

Sept. 20, 1949.

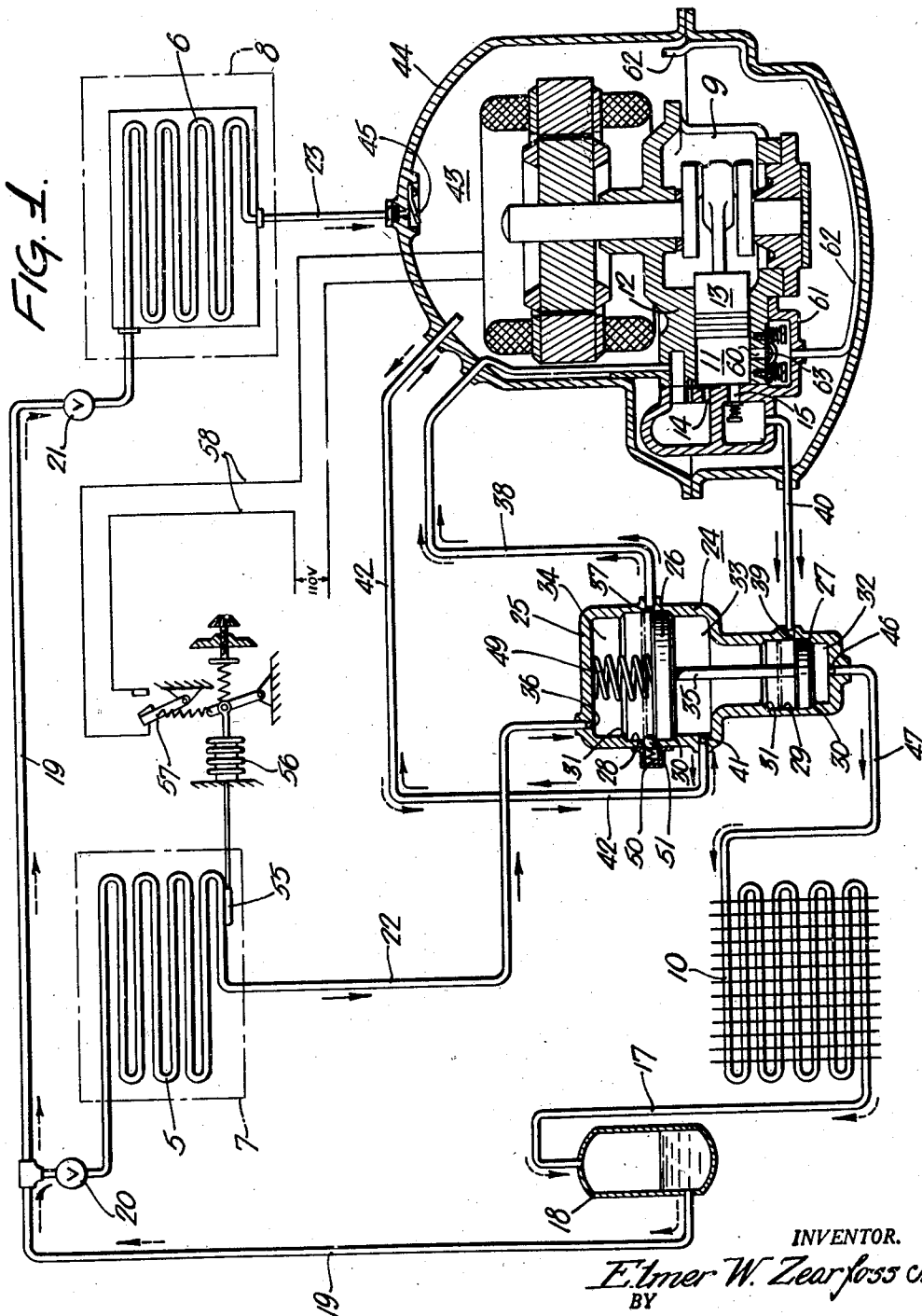
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2,482,569

TWO-TEMPERATURE REFRIGERATING SYSTEM

Filed Feb. 28, 1945

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

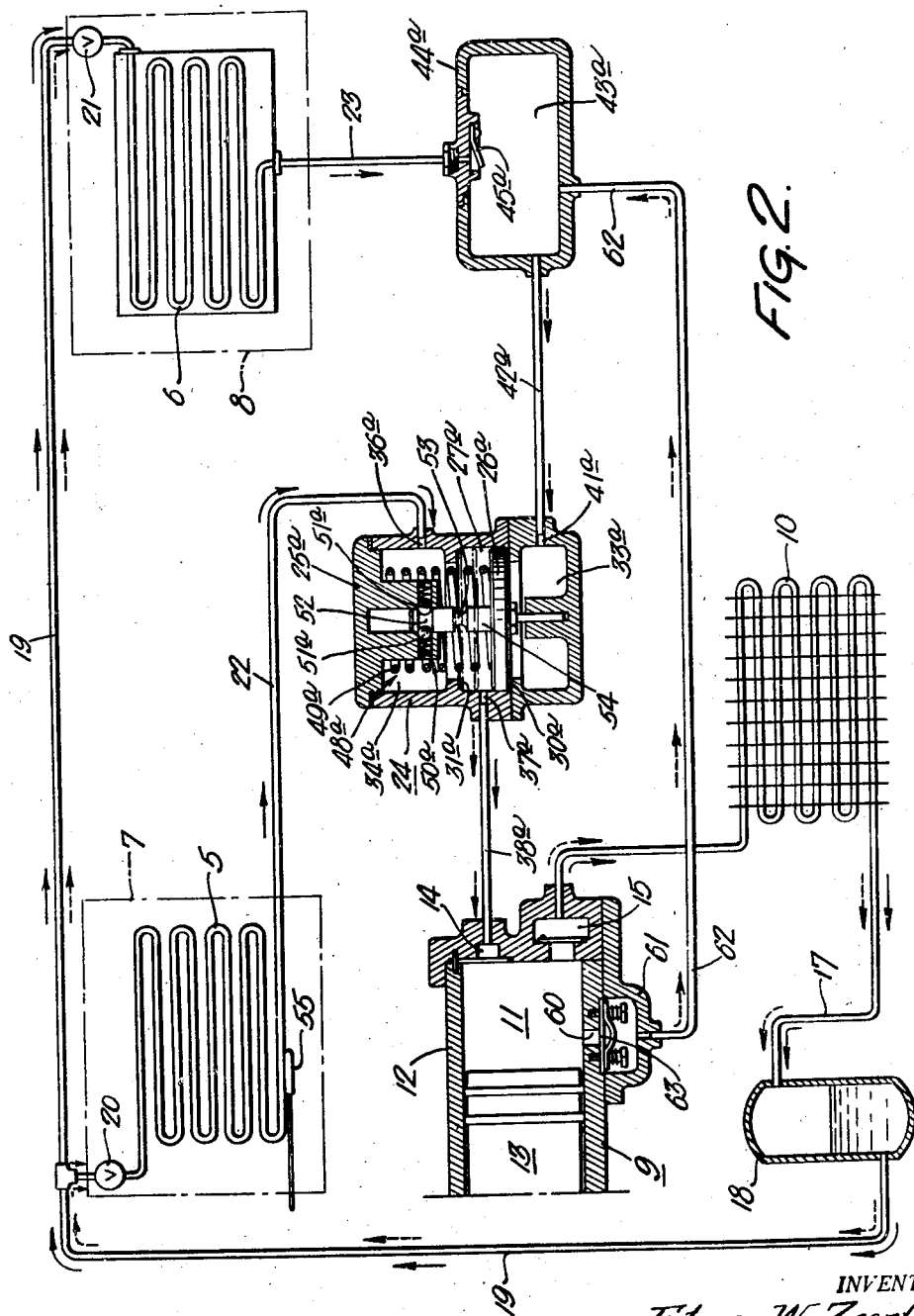


FIG. 2.

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2,482,569

TWO-TEMPERATURE REFRIGERATING SYSTEM

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Application February 28, 1945, Serial No. 580,108

12 Claims. (Cl. 62—115)

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The present invention relates to refrigeration and particularly to multi-temperature refrigerating systems. More especially, the invention is concerned with so-called two-temperature refrigerating systems and specifically pertains to an improved method and arrangement for obtaining two different refrigerating temperatures with a system including a single compressor and two separate evaporators which are respectively adapted to maintain two separate zones or isolated compartments at the different temperatures.

It is common knowledge in the art that, if an evaporator is capable of handling its refrigeration load, the temperature of the associated refrigerated zone or compartment will depend largely on the amount of evaporating refrigerant present within the evaporator and on the evaporating pressure. Therefore, if two or more evaporators included in one and the same system, are caused to operate at different pressures and are provided with an adequate supply of refrigerant, separate zones or isolated compartments with which the said evaporators are respectively associated may be effectively refrigerated and kept at different temperatures.

In the so-called two-temperature system including a single compressor and two separate evaporators (generally referred to as the low temperature evaporator and the high temperature evaporator, respectively), it has been proposed to utilize automatic temperature or pressure responsive means for controlling the flow of refrigerant through the system in accordance with rises, beyond pre-set limits, in the temperature or pressure of either or both of said evaporators. However, in such automatically controlled two-temperature system, one evaporator is given absolute preference over the other evaporator with the result that should the evaporator which has preference be under an unusually heavy load, the other evaporator may, in effect, be shut down for possibly dangerously long periods of time, because then the flow of refrigerant through the latter will be interrupted until the preferred evaporator is fully satisfied.

Attempts have been made to rectify this objectionable result by using either solenoid or pressure actuated valve mechanism controlled through temperature responsive means, such mechanisms functioning to transfer refrigerant from the evaporator which under normal conditions has preference, to the other evaporator when the temperature of the latter rises to an abnormally high value.

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The use of refrigeration control mechanisms of the kind above mentioned, not only complicates the system, but moreover introduces a number of critically related devices which in themselves are of a complicated nature, so that the proper function of the system no longer depends upon simple conditions within the system itself but must rely upon the accurate operation of each and every one of such devices.

It is an object of this invention to provide a system which is capable of affording two different refrigerating temperatures with two separate evaporators in circuit with a single compression chamber, and which is capable of keeping each evaporator within its desired temperature range without giving undue preference to either evaporator and without using complicated arrangements of intricate control devices.

It is also an object of the invention to provide a refrigerating system including two separate evaporators in circuit with a single compression chamber wherein the evaporators are operated respectively at different temperatures by controlling the flow of refrigerant directly in accordance with predetermined departures from an established state of balance between the suction pressure of one evaporator and the suction pressure of the other evaporator.

Another object of the invention is to provide a refrigerating system including a relatively low temperature evaporator and a relatively high temperature evaporator in circuit with a single compression chamber wherein said evaporators are maintained within their respective selected temperature ranges directly by conditions within the system itself.

Another object of the invention is to provide a two-temperature refrigerating system employing two evaporators operating at different pressures together with associated means for establishing an artificial balance between the evaporator pressures, said means being responsive to departures from said established pressure balance and operating to maintain the evaporators at their respective pressures and to thereby maintain the desired temperature range at which each evaporator is to function.

Still another and more specific object of the invention is to provide improved control means for a refrigerating system employing a plurality of evaporators adapted for operation at different suction pressures to refrigerate separate zones or isolated compartments at different temperatures, said control means functioning to establish a balance between such suction pressures and

being acted upon directly by predetermined departures from such established balance resulting from changes in the suction pressures in any or all of the evaporators, whereby flow of refrigerant through each evaporator is controlled in a manner to maintain the evaporator suction pressures within a given differential range and thereby tend to maintain a definite temperature difference between the evaporators.

Other objects and advantages of the invention will appear from the following description based upon the accompanying drawings in which:

Fig. 1 is a transverse vertical sectional view of a hermetic motor-compressor unit and control device incorporating the features of the invention and illustrating one embodiment of the improved two-temperature refrigeration system;

Fig. 2 is a semi-diagrammatic representation showing a slightly modified embodiment of the system.

As illustrated in the drawings, the refrigerating system contains at least two evaporators 5 and 6 respectively disposed within separate zones or isolated compartments 7 and 8 which are to be refrigerated and maintained at different temperatures.

The evaporators 5 and 6 are in circuit with a condensing unit which includes a motor-compressor 9 and a condenser 10. The motor-compressor 9 is of the type having a single compression chamber 11 which is defined by a cylinder 12 and is provided with the usual reciprocating piston 13, intake port 14 and exhaust port 15. The condenser 10 is connected, in the customary manner, for instance by means of a conduit 17, with a liquid receiver tank 18 adapted for the storage of condensed refrigerant. Liquid refrigerant from the tank 18 is supplied to the evaporators 5 and 6 through liquid line 19, refrigerant flow regulators 20 and 21, such as expansion or other suitable valves, being respectively associated with the evaporators to control the admission of liquid refrigerant therein. Refrigerant evaporated in the evaporators 5 and 6 is withdrawn therefrom through suction lines 22 and 23 respectively, at the proper rate to maintain the desired suction pressure within each evaporator.

In the arrangements shown in the drawings, the evaporator 5 is to cool its associated zone or compartment 7 at temperatures lower than those at which the evaporator 6 cools its associated zone or compartment 8. Therefore, in accordance with the accepted practice in the art, the evaporator 5 may be called the low temperature evaporator, and the evaporator 6 may be called the high temperature evaporator.

It is well understood in the art, that the ability of an evaporator to cool a zone or compartment to a certain temperature, is determined primarily by the suction pressure maintained in the evaporator and that the lower the suction pressure, the lower the temperature at which a zone or compartment may be cooled by the evaporator. Accordingly, if the evaporators 5 and 6 contained in the system shown in the drawings, are to cool their respective zones or compartments 7 and 8 to different temperatures, it is imperative that said evaporators be maintained at different suction pressures.

In accordance with the present invention, this is accomplished by controlling the communication between the evaporators 5 and 6 and the compression chamber 11, directly as a result of predetermined departures in an established condition of balance between the pressures in the two

evaporators. With this mode of control, it is possible to maintain a continuous differential within a given range between the pressures in the two evaporators so that, during operation of the system, and although both evaporators are in circuit with one and the same compression chamber, the supply of refrigerant to either evaporator at the expense of the other can continue only to the limit of the said range at which point the flow of the refrigerant through the one evaporator will be automatically interrupted and flow through the other initiated, this automatic periodic shift from one evaporator to the other continuing until both have been satisfied.

Control of the communication between the compression chamber and the said evaporators, is effectively accomplished by means of a single pressure responsive device, designated generally by the reference character 24 and included within the refrigerant circuit at a point intermediate the compression chamber and the evaporators in the manner to be presently described.

The system shown in Fig. 1 is capable of subjecting the evaporated refrigerant withdrawn from the low temperature evaporator to two-stage compression so that said evaporator may be operated effectively within a sub-zero temperature range. In this particular embodiment of the invention the pressure responsive device 24 preferably takes the form of a multiple valve mechanism comprising a valve casing 25 and a pair of spaced interconnected valve members 26 and 27, respectively mounted for axial movement within and longitudinal of said valve casing. Formed within the walls of the valve casing 25 and adapted to accommodate the valve members 26 and 27, are relatively spaced co-axial recesses 28 and 29 each having oppositely disposed valve seats 30 and 31. In mounting the valve members 26 and 27 in the manner stated, three distinct non-communicating spaces 32, 33 and 34 are provided within the valve casing 25.

The respective valve members are adapted to seat selectively on the valve seats 30 or 31, and it is to be noted that said members seat simultaneously on their respective valve seats 30 and simultaneously also on their respective valve seats 31. For that purpose, the valve members 26 and 27, as shown, are preferably connected rigidly by means of a rod 35 so that they move as a unit between the respective seats.

With reference to Fig. 1 of the drawings, it is pointed out that when the valve members 26 and 27 are seated on their respective seats 30 that is in the lower position as shown in full lines, a casing port 36, connected with the suction line 22 of the low temperature evaporator 5, is in communication with a port 37 which is connected through a conduit 38 with the intake port 14 of the compression chamber 11; and a casing port 39, connected with a conduit 40 leading from the exhaust port 15 of said chamber 11, is in communication with a port 41 which is connected through a conduit 42 opening into a hermetically sealed space 43. This space 43 is defined by a housing 44 which preferably is the motor-compressor housing into which also opens the suction line 23 of the high temperature evaporator 6. The opening of said suction line 23, however, is controlled by means of a suitable check valve 45 adapted to prevent the flow of gaseous refrigerant from the space 43 into said evaporator 6.

Referring again to the showing of Fig. 1, it will be noted that when the valve members 26 and 27 are seated on their respective seats 31, that is,

in the upper position as indicated in broken lines, the port 37 is in communication with port 41, and port 39 communicates with a port 46 which is connected through a conduit 47 with the refrigerant condenser 10.

The system including the control valve device 24 is a closed circuit, and it will be appreciated that a pressure differential may be maintained on opposite sides of the valve members 26 and 27. In this connection, it is pointed out that, in practice, the relative size or surface area ratio of the valve members 26 and 27 is such that under the prevailing pressures only the larger member, which in the embodiment shown in Fig. 1 is the member 26 controlling the communication between port 37 and either port 36 or port 41, is capable of actuating the valve structure; the forces exerted by the smaller member, which in the embodiment shown is the member 27 controlling the communication between port 39 and either port 41 or 46, being to all intents and purposes negligible. Because of this feature the valve member 26 may be termed the driving valve member.

In the circuit arrangement illustrated in Fig. 1, three distinct pressures are present, that is a high pressure which exists in the space 32 below the valve member 27, in the condenser 10, liquid receiver tank 18 and liquid line 19 up to the regulators 20 and 21; a low pressure which exists in the low temperature evaporator 5, suction line 22 and space 34 above the valve member 26; and, an interstage pressure which exists in the high temperature evaporator 6, suction line 23, hermetically sealed-space 43 and the space 33 between said valve members. Low or interstage pressure exists in the conduit 38, and interstage or high pressure exists in conduit 40, depending upon whether the valve members are seated in lower or upper position. From the foregoing, it will be understood that, normally, a definite pressure differential exists on the opposite sides of the driving valve member 26, the interstage pressure acting on the underside of the said valve member being greater than the low pressure acting on the upper side of said member.

In accordance with the present invention, these pressures are in effect equalized or balanced, and for that purpose suitable supplemental pressure developing means is provided, in the form in the present instance of a coil spring 49 arranged to act upon the upper side of the valve member 26. The spring 49 is adapted to establish an artificial pressure balance between the two evaporator pressures and, for that reason, the spring is so constructed that its pressure combined with the low pressure at a desired minimum value on the upper side of the driving valve member 26, will balance the interstage pressure at a desired minimum value on the underside of said valve member 26. Moreover, the spring 49 is constructed to have an exceedingly low "spring rate," so that its pressure on the valve member is not materially changed by movement of said valve member between its upper or lower positions.

Also, in accordance with the present invention, a means 50 is provided which is capable of resisting, within predetermined limits, a change in pressure on either the under side or the upper side of the driving valve member, such means thus providing for a predetermined pressure differential at which the valve is to operate in controlling the flow of refrigerant through the system. As shown in Fig. 1, this pressure re-

sisting means 50 may be in the form of spring pressed ball detents of the type represented at 51, mounted for engagement with either the upper or lower side edge portion of the valve member 26 depending upon whether said member is in the lower or upper position. With a device of this sort, it will be apparent that the pressure on either side of the valve member 26 must vary from the aforescribed balance established between the evaporator pressures, to an extent sufficient to overcome the resistance of such device before the valve can move from one to the other of its positions.

In order that the control device 24 and its mode of operation may be more clearly understood, the following specific example is given:

Assuming that the system is charged with "Freon-12" and it is desired to operate the evaporator 5 at say -5° F. and the evaporator 6 at say $+20^{\circ}$ F. Then, according to published temperature-pressure measurement tables, the pressure in evaporator 5 should be approximately 7 lbs. per sq. in. gage, and the pressure in evaporator 6 should approximate 21 lbs. per sq. in. gage. Thus a pressure differential of approximately 14 lbs. should exist between the two evaporators.

In accordance with the present invention, therefore, the spring 49 would be constructed to develop a force equal to this 14 lbs. differential, so that when the system is stabilized with the evaporator 5 at -5° F. and the evaporator 6 at $+20^{\circ}$ F., the pressures on the opposite faces of the driving valve member 26 tending to displace said member will be balanced. It now becomes clear that by using supplemental pressure means, such as spring 49, on the low pressure side of said valve member 26, slight variations from the balanced pressures due to temperature-pressure changes in either or both of the evaporators will be reflected on the valve and will tend to actuate the same. The extent of departure from the balance of pressures which is required to actuate the valve is determined by the pressure resisting means 50. For instance, if the spring pressed ball mechanisms 51 are constructed to resist unbalanced pressures of less than 2 lbs. upon the valve, then movement of the valve from one to the other of its positions will not take place unless there exists a differential of at least 2 lbs. between the pressures acting on the opposite sides of the valve member 26. Under these conditions, in other words, when the valve is in the lower position, it will be moved to the upper position only if the pressure below the driving valve member 26 reaches a value of at least 2 lbs. more than the value of the pressure above said member; and conversely, when the valve is in the upper position, it will be moved to the lower position only if the pressure above the driving valve member attains a value of at least 2 lbs. more than the value of the pressure below said member.

Because the control device 24 operates in the manner explained above, refrigeration will take place in that evaporator which, at the moment, demands it the most; that is, evaporated refrigerant will be withdrawn from the evaporator wherein the increased pressure has acted on the driving valve member 26 to move the same into that position which establishes communication between the said evaporator and the compression chamber.

Referring to Fig. 1, it will be seen that movement of the valve into lower position establishes

communication between the low temperature evaporator 5 and the compression chamber 11 through suction line 22, valve space 34 and conduit 38, and that movement of the valve into upper position establishes communication between the high temperature evaporator 6 and said compressing chamber through suction line 23, hermetically sealed space 43, conduit 42, valve space 33 and conduit 38.

As hereinbefore stated, the system as illustrated in Fig. 1 is capable of producing two-stage compression in addition to maintaining the evaporators 5 and 6 at different temperature-pressure values. This is accomplished in the following manner:

Let it be assumed that at the initiation of or during an "on-cycle" the condition within the system is such that the interstage pressure within the high temperature evaporator 6 and therefore within the space 43, as well as in the valve space 33, has been reduced to the desired minimum value, and that the pressure within the low temperature evaporator and consequently in the valve space 34 has increased sufficiently to unbalance the pressure on the driving valve member 26 to an extent such that the valve is moved to the lower position, that is, to the position shown in full lines. The flow of refrigerant then follows the course indicated by the solid arrows in Fig. 1, that is, low pressure gaseous refrigerant from the evaporator 5 is admitted to the compressing chamber 11 through the suction line 22, port 36, valve space 34, port 37, conduit 42 and inlet port 14, and is discharged at increased first-stage pressure into the hermetically sealed space 43 through exhaust port 15, conduit 40, port 39, valve space 33, port 41 and conduit 42. Discharge of gaseous refrigerant at increased first-stage pressure into the hermetically sealed space 13, will of course raise the value of the interstage pressure in said space, but because of the check valve 45 which will close under the pressure rise, the flow of such gaseous refrigerant into the high temperature evaporator is prevented so that the condition existing in said evaporator is not affected.

Withdrawal of gaseous refrigerant from the low temperature evaporator 5 reduces the pressure therein and therefore tends to maintain said evaporator at its desired temperature. However continued pumping of the refrigerant at increased first-stage pressure into the hermetically sealed space 43 causes the pressure therein to gradually increase until it reaches a value sufficiently high to overcome the pressure on the upper side of the driving valve member 26, at which point the valve unit is caused to move to the upper position, that is, the position shown in broken lines. When this occurs, the flow of refrigerant then follows the course indicated by the broken arrows, that is, gaseous refrigerant at interstage pressure is permitted to flow into the compressing chamber 11 through conduit 42, port 41, valve space 33, port 37, conduit 38 and intake port 14, and is discharged at condensing high or second-stage pressure into the condenser 10 through exhaust port 15, conduit 40, port 39, valve space 32, port 46 and conduit 47. The high pressure gaseous refrigerant gives up its heat in the condenser and condenses therein to return, in a liquified state, into the receiver tank 18 whence the liquid refrigerant is supplied to the evaporators 5 and 6 in properly metered quantities through flow regulator 20 and 21.

If at any time during second-stage operation

of the system, the temperature-pressure value in this high temperature evaporator 6, rises to a point above interstage pressure in the hermetically sealed space 43, then the check valve 45 will open, allowing the escape of gaseous refrigerant from said evaporator into said space to be withdrawn therefrom together with the gaseous refrigerant already therein. In this manner, the pressure in the high temperature evaporator 6 is reduced with the resulting tendency to maintain said evaporator at its desired temperature.

The second-stage operation of the system continues until the pressure on the upper side of the driving valve member 26 attains a value sufficient to again move the valve to the lower position thereby initiating another first-stage operation. This repeated switching from first-stage to second-stage operation and from second-stage to first-stage operation takes place until the system becomes stabilized with both evaporators at the desired lowest temperature-pressure value when the end of an "on-cycle" is reached.

From the foregoing description, it will be understood that while the system operates to maintain the evaporators respectively at their desired temperature levels, it does so without unduly impeding the performance of either evaporator since neither is completely shut down until the other is fully satisfied, but rather the evaporators are alternately subjected to refrigeration depending upon existing conditions within the system itself. Moreover because the system as shown in Fig. 1 is capable of producing two-stage compression, it is possible to operate and maintain the low temperature evaporator at temperature ranges much lower than would otherwise be practical with a compressing unit of equal displacement.

If it is not necessary or desired to operate and maintain the low temperature evaporators within such low temperature ranges, the embodiment of the system diagrammatically shown in Fig. 2 may be used. For all intents and purposes, this embodiment is substantially the same in construction and operation as that shown in Fig. 1, with the exception that it does not include the two-stage compression feature and therefore the pressure responsive device 24 is constructed and arranged in the refrigerant circuit to control only the flow from the evaporators 5 and 6 to the compression chamber 11 and not to control the flow from said chamber to the condenser 10.

With particular reference to Fig. 2, it will be noted that the pressure responsive device 24 comprises a valve mechanism including a valve casing 25a and a valve member 26a. This valve member is mounted for axial movement within and longitudinally of said valve casing which, for that purpose, is provided with a recess 27a defined by a pair of oppositely disposed valve seats 30a and 31a. As shown, these seats are located so that the space 27a has a height greater than twice the thickness of the valve member 26a which makes it possible for a part 37a, opening into said space at an intermediate point, to remain unobstructed whether the valve member 26a is in seated position on the seat 30a or on the seat 31a. Moreover the seats 30a and 31a are disposed intermediately of the valve casing so that a space 33a is provided below the valve seat 30a and a space 34a is provided above the valve seat 31a, each of said spaces 33a and 34a having a port opening therein as indicated at 41a and 36a respectively. The port 37a opening into

the intermediate space 27a between the valve seats 30a and 31a communicates with the inlet port 14 of the compression chamber 11, for instance, by means of a conduit 38a, whereas the port 36a opening into the upper space 34a is connected directly with the suction line 22, leading from the low temperature evaporator 5, and the port 41a opening into the lower space 33a is connected indirectly with the suction line 23 of the high temperature evaporator through a conduit 42a and a hermetically sealed space 43a defined by a housing 44a which, as in Fig. 1, may be the motor-compressor housing.

From the foregoing, it will be noted that when the valve member 26a is in lower position shown in full line, that is, when said member is seated on seat 30a, communication is established between the low temperature evaporator 5 and the compression chamber 11; but when the valve member 26a is in upper position shown in broken line, that is when said member is seated on seat 31a, communication is established between the high temperature evaporator 6 and said compression chamber 11. Therefore, since the pressure in the high temperature evaporator 6 is greater than the pressure in the low temperature evaporator 5, the effective pressure on the underside of the valve member 26a is normally greater than the effective pressure on the upper side of said member. As in the embodiment shown in Fig. 1, these pressures are equalized or balanced by means of supplemental pressure means 48a, such as a coil spring 49a which is arranged to act in the same manner as hereinbefore described in connection with spring 49 of the embodiment shown in said Fig. 1. Also as in that embodiment, pressure resisting means 50a in the form of spring pressed ball detents 51a, are provided to establish the predetermined pressure differential at which the valve member 26a is to move from one position to another, said mechanisms being adapted to resist, within selected limits, a change in the pressure value on either the lower or upper side of said valve member.

While the association of the spring pressed ball devices 51a with the valve member 26a as shown in Fig. 2, differs somewhat from the embodiment shown in Fig. 1, it will be noted that the action is the same in both instances. In Fig. 2, these devices are mounted for selective engagement either with a groove 52 or a groove 53 respectively disposed in spaced superimposed relation on a rod 54 suitably carried by the valve member 26a for movement therewith. Thus, when valve member 26a is in the lower position and the spring pressed balls engage the groove 52, the pressure on the underside of the valve member must reach a value great enough to overcome the pressure on the upper side of said member and the resistance imposed by said ball devices before the valve may move to the upper position. Likewise, when valve member 26a is in the lower position and the spring pressed mechanisms engage the groove 53, the pressure on the upper side of the valve member must attain a value sufficient to overcome both the pressure on the underside of said member and the resistance of the ball devices before the valve may move to the lower position.

The operation of the embodiment shown in Fig. 2 may be summarized as follows:

As shown, it is assumed that the system is operating on an "on-cycle" and that the pressure in the low temperature evaporator 5 has caused the valve member 26a to move to its lower posi-

tion. Therefore the flow of refrigerant follows the course indicated by the solid arrows, that is, gaseous refrigerant at the pressure existing in the low temperature evaporator 5 is admitted into the compression chamber 11 through the suction line 22, port 36a, valve casing spaces 34a and 27a, port 37a, conduit 38a and intake port 14, and is compressed in said chamber 11 and discharged at condensing pressure through the exhaust port directly into the condenser 10, to be condensed therein and delivered, in liquified state, into the receiver tank 18 whence liquid refrigerant may be supplied through liquid line 19 to the evaporators 5 and 6 in quantities controlled by the liquid flow regulators 20 and 21. It will be understood that the pressure in the low temperature evaporator is thus reduced, thereby tending to maintain the desired temperature-pressure value in said evaporator.

If during operation of the system, the pressure in the high temperature evaporator should rise to a point sufficient to cause the valve member 26a to move to its upper position shown in broken lines, then the flow of refrigerant follows the course indicated by the broken arrows, that is, gaseous refrigerant at the pressure existing in the high pressure evaporator 6 is admitted into the compression chamber 11 through the suction line 23, hermetically sealed space 43a, conduit 42a, port 41a, valve casing spaces 33a and 27a, port 37a, conduit 38a and intake port 14. The gaseous refrigerant thus admitted in the compressing chamber, is compressed, condensed and made available for the evaporators 5 and 6 in the same manner as above stated. The withdrawal of gaseous refrigerant from the high temperature evaporator 6 reduces its pressure thereby tending to maintain said evaporator at the desired temperature-pressure level.

From the foregoing it will be apparent that in the system shown in Fig. 2, as in that appearing in Fig. 1, the valve member 26a is shifted back and forth from one position to the other in response to predetermined departures from an established balance in the pressure values on opposite sides of said member, and that such departures are a direct result of changes in the desired temperature-pressure levels in the respective low and high temperature evaporators. Accordingly, in the system shown in Fig. 2, as in the system shown in Fig. 1, neither evaporator has actual preference over the other, but refrigeration will occur alternately therein depending upon which evaporator demands the most refrigeration at any one moment during operation of the system. In this manner, each evaporator may be adequately maintained at its respective temperature level without detrimentally interfering with the operation of the other. Alternative switching from one evaporator to the other may continue throughout an entire "on-cycle" that is, until both evaporators are fully satisfied when an "off-cycle" will take place.

The occurrences of "on-cycles" and "off-cycles" in both embodiments of the system shown in Figs. 1 and 2 respectively, may be governed by any of the well known cycling control devices associated directly with one or both of the evaporators 5 and 6, or with one or both of the refrigerated zones or compartments 7 and 8. By way of example, there is shown in the drawings, a temperature type control device associated with the low temperature evaporator 5, such device operating from a thermostatic bulb 55 with a bellows or diaphragm 56 to actuate a switch 57 for open-

ing and closing an electric circuit 58 adapted to supply current to the motor-compressor. Such a temperature controlling device, as well known in the art, will close the switch 57 thus starting the motor-compressor when the temperature reaches a predetermined high level, and will open the switch thus stopping the motor-compressor when the temperature reaches a predetermined low level.

With particular reference to Fig. 2, a check valve 45a is preferably provided at the point of communication between the suction line 23 and the hermetically sealed space 43a, to prevent gaseous refrigerant from entering the low temperature evaporator 6, whenever the pressure in said space rises above the pressure in said evaporator.

Since in both embodiments of the invention shown in the drawings, the low and high temperature evaporators are adapted to communicate with one and the same compression chamber 11, it will be understood that the motor-compressor, at all times, will handle gas of a certain density and weight and, at other times, will handle gas of a different density and weight depending upon whether the compression chamber 11 is in communication with the evaporator 5 or the evaporator 6. In accordance with the invention, provision is made for compensating this difference in gas density and weight so as to equalize the number of strokes required for and the amount of work performed in each phase of operation. As shown in the drawings, this is accomplished by providing a port 60 in the wall of the compressor cylinder 12 at a point intermediate the ends of the compression chamber 11 to establish a communicating connection between the compression chamber 11 and the hermetically sealed space 43 (Fig. 1), or 43a (Fig. 2), the connection including a casing 61, a tube 62, and a valve 63 which controls the passage of gaseous refrigerant through said port into said space in the manner now to be described.

When gaseous refrigerant at the pressure existing in the low temperature evaporator 5 is admitted into and compressed within the compression chamber 11, the valve 63 remains closed because then the pressure in said chamber is always lower than the pressure in the casing 61 which is in communication, through the tube 62, with the hermetically sealed space wherein exists a pressure at least equal to the pressure of the high temperature evaporator 6. When gaseous refrigerant at the pressure existing in the high temperature evaporator 6 is admitted into the compression chamber 11, the valve 63 still remains closed because then the pressure on both sides of this valve is equal, but the valve 63 opens as the compression stroke of piston 13 begins due to the increased pressure in said chamber. In this manner a portion of the heavier gaseous refrigerant admitted in the compression chamber 11 may be bled back into the hermetically sealed space to be re-expanded therein. Movement of the piston over the part of the compression stroke which remains after the port 60 is covered, effects normal compression of the heavier gas. By locating the port 60 so that a part of the heavier gaseous refrigerant is bled away as described above, the weight of the refrigerant handled during compression of gaseous refrigerant from either the low or high temperature evaporator may be substantially balanced and therefore, the work done per stroke and the number of strokes required for proper compression substantially equalized.

It will be understood that the invention is not

limited to the specific embodiments herein shown and described, and that such embodiments are subject to modification within the scope of the appended claims.

I claim:

1. In a refrigerating system including a compressor, a condenser, a high temperature evaporator, and a low temperature evaporator, an hermetically sealed chamber connected between the high temperature evaporator and the compressor, a check valve permitting flow of fluid from the last-named evaporator to said chamber while preventing reverse flow, and valve means controlling the connection of the compressor with the low temperature evaporator and with said chamber, said valve means including an element adapted in one position to connect the said low temperature evaporator directly with the suction side of said compressor and in an alternative position to connect the suction side of the compressor with said chamber, said valve means including also an element adapted in alternative positions corresponding to the alternative positions of the first-named element to connect the discharge side of said compressor with the said chamber and with the condenser respectively.

2. In two temperature refrigeration employing two evaporators operated at different individual pressures from a common compression-condenser system, the method which comprises connecting the evaporators individually and alternately with the suction side of said compressor, diverting the liquid refrigerant discharge of the compressor from the condenser to a pressure accumulator when one of said evaporators is connected to the suction side of the compressor, directing the refrigerant discharge of the compressor to the condenser when the other of said evaporators is connected to the suction side of the compressor and simultaneously connecting the accumulator chamber to the suction side of the compressor to obtain a resultant second stage compression of the refrigerant.

3. In a refrigerating system including a compressor, a condenser, a high temperature evaporator, and a low temperature evaporator, an hermetically sealed chamber connected between the high temperature evaporator and the compressor, a check valve permitting flow of fluid from the high temperature evaporator to said chamber while preventing reverse flow, and valve means controlling the connection of the compressor with the low temperature evaporator and with said chamber, said valve means including an element adapted in one position to connect the last-named evaporator directly with the suction side of said compressor and in an alternative position to connect the suction side of the compressor with said chamber, said valve means including also an element adapted in alternative positions corresponding to the alternative positions of the first-named element to connect the discharge side of said compressor with the said chamber and with the condenser respectively.

4. In a refrigerating system including a compressor, a condenser, a high temperature evaporator, and a low temperature evaporator, an hermetically sealed chamber connected between the high temperature evaporator and the compressor, and valve means controlling the connection of the compressor with the low temperature evaporator and with said chamber, said valve means including an element adapted in one position to connect the last-named evaporator directly with the suction side of said compressor and in

an alternative position to connect the suction side of the compressor with said chamber, said valve means including also an element adapted in alternative positions corresponding to the alternative positions of the first-named element to connect the discharge side of said compressor with the said chamber and with the condenser respectively.

5. In a refrigerating system including a compressor, a condenser, a high temperature evaporator, and a low temperature evaporator, a sealed chamber connected to the high temperature evaporator and to the suction side of said compressor, a check valve permitting passage of fluid from the high temperature evaporator to the chamber and preventing flow in the reverse direction, and valve means for controlling the connections between the compressor and the low temperature evaporator and between the compressor and said chamber, said means including a pair of valve elements, one of said valve elements being exposed at one side to the pressure in the low temperature evaporator and at the opposite side to the pressure in said chamber so as to move under the influence of said pressures into alternative positions in one of which the said suction side of the compressor is connected to the said low temperature evaporator and in the other of which the suction side of the compressor is connected to the sealed chamber, the other valve element operating in synchronism with the valve element first named to connect the said chamber directly with the discharge side of the compressor when the said low temperature evaporator is directly connected to the suction side of the compressor and for connecting the discharge side of the compressor with the condenser when the said chamber is directly connected to the suction side of said compressor.

6. A refrigerating system according to claim 5 wherein pressure means operates on the first named valve element to augment the low temperature evaporator pressure to which one side of the element is subjected whereby said element may be movable between the said alternative positions in response to departures from a predetermined pressure differential at the opposite sides of said element.

7. A refrigerating system according to claim 6 wherein means is provided for preventing movement of said first named valve element until said departure from the predetermined pressure differential has exceeded a predetermined magnitude.

8. A refrigerating system according to claim 5 wherein the said sealed chamber takes the form of a housing embracing the compressor unit.

9. A refrigerating system according to claim 5 wherein means is provided for bleeding a part of the refrigerant compressed in an individual compression stroke of the compressor into the said sealed chamber, said bleeding means being controlled by a check valve loaded to permit said bleeding only when the pressure of the refrigerant in the compressor has reached a predetermined value.

10. In a refrigerating system including a compressor, a condenser adapted to receive compressed refrigerant from the compressor, a high

temperature evaporator, and a low temperature evaporator, said evaporators being connected in parallel between the condenser and the suction side of said compressor, a sealed chamber included in the connection between the high temperature evaporator and the suction side of the compressor, a check valve permitting flow from the high temperature evaporator to the said chamber while preventing a reverse flow, and a valve device exposed to the pressures within the low temperature evaporator and within said chamber and responsive to departures from a predetermined differential between said pressures for connecting said low temperature evaporator and chamber individually and alternately to the suction side of said compressor, said valve device including means for connecting the discharge side of said compressor with the said chamber when the low temperature evaporator is connected to the suction side of the compressor, and for connecting the discharge side of the compressor with the condenser when the said chamber is connected with the suction side of said compressor.

11. In a refrigerating system including a compressor having a compression chamber with suction and discharge ports, a condenser connected to said discharge port, a high temperature evaporator, and a low temperature evaporator connected in parallel between the condenser and the suction port of said compressor, an accumulator chamber in the connection between the high temperature evaporator and the compressor through which chamber the refrigerant flows in passing from the high temperature evaporator to the said suction port, a check valve permitting flow from the high temperature evaporator to the chamber while preventing reverse flow, valve means for connecting the accumulator chamber and the low temperature evaporator individually and alternately to the suction port of said compressor, and secondary valve means operative when the said low temperature evaporator is connected to the suction port for diverting the refrigerant discharge of said compressor to the accumulator chamber to the exclusion of flow of said discharge to the condenser, and operative when the accumulator chamber is connected to the said suction port for directing the discharge of the compressor to the condenser.

12. A refrigerating system according to claim 11 including means operative while the said accumulator chamber is connected with the suction port of the compressor for bleeding a portion of the refrigerant from the said compression chamber when pressure in said chamber exceeds a predetermined maximum and directing the refrigerant thus withdrawn from the compression chamber back to the accumulator.

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The following references are of record in the file of this patent:

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