Dec. 8, 1936. A. F. EVERS, JR 2,063,496

METHOD OF REFRIGERATION

Original Filed July 8, 1935 2 Sheets-Sheet 1

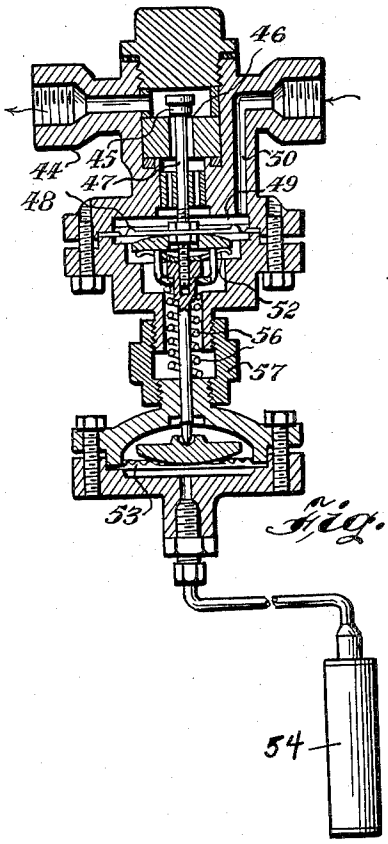


Fig. 1.

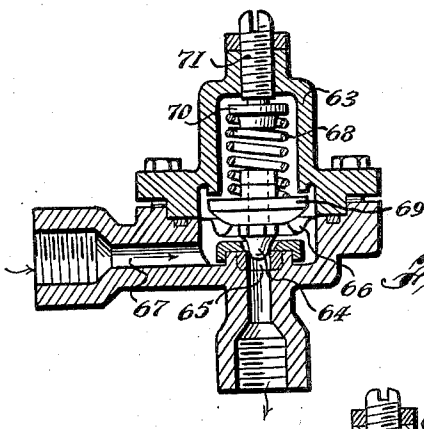


Fig. 2.

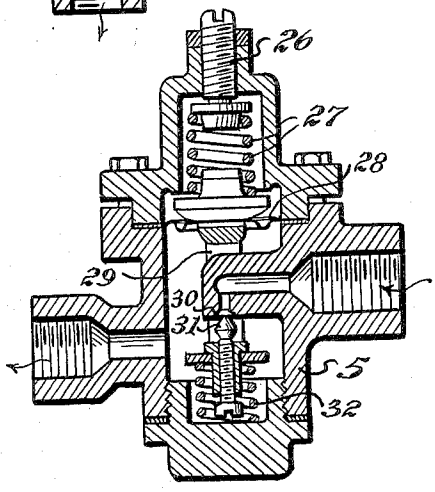


Fig. 3.

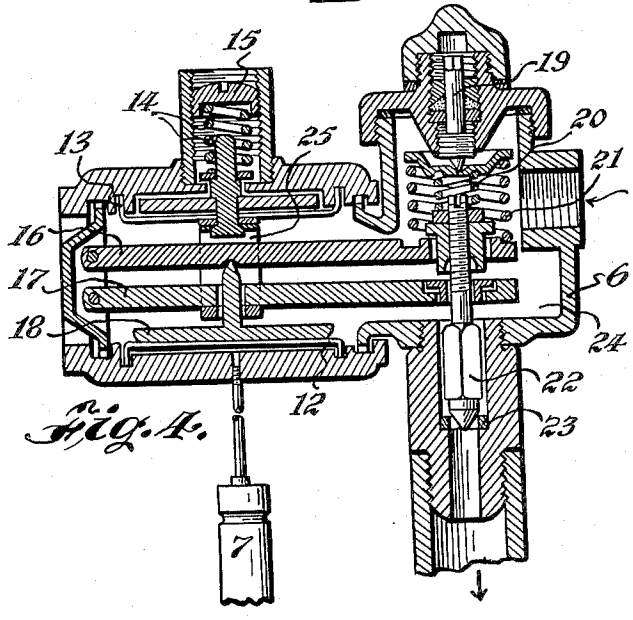


Fig. 4.

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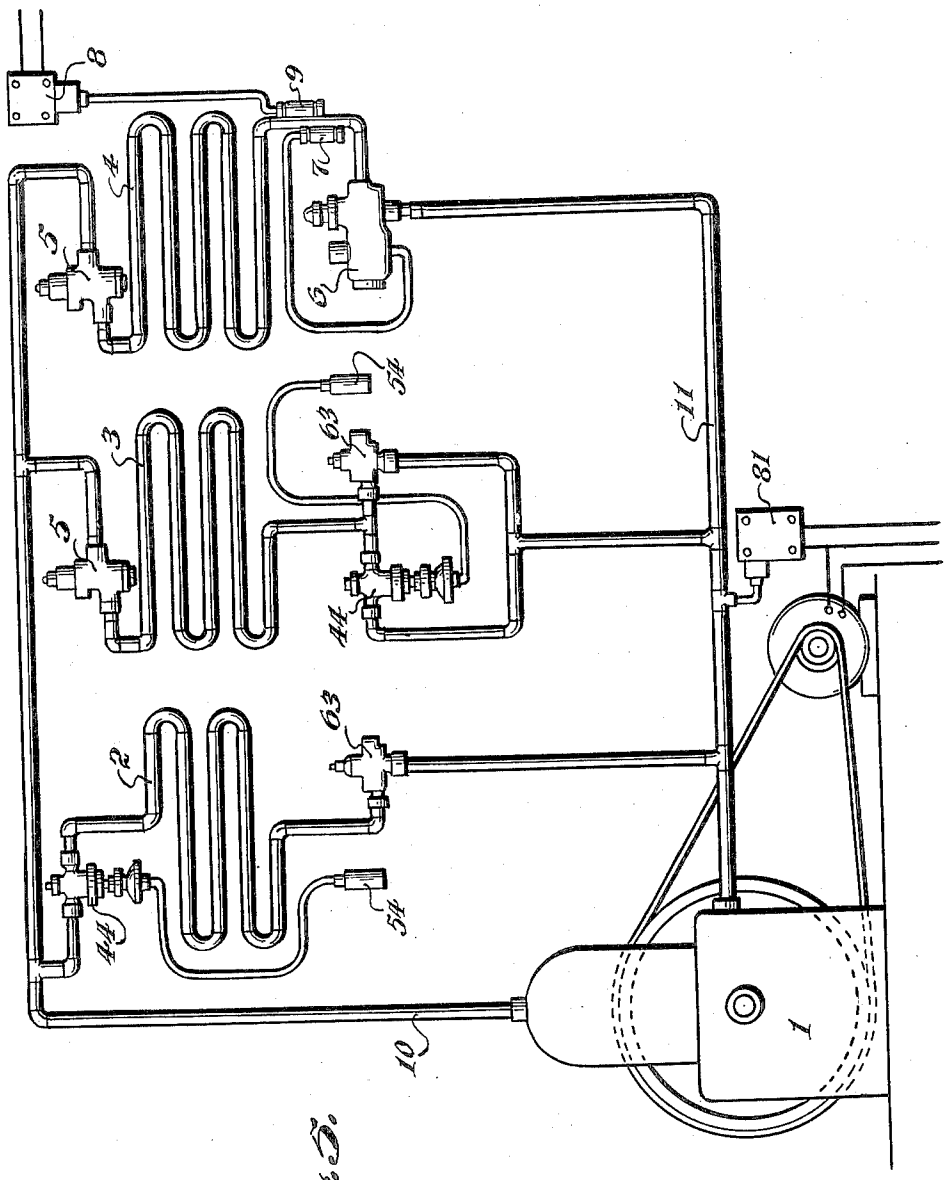


Fig. 2.

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Patented Dec. 8, 1936

2,063,496

UNITED STATES PATENT OFFICE

2,063,496

METHOD OF REFRIGERATION

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Original application July 8, 1935, Serial No. 30,337. Divided and this application November 2, 1935, Serial No. 48,028

2 Claims. (Cl. 62—8)

My invention relates to improvements in methods of refrigeration and it consists in the combinations, constructions and arrangements herein described and claimed.

This application is a division of my earlier filed application Serial No. 30,337, now matured into Patent No. 2,053,365.

In particular my invention relates to multi-temperature refrigeration systems where two or more evaporators are maintained at different temperatures by a single compressor. The method employed is of the type whereby an evaporator's temperature is thermostatically controlled at its outlet.

An object of my invention is to provide a comparatively cheap multi-temperature refrigeration system.

A further object is to provide a comparatively simple multi-temperature refrigeration system.

A further object is to provide a thoroughly reliable multi-temperature refrigeration system in which the isolated evaporator has the following control qualifications:

(*a*) capability of using a simple pressure reducing inlet valve thereby obtaining a constant refrigerating pressure,

(*b*) individual self-contained (non-electric) thermostatic outlet control means,

(*c*) efficient control means whereby the refrigerating effect is quickly changed from full off to full on condition and likewise reversed quickly,

(*d*) a method of thermostatic control which while producing a snap action effect nevertheless utilizes pressure actuated means devoid of secondary spring-loaded differential snap mechanisms such as toggle joints, latching devices or snapping spring discs and diaphragms,

(*e*) reliable thermostatic outlet control means in which the evaporator pressure is both constantly and usefully in opposition to the thermostatic pressure.

Other objects and advantages will appear in the following specification and the novel features of the invention will be particularly pointed out in the appended claims.

My invention is illustrated in the accompanying drawings forming part of this application in which

Figure 1 is a vertical sectional view of a well known type of thermostatically controlled valve.

Figure 2 is a vertical sectional view of a well known type of outlet or constant pressure valve.

Figure 3 is a vertical sectional view of a well known type of expansion or pressure reducing valve.

Figure 4 is a vertical sectional view of my new thermostatically controlled outlet valve, same being designed expressly for the circuit described in the following specification.

Figure 5 is a diagrammatic representation of a circulating multi-temperature refrigeration system embodying the present invention illustrating three evaporators connected to the system in parallel arrangement.

The refrigeration system represented in Figure 5 is complete and includes a high side or complete compressing unit, a low side including the three evaporators **2**, **3**, and **4** together with their control valves and the necessary electrical controls which may be either of the pressure or the temperature type. Since the operation of a common multi-temperature refrigeration system is well known and as numerous parts of the system represented in Figure 5 are in common usage I shall give a detailed description only of those parts which relate closely to my invention. The control valves **44**, **63**, and **5** shown in section in Figures 1, 2, and 3 respectively, and their operation are well known so my description of them will be only of a limited nature.

In Figure 5 the high side **1** together with the evaporator **2** and its controls form a well known type of refrigeration system. Liquid refrigerant coming from the high side **1** is conducted to the thermostatic expansion valve **44** by the liquid line **10**. Entering the valve **44** it is here regulated in pressure for efficient heat absorption after which it is passed into the evaporator **2**. After passing through the evaporator **2** the refrigerant, now in a gaseous form but still under control, discharges through the outlet valve **63**. From here it is conveyed by the suction line **11** back to the high side **1**.

The above-described circuit, being well known, will not be dwelt upon in length here. The feature of this circuit which I wish to point out specifically is that its control is effected through the thermostatically controlled inlet valve **44** whose pressure chamber **49** and passageway **50** form an outlet from same for the refrigerant. A more detailed description of this refrigeration circuit may be had by referring to Patent No. 1,185,597—A. H. Eddy—May 30, 1916.

At this point in my description I wish to call attention to the fact that in multi-temperature refrigeration systems the evaporator which requires isolating control mechanism is never the coldest evaporator. Also it may be noted that the controls herein referred to unless otherwise specified are refrigerant valves.

In Figure 5 the high side 1 together with the evaporator 3 and its controls 44, 63, and 5 illustrate my new circuit. Starting with a warm evaporator, liquid refrigerant coming from the high side 1 enters the expansion valve 5. Here its pressure is so regulated that it will absorb heat efficiently at the low temperature which the evaporator 3 is to reach, after which it flows into same. After passing through the evaporator 3 the refrigerant, now in a gaseous form but under a constant set pressure, enters the pressure chamber 49 of the valve 44 by way of the passageway 50. Continuing through the open valve 44 the refrigerant returns to the high side 1 by way of the suction line 11. Here it may be noted that the refrigerant's path of travel through the outlet valve 44 is in reverse order to the direction which it followed in passing through the inlet valve 44 connected to the evaporator 2.

Thus far the action of the evaporator 3 is under the following conditions: the compressor is in motion, the outlet valve 63 closed, the pressure in the evaporator 3 at a constant set value and the temperature of the bulb 54 sufficiently high that its liquid's corresponding pressure, which is exerted together with the force of the springs 52 and 56 against the under side of the diaphragm 48, is sufficient to overcome the combined pressures of all opposing regulatory forces which bear against the upper side of the diaphragm.

In the valve 44 which is of an older type using a thermal liquid of low volatility the number of springs used and their arrangement is somewhat different from that of present day valves which generally use a more volatile liquid. The principle of operation, however, remains the same. The regulatory force which bears against the upper side of the diaphragm 48 is, in this instance, the constant or refrigerating pressure in the evaporator 3 which is governed by the inlet valve 5.

Refrigeration taking place the bulb 54 is cooled simultaneously with the evaporator 3 down to a temperature point where its thermal liquid's corresponding pressure on the under side of the diaphragm 48 is insufficient, together with the additional force of the springs 52 and 56, to withstand the constant refrigerating evaporator pressure which bears against the upper side of this diaphragm. The downward movement of the diaphragm 48 now closes the valve disc 45 first lightly and then firmly against the seat 46 thereby stopping the refrigerating cycle with an unhesitating, complete movement.

To explain this latter action it may be observed that the instant the valve disc 45 is closed lightly the boiling refrigerant in the evaporator 3 raises the pressure in same. The reasons for this occurrence being well known will not be discussed here. Being operable likewise against the diaphragm 48 this increase in pressure is transmitted to the valve disc 45.

Simultaneously the first rise in pressure closes also the expansion valve 5. All three valves connected to the evaporator 3 are now in a closed position. As the boiling refrigerant continues to raise the pressure it is released by the outlet valve 63 at a predetermined setting which, in the present instance, is a few pounds per square inch higher in value than the constant or refrigerating pressure heretofore maintained in the evaporator 3 by the expansion valve 5. In addition to its designated function the outlet valve 63 by its setting governs also the starting or cutting-in point of the evaporator 3. When the temperature of the evaporator 3 together with that of the bulb 54 rises that number of degrees which corresponds to the difference in the pressure settings of the valves 63 and 5, the thermal pressure on the under side of the diaphragm 48 will rise sufficiently to overcome the upper side opposing back pressure causing the valve disc 45 to open. The pressure in the evaporator 3 now drops to its constant or refrigerating value, the valve disc 45 opens to its maximum position thereby starting the refrigerating cycle with an unhesitating complete movement, the valve 5 functions in an intermittently open position, refrigeration takes place and the cycle is completed.

With the evaporator 4 I have substituted my new combination outlet valve 6 in place of the special combination of the valves 44 and 63 as shown. This substitution while increasing the cheapness and, due to the needle and seat arrangement, the efficiency of the system, nevertheless retains the same operating principle effective with the evaporator 3.

Liquid sulphur dioxide, for example, coming from the high side 1 enters the expansion valve 5. Here its back pressure is reduced to 2 pounds gauge pressure. This value is now held both in the evaporator 4 and the pressure chamber 24 of the valve 6 as long as refrigeration takes place. When the temperature in the evaporator 4 reaches a predetermined low point, 38 degrees Fahrenheit for example, the bulb 7 is cooled sufficiently whereby its liquid's thermal pressure on the under side of the diaphragm 12 is overcome by the combined forces exerting against the upper side of the diaphragm, namely 2 pounds evaporator pressure and springs 20 and 21. The valve 6 is now closed and the boiling refrigerant in the evaporator 4 and the valve 5 causes a rise in pressure in these two members, likewise in the pressure chamber 24 of the valve 6. This rise in pressure firmly closes the valves 5 and 6.

As the refrigerant in the evaporator 4 continues to boil and its pressure rises to 7 pounds per square inch the resistance of the springs 14 and 20 which directly and indirectly, respectively, bear against the upper side of the diaphragm 13, together with the refrigerant pressure holding the needle 22 against the seat 23, is overcome causing the needle to be raised.

The valve 6 is now functioning as an outlet valve and the pressure in the evaporator 4 remains constant at 7 pounds gauge reading. The remaining refrigerant in the evaporator 4 continues to boil and pass on to the high side 1 until finally only enough is left to maintain the 7 pounds leaving the needle 22 closed. As the temperature of the evaporator 4 together with that of the liquid in the bulb 7 rises the corresponding thermal pressure under the diaphragm 12 increases to the point where it now overcomes all the forces which bear against the upper side of the diaphragm, namely the refrigerant pressure 7 pounds in addition to the springs 20 and 21. The needle 22 is now raised and the pressure in the evaporator 4 and the valves 5 and 6 is immediately reduced to 2 pounds per square inch, refrigeration takes place and the cycle is completed.

Any interruption in the compressor's motion will, of course, halt the above-described action and possibly permit a pressure higher than 7 pounds to build up in the evaporator 4. However immediately the motor is restarted the performance of the evaporator together with that

of its valves will follow the course of action just outlined.

The operation of the evaporator 4 thus far has been without provision for electrical control of the compressor 1. This may be accomplished by using the pressure type thermostatic switch 81 which is so regulated that its turning-on point is not higher than that pressure value which is the lowest possible in the evaporator 4, which in the present illustration is 2 pounds per square inch gauge pressure. This arrangement permits the switch 81 to start the motor immediately the valve 6 is opened. When the valve 6 closes, providing the other evaporators in the system are refrigerated, the switch 81 is opened by the compressor's suction.

Should a temperature type of thermostatic control be desired it may be the switch 8 whose bulb 9 is mounted in close thermal contact with both the evaporator and the bulb 7.

The metering means which I have illustrated in connection with the evaporators 3 and 4 has been the expansion valve 5. I do not limit my new circuit to this type of inlet control. For an example, it is quite possible to use the thermostatic inlet valve 44 shown connected to the evaporator 2 in its same relative position with the evaporator 4.

For best results when it is desired to use the inlet valve 44 in conjunction with the evaporator 4 and the outlet valve 6 its bulb 54 should be in loose thermal contact with the evaporator, the same as it is shown with the evaporator 2. Also the thermic receptacle 54 should have only a limited charge of thermal liquid. This arrangement permits the liquid in the bulb 7 to exert both a higher and a lower thermal pressure than the co-incidental value within the bulb 54 or in other words a wider pressure differential thereby performing in substance the same function relative to the evaporator back pressure as was originally obtained. In this particular arrangement the evaporator's refrigerating pressure may be described as being under limited thermostatic control, thereby properly distinguishing same from the somewhat similar, as regards control effect, constant pressure condition maintained by the valve 5.

Observing the action of the evaporators 3 and 4 it is now evident that their control is effected thermostatically at their outlets. Starting the cycle with a warm evaporator, upon its temperature reaching a desired low point the controlled refrigerating back pressure overcomes a falling thermostatic pressure. At this point the evaporator is closed, refrigeration is stopped and the control mechanism in a state of balance which may be upset by a change in value of either the back pressure or the thermostatic pressure. By permitting the back pressure to rise only that amount whose equivalent in temperature is the desired differential, the subsequent rise in thermostatic pressure overcomes the back pressure at a desired high temperature thereby opening the evaporator, reducing the back pressure to its refrigerating value and completing the cycle.

While the design of the complete evaporators 3 and 4 is conventional I do not hold my new circuit to these particular forms. Without changing the principle of operation is is quite possible to employ different forms.

For an example, the inlet valves 5 may be close coupled to both the valves 44 and 63 and to the valve 6 thereby placing the larger part of the evaporators 3 and 4 in direct connection with the suction line 11. Such an arrangement would still leave the pressure chambers of all the valves to function as parts of the evaporators and the operating principle would remain unchanged.

In the structure of the valve 6 I provide a gas-tight housing 6, a temperature responsive means consisting primarily of the closed volatile liquid chamber lying immediately under the diaphragm 12, said chamber extending through a capillary tubing to the sensitive bulb 7. The diaphragm 12 is constantly subject on the one side to the thermostatic pressure originating in bulb 7 and constantly subject on the other side to the evaporator pressure which always exists inside the housing 6. Through the retaining plate 18 the diaphragm 12 bears upwardly against the midsection of the lever 16.

The lever 16 is hinged at the one end to a side wall of the housing while the other end is acted upon by the adjustable spring 21 also enclosed within the housing. The spring 21 opposes the thermostatic pressure. The spring end of the lever 16 terminates under an adjustable nut forming part of the needle 22 while the stuffing-box spindle 19 permits external adjustment of the spring 21.

The temperature responsive means just described bears upwardly against the needle 22 in such manner that a rise in temperature above a pre-determined setting will open the needle permitting refrigeration to take place while a fall in temperature reverses this movement. The small flexible spring 20 is positioned between the spindle 19 and the needle 22 and tends constantly to close the latter.

The function of the structure thus far described is identical to the function of the valve mechanism 44 shown in connection with the evaporator 3.

In the structure of the valve 6 I provide also a diaphragm 13 which forms a flexible upper wall of the housing 6 and is acted upon on the under side by the refrigerant pressure within the valve, this pressure being opposed on the upper side by atmospheric pressure in combination with the adjustable spring 14. The diaphragm 13 is connected through a flexible joint to the midsection of the lever 17 which is hinged at one end to a side wall of the housing 6 while the other end terminates under an adjustable bushing forming part of the needle 22. Any upward movement of the diaphragm 13 is transmitted to the needle, moving same to open position while a reverse movement permits the spring 20 to close the needle.

This secondly described structure is similar in function to the valve mechanism 63 and serves to vent what small portion of boiling refrigerant is left in the evaporator at the beginning of an off cycle, leaving only a very small quantity of vapor to aid in the valve's control.

The levers 16 and 17 bear upwardly against the needle 22 in such manner that they may work independently to lift same from the seat 23 which is positioned within a removable plug forming an outlet to the valve. The inlet to the valve is formed within the housing.

From the foregoing description it may now be seen that the function of the mechanism comprising the combination of valves 44 and 63 is identical to the function of the valve 6. It is further evident that the proper operation of the valve 6 will occur only when same is used in conjunction with an evaporator in which the refrigerating pressure is controlled by a diaphragm

actuated pressure reducing valve. This general type of expansion valve may be subdivided into two forms, an automatic which produces a constant refrigerating pressure, and a thermostatic which in the present arrangement may produce only a limitedly varying refrigerating pressure. In either instance the refrigerating pressure works in conjunction with the outlet valve 6 and the relation of the two types of refrigerating pressures toward the valve 6 may be termed "constant" and "effectively constant" respectively.

The novel feature of the method of refrigeration herein described is that at the evaporator's outlet the evaporator pressure is both constantly and usefully in opposition to the thermostatic controlling pressure.

I claim:

1. In a circulating multi-temperature refrigeration system as described and in an evaporator in which the refrigerating pressure is held constant by a diaphragm actuated inlet valve, that method of controlling said evaporator's temperature at its outlet which consists in first utilizing the evaporator's refrigerating pressure to overcome a constantly opposing thermostatic controlling pressure when a desired low temperature is reached thereby stopping refrigeration by closing the evaporator outlet, second in a pressure relieving manner halting the ensuing rise in the evaporator's idle pressure when same corresponds to that temperature which is the upper limit of the desired evaporator temperature range and finally in utilizing said thermostatic pressure to overcome said idle pressure thereby starting refrigeration by opening said evaporator outlet, completing the cycle.

2. In a circulating multi-temperature refrigeration system as described and in an evaporator in which the refrigerating pressure is held limitedly thermostatically varying by a diaphragm actuated inlet valve, that method of controlling said evaporator's temperature at its outlet which consists in first utilizing the evaporator's refrigerating pressure to overcome a constantly opposing thermostatic controlling pressure when a desired low temperature is reached thereby stopping refrigeration by closing the evaporator outlet, second in a pressure relieving manner halting the ensuing rise in the evaporator's idle pressure when same corresponds to that temperature which is the upper limit of the desired evaporator temperature range and finally in utilizing said thermostatic pressure to overcome said idle pressure thereby starting refrigeration by opening said evaporator outlet, completing the cycle.

ADOLPH F. EVERS, JR.