

May 12, 1964

F. A. SCHUMACHER

3,132,491

HOT GAS DEFROST REFRIGERATING SYSTEM AND VALVE MEANS THEREFOR

Filed Sept. 21, 1962

FIG. 1

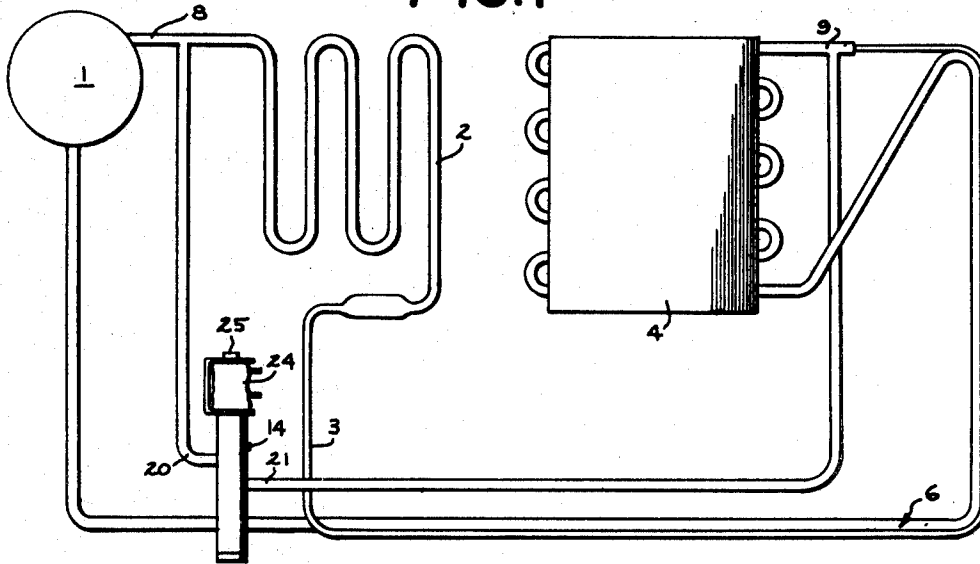


FIG. 2

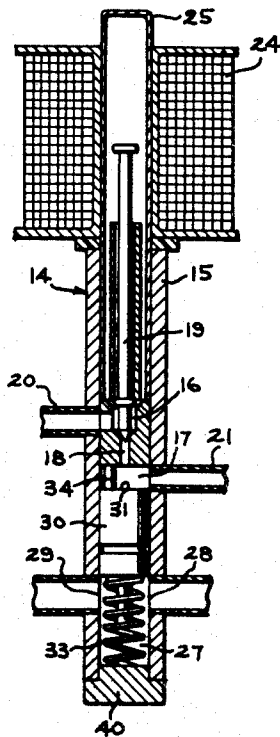


FIG. 5

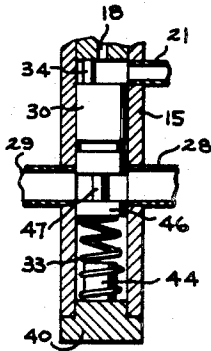


FIG. 3

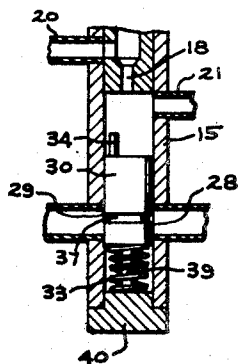
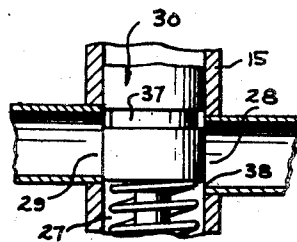


FIG. 4



INVENTOR.
FRANK A. SCHUMACHER

BY *Walter Hule*

HIS ATTORNEY

1

3,132,491

HOT GAS DEFROST REFRIGERATING SYSTEM AND VALVE MEANS THEREFOR

Frank A. Schumacher, Louisville, Ky., assignor to
General Electric Company, a corporation of New York
Filed Sept. 21, 1962, Ser. No. 225,321
7 Claims. (Cl. 62-278)

This application is a continuation-in-part of my copending application Serial No. 155,604, filed November 29, 1961, now abandoned, and assigned to the same assignee as the present invention.

This invention relates to refrigeration systems and is more particularly concerned with an improved valve means for periodically directing the flow of hot compressed refrigerant to the evaporator for defrosting purposes and simultaneously restricting the return flow of refrigerant from the evaporator to the compressor component of the system.

During normal or refrigerating operation of a refrigerating system including a compressor, a condenser, a flow restrictor, an evaporator and a suction line connected in closed series connection, frost tends to collect on the evaporator component of the system. A known means for removing this frost layer by warming the evaporator to defrosting temperatures comprises the periodic introduction of hot compressed refrigerant from the high pressure side of the system directly into the evaporator where it condenses and warms the evaporator to defrosting temperatures. The present invention is generally concerned with a refrigerating system of this type including improved flow control means for controlling the flow of refrigerant during the defrost operation of the system.

It is an object of the present invention to provide a hot gas defrosting refrigerating system including an improved valve means for controlling and modifying the flow of refrigerant through the system during defrost operation thereof.

Another object of the invention is to provide a unitary valve means adapted to automatically restrict the return flow of refrigerant from the evaporator to the compressor during the period that hot compressed refrigerant is being introduced into the evaporator for defrost purposes.

A further object of the invention is to provide a simple and reliable flow control valve for a hot gas defrost refrigerating system including means for introducing a restriction to the flow of refrigerant from the evaporator to the compressor whenever hot compressed refrigerant is introduced by operation of the valve into the evaporator component of the system and for removing the restriction upon operation of the valve to return the system to normal refrigerating operation.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In carrying out the objects of the present invention, there is provided a refrigerating circuit including a compressor, a condenser, a flow restrictor, an evaporator and a suction line connected in closed series-flow relationship so that during normal or refrigerating operation of the system the compressor withdraws low pressure refrigerant from the evaporator and discharges high pressure or compressed refrigerant into the condenser where it is condensed before flowing through the flow restrictor into the evaporator. For the purpose of periodically warming the evaporator to defrosting temperatures in order to melt frost accumulated thereon, the system includes a unitary valve structure for introducing hot compressed refrigerant directly into the evaporator and for restricting the flow of refrigerant from the evaporator to the compressor dur-

2

ing the defrost operation of the system. In its preferred form, the single or unitary valve provided for this purpose comprises a cylindrical valve body having an upper high pressure inlet chamber connected to the normal refrigerant circuit between the compressor and the restrictor and an intermediate outlet chamber having an outlet connection to the inlet end of the evaporator. The valve includes a normally closed valve port between these chambers which, when open, permits flow of hot compressed refrigerant directly to the evaporator. The valve also includes a suction line chamber at the lower end thereof having two suction line connections and a movable piston which forms a wall between the intermediate and suction chambers. Upon an increase in pressure in the intermediate chamber resulting from opening of the valve port, the piston is adapted for movement from a normal position in which the two suction line connections are open to the suction chamber to a second position in which the piston overlies the two suction line connections. The valve also includes means for restricting but not completely interrupting the flow of refrigerant through the suction line when the piston is in its second position.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

FIGURE 1 is a diagrammatic illustration of a refrigeration system embodying the present invention;

FIGURE 2 is a vertical sectional view of one form of valve employed in the practice of the present invention;

FIGURE 3 is a sectional view of a portion of the valve shown in FIGURE 2 with the piston in its suction line restricting position;

FIGURE 4 is an enlarged view of a portion of the valve of the present invention illustrating a preferred embodiment thereof, and

FIGURE 5 illustrates a modification of the valve of the present invention.

With reference to FIGURE 1 of the accompanying drawing, there is illustrated a refrigerating system including a compressor 1, a condenser 2, a capillary flow restrictor 3, an evaporator 4, and a suction line 6 which are connected in series-flow relationship to form a normal refrigerating system in which the capillary flow restrictor 3 maintains a pressure differential between the condenser and the evaporator such that circulating refrigerant will be maintained at condensing pressures within the condenser and will vaporize in the evaporator. Gaseous refrigerant is withdrawn from the evaporator through the suction line 6 by the compressor 1 which compresses the refrigerant and discharges the compressed refrigerant through a discharge line 8 into the condenser 2.

When a refrigerating system of this type is designed for continuous operation of the evaporator at subfreezing temperatures, there is a gradual accumulation of frost on the evaporator and other low temperature components of this system. This frost layer must be removed periodically in order that the system will operate at maximum efficiency.

In accordance with the present invention, a single or unitary valve is provided for both introducing hot compressed refrigerant directly into the evaporator for defrost purposes and for automatically restricting the return flow of refrigerant from the evaporator to the compressor during defrost operation so as to maintain condensing pressures within the evaporator during the defrost period.

This valve, which is generally indicated by the numeral 14 in FIGURE 1 of the drawing, is shown in detail in FIGURE 2 of the drawing. In the preferred form thereof, it comprises a cylindrical valve body 15 having therein a plurality of chambers including an upper high pressure chamber 16 and an intermediate outlet or low pressure chamber 17. The chambers 16 and 17 are connected by a valve port 13 which, during normal refrigerating opera-

3

tion of the system, is closed by a needle valve 19. The high pressure chamber 16 has an inlet connection 20 connecting that chamber to a high pressure portion of the system between the compressor 1 and the flow restrictor 3, preferably to the discharge line 8 leading from the compressor 1 to the condenser 2. The chamber 17 has an external connection 21 connecting that chamber to the inlet end 9 of the evaporator so that it is normally filled with low pressure refrigerant. When it is desired to defrost the evaporator by introducing hot compressed refrigerant directly into the evaporator, a solenoid 24 surrounding the upper or plunger portion 25 of the valve is energized causing the needle valve 19 to lift and open the port 18. Hot compressed refrigerant can then flow from the compressor through the port 18 and directly into the evaporator inlet 9.

In accordance with the present invention, the valve 14 also includes means for automatically restricting the flow of refrigerant from the evaporator 4 to the compressor 1 during defrost operation of the system. To this end the valve includes a suction gas chamber 27 at the opposite or lower end of the valve body from the high pressure chamber 16. This suction chamber 27 is connected directly into the suction line 6 and includes an inlet port or connection 28 for receiving refrigerant from the evaporator and an outlet port 29 connected to the compressor intake. A movable piston 30 separates the suction chamber 27 from the chamber 17 and the upper face 31 of this piston forms one wall of the low pressure chamber 17. The piston 30 is normally positioned during refrigerating operation of the system between the outlet connection 21 and the two suction line ports or connections 28 and 29. In this position, the piston permits unrestricted flow of suction gas from the evaporator to the compressor 1. A spring means 33 serves to bias the piston 30 upwardly within the valve body to this normal position and a stop 34 in the form of a pin affixed to the surface 31 of the piston is adapted to engage the lower surface of the port member 18 to limit the upward movement of the piston and thereby prevent the piston from closing the low pressure chamber outlet 21.

The spring 33 is of a strength such that when the valve port 18 is open, the high pressure refrigerant introduced through that port into the chamber 17 will cause the piston 30 to move downwardly against the biasing action of spring 33 to a lower position as shown in FIGURE 3 of the drawing in which the piston 30 overlies both of the connections 28 and 29, or in other words is in the path of the refrigerant suction gas flowing from the evaporator to the compressor through the chamber 27. A circumferential groove 37 provided in the cylindrical walls of the piston 30 provides a restricted connection between the inlet and outlet connections or ports 28 and 29 when the piston 30 is in its lower position thereby permitting a restricted flow of refrigerant from the evaporator back to the compressor during the defrosting operation. A stop pin 39 provided on the lower face of the piston 30 engages the end cap 40 of the valve to limit the downward travel of the piston and position the restricting groove 37 in communication with the inlet and outlet connections 28 and 29.

The groove 37 is designed to provide a restriction such that during defrost operation, refrigerant will be returned to the compressor at a rate sufficient to maintain proper low and high side pressures in the system. Preferably the low side or compressor intake pressure is slightly higher during defrost than during normal operation. The high side pressure, that is, the pressure within the defrosting evaporator, should be sufficient to ensure substantially complete condensation of the gaseous refrigerant being supplied to the evaporator.

As has been previously indicated, the valve 14 provides the dual function of controlling the flow of high pressure refrigerant through the system and of restricting the flow of low pressure refrigerant from the evaporator to the

4

compressor during defrost operation of the system. During normal refrigerating operation, the port 18 of the valve 14 is closed by the needle valve 19 and the refrigerant compressed by the compressor 1 flows through the condenser 2, the restrictor 3 and into the evaporator 4 for normal cooling operation of the evaporator. Periodic energization of the solenoid 24 by any suitable defrost control means causes the needle 19 to move upwardly and open the port 18. When this port is opened, there is a preferential flow of warm refrigerant from the high pressure side of the system to the evaporator inlet or, in other words, a refrigerant flow which bypasses the restrictor 3. This preferential flow results from the lower flow restriction offered by the valve 14 and the associated connections of the chambers 16 and 17 to the remaining portions of the system as compared with the flow restriction provided by the flow restrictor 3. Also when the valve port 18 is opened, the increase in pressure in the chamber 17 forces the piston 30 downwardly to insert the restriction 37 into the suction line 6. The restriction 37 causes the warm high pressure gaseous refrigerant to condense in the evaporator 4 so that its heat of condensation aids in warming the evaporator to defrost temperatures.

With the valve port 18 open and the restriction 37 interposed in the suction line between the evaporator and the compressor, the intermediate chamber 17 as well as the evaporator 4 and the portion of the suction line up to the suction port 28 is filled with high pressure refrigerant. The suction chamber 27 which is disconnected from the suction ports 28 and 29 by the lowered piston is filled with low pressure refrigerant, this chamber 27 being at suction pressure when the piston is first moved to its lower position. During the period that the piston is in its lower position, the pressure within the suction chamber 27, due to leakage around the piston 30, is somewhere between the high upstream pressure at the port 28 and the low downstream or compressor suction pressure at the port 29 and is generally stabilized at a value which is the mean or average of the pressures in the conduit ports 28 and 29. The pressure differential across the piston 30, or in other words, the difference between the pressures in the chambers 17 and 27 is sufficient to resist the biasing action of the compressed spring 33 and hold the piston 30 in its lower or defrost position as long as the valve port 18 is opened.

Operation of the system on the defrost cycle continues until the evaporator has been warmed to defrosting temperatures. At this point, means (not shown) responsive to an above freezing temperature of the evaporator de-energizes the solenoid 24 whereupon the port 18 is again closed. Closing of the port 18 cuts off the chamber 17 from the high pressure side of the system and results in a lowering of the pressure in that chamber. As the pressure in the chamber 17 gradually decreases, the compressed spring 33 moves the piston 30 upwardly towards its normal position and when the piston finally clears both of the ports 28 and 29, the system is reset for operation on a normal refrigerating cycle.

While the downward travel of the piston at the initiation of defrost is quite fast due to the sudden increase in pressure in the chamber 17, the return travel is slower due to the fact that the balance of pressure conditions on the piston including the pressure of the spring thereon must be reversed before the piston will rise to its normal position. In other words, in order that the piston return to its normal or upper position when needle valve 19 is closed at the end of a defrost cycle, it is necessary that the pressure exerted on the piston 30 by the refrigerant in the chamber 27 plus the biasing force of the spring 33 be greater than the pressure exerted on the piston by the refrigerant in chamber 17.

At the end of a defrost cycle, when the needle valve closes port 18 so that the flow of higher pressure refrigerant into chamber 17 is stopped, the pressure in the chamber 17 tends to become the same as the pressure

5

at the port 28 since the two are connected through the evaporator. Also, since the evaporator is then connected in the system downstream from the flow restrictor 3, its pressure and hence the pressure in chamber 17 gradually decreases. These changing conditions result in a drop in pressure in the chamber 17 which may cause the piston to rise but as the spring 33 expands, the force exerted thereby on the piston diminishes. If the rise is sufficient to cause the lower end of the piston 30 to open communication between the suction chamber 27 and both of the ports 28 and 29, the pressure in the chamber 27 will become the same as the pressure at the port 28 and hence in the chamber 17 so that the spring can then return the piston completely to its normal or upper position.

To assure an early and positive equalization of the pressures in chambers 17 and 27 and to avoid any possibility of the chamber 27 becoming connected to the lower pressure port 29 before it is connected to the high pressure port 28 with the result that its pressure drops rather than increases, the port 28 is preferably offset slightly downwardly from or lower than the port 29. This construction is illustrated in FIGURE 4 of the drawing in which the piston is shown at one point in its upward travel from its defrost position to its normal position. While both ports are closed when the piston is in its lower or defrost position, during rise of the piston following a defrost cycle, the bottom wall of the piston first clears the port 28 and provides a connection between the port 28 and the suction chamber 27 thereby admitting to chamber 27 refrigerant at the same pressure as that in port 28 and hence in chamber 17. The resultant equalization fluid pressures on the piston 30 then permits the spring 33 to take over and move the piston completely to its upper position.

Preferably, also the length of that portion of the piston below the groove 37, that is the distance between the groove and the lower face of the piston should be such that the ports 28 and 29 are at all times interconnected either below the piston, when the piston is in its upper position, or through the groove 37 when the piston is in its defrost position. Otherwise, at some point in the return travel of the piston to its normal position, the piston might completely close off both ports and thereby delay the change in pressure conditions required to restore the system to normal refrigerating operation.

Various changes in the valve structure can be made without affecting its operation. Under some system conditions, flow of refrigerant over and through the spring 33 has been found to cause a hissing or vibrating noise in the system. This can be avoided by the modification illustrated in FIGURE 5 of the drawing in which the piston 30 is so designed that no portion of the spring 33 is in the path of the suction gas. In this modification the piston includes a spring engaging portion 46 for engaging the upper end of the spring 33 and this portion is connected to the main portion of the piston 30 by a small shaft 47 which spaces the spring engaging portion 46 from the main body of the piston 30 to provide for unrestricted flow of refrigerant between the ports 28 and 29 when the piston is in its upper or normal position. Also instead of providing a pin 39 for limiting the downward travel of the piston 30, a stop 44 on cap 40 may be used for this purpose and also for the purpose of providing means for mounting the spring 33. Otherwise the operation of the modification illustrated in FIGURE 5 of the drawing is the same as the operation of that illustrated in FIGURES 2, 3 and 4 of the drawing.

While there has been shown and described particular embodiments of the present invention, it will be seen that the invention is not limited thereto. For example, while port 28 is preferably offset from port 29 to assure an early increase in the pressure in chamber 27, it will be obvious that the same result can be obtained by notch-

6

ing the lower edge of port 28 and the adjacent portion of the valve body. It is, therefore, intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A valve for controlling the flow of refrigerant between the compressor and evaporator components of a refrigerating system, said valve comprising:

- (a) a cylindrical valve body having first, second and third chambers therein,
- (b) said first chamber having an inlet for connection with the compressor discharge,
- (c) said second chamber being disposed between said first and third chambers and having an outlet for connection to the inlet end of said evaporator,
- (d) said third chamber having spaced inlet and outlets for connection respectively to the outlet end of said evaporator and the compressor intake,
- (e) a valve port interconnecting said first and second chambers and a valve member normally closing said valve port and means for moving said valve member to a position in which said port is open,
- (f) a piston slidably arranged in said valve body forming a movable wall dividing said second and third chambers, said piston being movable between a first position providing unrestricted communication between said third chamber inlet and outlet connections and a second position in which said piston covers said third chamber inlet and outlet connections,
- (g) means providing restricted communication between said third chamber inlet and outlet connections when said piston is in its second position, and
- (h) spring means for normally positioning said piston in said first position when said valve port is closed by said valve member and for permitting movement of said piston to its second position upon movement of said valve member to open said valve port to introduce high pressure refrigerant into said second chamber.

2. A valve for modifying the flow of refrigerant in a refrigerating system including a compressor, a condenser, a restrictor, an evaporator and a suction line normally connected in closed, series flow relationship in order to introduce compressed refrigerant from the compressor directly into the evaporator and automatically restrict the flow of refrigerant through the suction line, said valve comprising:

- (a) a cylindrical valve body, said body including,
- (b) an inlet chamber having an inlet for connection to the compressor discharge,
- (c) an outlet chamber having an outlet for connection to the inlet end of the evaporator,
- (d) a first suction line connection to said evaporator and a second suction line connection to said compressor intake, said suction line connections being spaced from said outlet,
- (e) normally closed valve means between said inlet and outlet chambers and means for opening said valve means, and
- (f) a piston in said valve body forming one wall of said outlet chamber and normally positioned within said valve body between said outlet and said suction line connections and movable to a second position between said suction line connections by an increase in pressure in said outlet chamber when said valve means is open, said piston including means defining a restricted communication between said suction line connections when said piston is in said second position.

3. A valve for use in a refrigerating system including a compressor, a condenser, a restrictor, an evaporator and a suction line normally connected in closed, series flow relationship to periodically introduce compressed

refrigerant from the compressor directly into the evaporator and simultaneously restrict the flow of refrigerant through the suction line, said valve comprising:

- (a) a cylindrical valve body, said body including,
- (b) an inlet chamber adjacent one end of said body 5 and having an inlet for connection to the compressor discharge,
- (c) an outlet chamber intermediate the ends of said valve body and having an outlet for connection to the inlet end of the evaporator, 10
- (d) a first suction line connection to said evaporator and a second suction line connection to said compressor intake, said suction line connections being adjacent the other end of said valve body and spaced from one another, 15
- (e) normally closed valve means between said inlet and outlet chambers and means for opening said valve means,
- (f) a piston in said valve body forming one wall of said outlet chamber and normally positioned intermediate said outlet connection and said suction line connections, said piston being movable to a second position between said suction line connections by an increase in pressure in said outlet chamber when said valve means is open, said piston including an annular groove defining a restricted communication between said suction line connections when in said second position. 20

4. A unitary valve for modifying the flow of high pressure refrigerant to the evaporator component of a 30 refrigerating system and automatically restricting the flow of low pressure refrigerant in the system during the modified flow, said valve comprising:

- (a) a cylindrical valve body including,
- (b) a high pressure inlet chamber at the upper end 35 of said body,
- (c) a low pressure chamber at the lower end of said body and having circumferentially spaced inlet and outlet ports,
- (d) an intermediate outlet chamber, 40
- (e) normally closed valve means between said inlet and outlet chambers and means for opening said valve means,
- (f) a movable piston within said valve body between said outlet chamber and low pressure chamber 45 forming one wall of each of said chambers,
- (g) means for normally positioning said piston within said valve body between said valve means and said low pressure chamber ports and for permitting movement of said piston downwardly to a second position overlying both of said low pressure ports upon opening of said valve means to increase the pressure in said outlet chamber, 50
- (h) means defining a restricted communication between said suction line ports when said piston is in said second position, 55
- (i) said inlet port being lower than said outlet port whereby during return movement of said piston to its normal position said inlet port is connected to said suction chamber ahead of said outlet port. 60

5. A valve for modifying the flow of high pressure refrigerant to the evaporator component of a refrigerating system and automatically restricting the flow of low pressure refrigerant in the system during the modified flow, said valve comprising: 65

- (a) a cylindrical valve body including,
- (b) a high pressure inlet chamber at the upper end of said body,
- (c) a low pressure chamber at the lower end of said body and having circumferentially spaced inlet and 70 outlet ports,
- (d) an intermediate outlet chamber,
- (e) normally closed means between said inlet and outlet chambers, and means for opening said valve means, 75

- (f) a movable piston within said valve body between said outlet chamber and low pressure chamber forming one wall of each of said chambers,
- (g) means for normally positioning said piston within said valve body between said valve means and said low pressure chamber ports and for permitting movement of said piston downwardly to a second position overlying said low pressure ports upon opening of said valve means to increase the pressure in said outlet chamber,
- (h) said piston including a circumferential groove defining a restricted communication between said suction line ports when said piston is in said second position,
- (i) said inlet port being lower than said outlet port whereby during return movement of said piston to its normal position said inlet port is connected to said suction chamber ahead of said outlet port.

6. A valve for modifying the flow of refrigerant in a refrigerating system including a compressor, a condenser, a restrictor, an evaporator and a suction line normally connected in closed, series flow relationship in order to introduce high pressure refrigerant directly into the evaporator and automatically restrict the flow of refrigerant through the suction line, said valve comprising:

- (a) a cylindrical valve body including,
- (b) an inlet chamber at one end of said body and having an inlet for high pressure refrigerant,
- (c) a suction chamber at the other end of said body and having an inlet port for connection to said evaporator and an outlet port for connection to said compressor intake, said outlet port being circumferentially spaced from said inlet port,
- (d) an intermediate outlet chamber having an outlet for connection to the inlet end of the evaporator,
- (e) valve means between said inlet and outlet chambers, and means for opening said valve means,
- (f) a movable piston between said outlet and suction chambers forming one wall of each of said chambers,
- (g) spring means for normally positioning said piston within said valve body between said valve means and said suction chamber ports and for permitting movement of said piston to a second position sealing said suction chamber ports from said suction chamber upon an increase in pressure in said outlet chamber,
- (h) means defining a restricted communication between said suction line connections when said piston is in said second position,
- (i) said suction chamber ports being offset from one another so that during return movement of said piston to its normal position said inlet port is connected to said suction chamber ahead of said outlet port.

7. A valve for controlling the flow of refrigerant between the compressor and evaporator components of a refrigerating system, said valve comprising:

- (a) a cylindrical valve body having first, second and third chambers therein,
- (b) said first chamber having an inlet for connection with the compressor discharge,
- (c) said second chamber being disposed between said first and third chambers and having an outlet for connection to the inlet end of said evaporator,
- (d) said third chamber having spaced inlet and outlet ports for connection respectively to the outlet end of said evaporator and the compressor intake,
- (e) a valve port interconnecting said first and second chambers, a valve member normally closing said valve port, and means for moving said valve member to a position in which said valve port is open,
- (f) a piston slidably arranged in said valve body forming a movable wall dividing said second and third chambers and being movable between a first position 940

- tion providing unrestricted communication between said third chamber inlet and outlet ports and a second position in which said piston covers said third chamber inlet and outlet ports,
- (g) said piston including an annular groove in the side wall thereof providing restricted communication between said third chamber inlet and outlet ports when said piston is in its second position, and
- (h) spring means for normally positioning said piston in said first position when said valve port is closed by said valve member and for permitting movement of said piston to its second position upon opening of said valve port to introduce high pressure refrigerant into said second chamber,
- (i) said third chamber inlet and outlet ports being offset from one another so that during return movement of said piston to its first position said third chamber is first connected to said inlet port before said third chamber is connected to said outlet port.

5 1,394,900
2,372,456
2,525,560
2,631,441
2,679,141
2,729,069
10 2,743,587
2,823,691
2,983,114
3,003,334

15 19,025
625,685

References Cited in the file of this patent

UNITED STATES PATENTS

Hibner ----- Oct. 25, 1921
Stewart ----- Mar. 27, 1945
Pabst ----- Oct. 10, 1950
Shoemaker ----- Mar. 17, 1953
Philipp ----- May 25, 1954
Collins ----- Jan. 3, 1956
Hubacker ----- May 1, 1956
Chatham ----- Feb. 18, 1958
Noakes ----- May 9, 1961
Mahalick ----- Oct. 10, 1961

FOREIGN PATENTS

Germany ----- Oct. 25, 1956
Great Britain ----- July 1, 1949