporator 13 is filled with liquid refrigerant which passes through the conduit 25 to the evaporator 14 wherein it is
35 vaporized.

The foregoing operation may be made clear by considering pressures and temperatures of the fluids above and below the diaphragm 31
40 under two different temperatures of vaporization in the evaporator 13. It will be assumed that the superheat is zero when the temperature of the refrigerant (CCl_2F_2) is -5°F ., so that liquid refrigerant passes through the conduit 25 to the
45 evaporator 14. The pressure of the refrigerant impressed on the under side of the diaphragm 31 is approximately $21\frac{1}{2}$ lbs. per sq. in. absolute as shown at "A" in Fig. 3. As the temperature of the fluid (SO_2) in the chamber 32 is also -5°F ., the pressure thereof is approximately 9 lbs. per
50 sq. in. absolute as shown in Fig. 3 at "B". This represents a pressure differential of $12\frac{1}{2}$ lbs. per sq. in. on the diaphragm which is opposed by the bias of the spring 30. Under these pressure values, the valve 29 is actuated to admit liquid
55 refrigerant in such quantities that the evaporator 13 is filled and overflow into the evaporator 14 is effected.

When the temperature of vaporization in the evaporator is 15°F ., the absolute pressure of the
60 refrigerant in the evaporator 13 and the chamber 28 is approximately $32\frac{1}{2}$ lbs. per in. absolute as shown at "C" in Fig. 3. As the bias of the spring 30 represents $12\frac{1}{2}$ lbs. per sq. in., the pressure of the fluid above the diaphragm equals the
65 difference or 20 lbs. per sq. in. absolute. Sulphur dioxide, at 20 lbs. per sq. in. absolute, corresponds to a temperature of approximately 27°F . as shown at "D" in Fig. 3, or the temperature of the vapor passing through the conduit 25. Accord-
70 ingly, the vapor is superheated 12°F . when vaporized at 15°F .

From the foregoing, it will be apparent that the amount of superheat in the vapor leaving the
75 evaporator 13 will be progressively decreased as the saturated temperature decreases from 15°F .

to -5°F . and that the amount of liquid refrigerant in the evaporator 13 will progressively increase until it overflows into the evaporator 14 at -5°F . The temperature at which superheating of the refrigerant ceases may be varied by adjusting the bias of the spring 30. Suitable means may be provided for adjusting the spring 30, such as for example, a screw 35 projecting exteriorly of the casing 26. Increasing and decreasing the bias of the spring 30 respectively increases and de-
10 creases the saturated temperature within the evaporator 13 at which superheating ceases.

Automatic control of the operation of the condensing unit 15 in response to temperature conditions within the chambers 11 and 12 may be
15 provided. As shown, a thermostat 36 of the gas type and responsive to the temperature of the evaporator 13, may be employed for actuating a switch 37 that controls energization of the compressor motor 17. The source of power for the
20 motor 17 is represented by line conductors L_1 and L_2 . A thermostat 38, shown by way of example of the expansible metal type and responsive to the temperature of the air in the chamber 12, may also control operation of the condensing
25 unit 15. The thermostat 38 may be connected in parallel with the thermostat 36, as shown.

Operation

As shown in the drawing, both thermostats 36
30 and 38 are in their circuit open position as the temperature of evaporator 13 and the air within the chamber 12 are below values at which the respective thermostats close and energize the
35 motor 17. Assume a rise in the temperature of the evaporator 13 to a value of 15°F ., for example. The switch 37 is closed and operation of the condensing unit 15 is initiated. Refrigerant is circulated through the evaporators 13 and 14 and the device 24 operates to maintain a relatively high superheat in the refrigerant evapo-
40 rated in the evaporator 13. The refrigerant vapor passes through the conduit 25 and the evaporator 14 and is further superheated as described heretofore.

The temperature of the evaporator 13 is gradually reduced to a value of say -3°F . at which
45 temperature the thermostat 36 acts to open the switch 37 whereby the condensing unit 15 stops and circulation of refrigerant ceases. During the refrigeration of the evaporator 13, the superheat in the vapor is gradually reduced and the effective cooling area of the evaporator 13 gradually in-
50 creases. The superheat in the vapor at -3°F . is of relatively low value so that only superheated vapor is passed to the evaporator 14 during refrigeration of the evaporator 13. In this connection, it will be assumed that superheating of the vapor in the evaporator 13 ceases at -5°F .

When the temperature of the air in the chamber 12 increases to a predetermined value, the
55 thermostat 38 effects operation of the condensing unit 15 for the circulation of refrigerant. Cooling of the evaporator 13 is first effected until its temperature is depressed to -5°F . or the temperature at which liquid refrigerant is passed to the evaporator 14. Vaporization is effected in the evaporator 14 for cooling air in the chamber 12 and continues until the tem-
60 perature thereof is depressed to the desired value at which time the thermostat 38 opens and terminates operation of the condensing unit 15.

From the foregoing, it will be apparent that cooling of the evaporator 13 precedes cooling of the evaporator 14 when the latter requires cool-

ing as vaporization can only be effected in the evaporator 14 when the temperature of the evaporator 13 is depressed to -5° F. in the example under consideration.

When both thermostats 36 and 38 call for cooling, the condensing unit operates to circulate refrigerant. The thermostat 36 opens at -3° F. but energization of the motor 17 is continued by the thermostat 38. Circulation of refrigerant, therefore, continues and as the temperature of the evaporator 13 is depressed to -5° F., superheating of the vapor in the evaporator 13 ceases and liquid refrigerant passes to the evaporator 14. This operation continues until the thermostat 38 is satisfied and operates to terminate operation of the condensing unit 15.

The form of control system described is shown by way of example and it will be understood that other forms may be employed to control a refrigerating system constructed in accordance with my invention.

From the foregoing, it will be apparent that I have provided an improved method and apparatus for controlling the operation of a refrigerating element wherein the effective cooling area thereof progressively increases as the temperature and pressure of vaporization therein decreases. It will be apparent, furthermore, that I have provided a novel two temperature refrigerator which is simple in construction and which may be inexpensively produced.

It is to be understood that the specific forms of the refrigerator cabinet structure and of the condensing unit disclosed are shown by way of example and that other suitable forms of these elements may be employed equally well without departing from the spirit of my invention.

While I have shown the device 24 for controlling the vaporization of refrigerant and the effective area of the evaporator structure as a thermostatic expansion valve, it will be understood that my invention contemplates the employment of other suitable devices for this purpose.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various 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 controlling the operation of first and second refrigerant evaporators which comprises, admitting condensed refrigerant to the evaporators in such manner that it flows into the first evaporator in preference to the second evaporator, conveying vaporized or condensed refrigerant from the first evaporator to the second evaporator, and controlling the superheat in the refrigerant conveyed from the first to the second evaporator in such manner that the superheat progressively decreases as the pressure of the refrigerant progressively decreases, whereby superheated refrigerant vapor is conveyed to the second evaporator when the pressure of the refrigerant is relatively high and liquid refrigerant is conveyed to the second evaporator when the pressure is relatively low.

2. In refrigerating apparatus, the combination of relatively low and high temperature evaporators, means for supplying refrigerant to the evaporators, and first and second temperature

responsive means for controlling the operation of the refrigerant supply means, said first temperature responsive means being effective to operate the refrigerant supply means so that vaporization is effected in the low temperature evaporator and said second temperature responsive means being effective to operate the refrigerant supply means so that vaporization is effected first in the low temperature evaporator and thence in the higher temperature evaporator.

3. In refrigerating apparatus, the combination of first and second evaporators, means for supplying condensed refrigerant to the evaporators so that the condensed refrigerant flows into the first evaporator in preference to the second evaporator, and means for controlling the flow of condensed refrigerant to the evaporators in response to the superheat of the refrigerant vaporized in the first evaporator, said means effecting a relatively high superheat when the pressure of the vaporized refrigerant is relatively high and progressively decreasing the amount of superheat in the vaporized refrigerant as its pressure decreases, whereby the amount of liquid refrigerant in the first evaporator increases as its pressure decreases until liquid refrigerant substantially fills the first evaporator and overflows into the second evaporator when the pressure is reduced to a predetermined value.

4. In refrigerating apparatus, the combination of first and second evaporator elements, means for condensing refrigerant vaporized in the evaporator elements, means for conveying the condensed refrigerant to said evaporator elements in such manner that the condensed refrigerant flows into the second element only after the first element is filled with condensed refrigerant, and means responsive to the superheat of the refrigerant vaporized in the first evaporator element for controlling the admission of condensed refrigerant to the evaporator elements, said controlling means effecting high superheat when the temperature of the vaporized refrigerant is relatively high and zero superheat when the temperature of the vaporized refrigerant has been reduced to a predetermined low value, at which time condensed refrigerant is passed to the second evaporator element.

5. In refrigerating apparatus, the combination of first and second evaporators, means for supplying condensed refrigerant to the evaporators so that the condensed refrigerant flows into the first evaporator until filled and thence into the second evaporator, means responsive to the difference in the saturated and superheated temperatures of the refrigerant vaporized in the first evaporator for controlling the flow of condensed refrigerant to the evaporators, said means effecting a progressive reduction in said temperature difference as the pressure and saturated temperature of the refrigerant is decreased, whereby the first evaporator is partly filled with liquid refrigerant when its temperature is relatively high and is substantially filled with liquid refrigerant when its temperature is depressed to a predetermined value, at which time liquid refrigerant is delivered to the second evaporator for vaporization therein.

6. In refrigerating apparatus, the combination of means defining low and higher temperature cooling chambers, first and second evaporators disposed for cooling the low and higher temperature chambers, respectively, said first and second evaporators being connected in series in the order named for the flow of refrigerant therethrough,

circulating means for withdrawing vaporous refrigerant from the second evaporator and for translating condensed refrigerant to the first evaporator and a device for controlling the flow of condenser refrigerant and responsive to the superheat of the refrigerant vaporized in the first evaporator, said device being so constructed and arranged that the superheat in the vapor is progressively reduced as the pressure of the refrigerant is reduced, whereby the portion of the first evaporator which contains liquid refrigerant progressively increases as the pressure of vaporization decreases; the arrangement being such that superheated vapor is admitted to the second evaporator when the pressure and temperature of the refrigerant in the first evaporator is relatively high and liquid refrigerant is admitted to the second evaporator for vaporization therein when the pressure of the refrigerant is relatively low.

7. The combination as claimed in claim 6 including first and second means responsive to respective temperatures in the low and higher temperature cooling chambers for controlling the operation of the circulating means.

8. In a refrigerating system, the combination of a source of condensed refrigerant, an evaporator, a valve for controlling the admission of the condensed refrigerant to the evaporator, a pressure responsive device actuated by the pressure of the refrigerant vaporized in the evaporator for actuating the valve, and an element responsive to the final temperature of the vaporized refrigerant and having a volatile fluid therein, the pressure of which is a function of said final temperature and which is impressed on the pressure responsive device in opposition to the pres-

sure of the vaporized refrigerant, said volatile fluid having pressure-temperature characteristics which differ from the pressure temperature characteristics of the refrigerant controlled thereby in that the pressure of the volatile fluid varies less with a given change in temperature than the pressure of the refrigerant.

9. The method of operating a refrigerant evaporator having a passage in which liquid refrigerant is admitted to one end and is removed from a second end as a vapor or a liquid, which includes applying heat to the refrigerant as it passes through the passage, evaporating the liquid refrigerant at saturation temperature, raising the temperature of the vapor, controlling the admission of the liquid to the passage in accordance with the difference between the final superheat temperature and the saturation temperature, and progressively reducing said temperature difference to zero as the saturation temperature is reduced to a predetermined value, whereby the portion of the passage containing liquid moves progressively toward said second end until liquid is discharged therefrom.

10. The method of controlling the operation of a refrigerant evaporator which comprises admitting condensed refrigerant to a portion of the evaporator for vaporization, withdrawing the vaporous refrigerant from a second portion of the evaporator, controlling the admission of condensed refrigerant to the evaporator in response to predetermined values of the superheat in the withdrawn vapor and progressively reducing said superheat values in response to progressive reductions in the pressure and temperature of the vaporous refrigerant.

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CERTIFICATE OF CORRECTION.

Patent No. 2,133,950.

October 25, 1938.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 61, after the word "per" insert sq.; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of December, A. D. 1938.

Henry Van Arsdale |

(Seal)

Acting Commissioner of Patents.