Aug. 29, 1950 C. L. AUGHEY ET AL 2,520,191

REFRIGERANT EXPANSION VALVE

Filed June 16, 1944 3 Sheets-Sheet 1

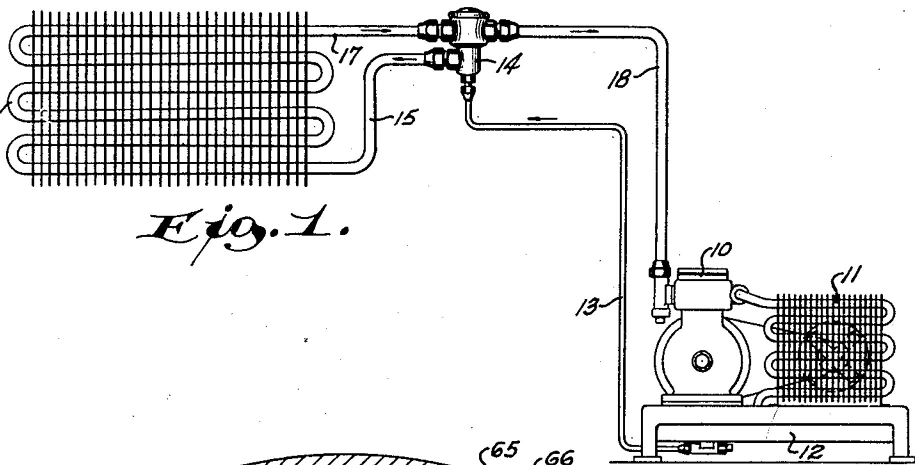

Fig. 1.

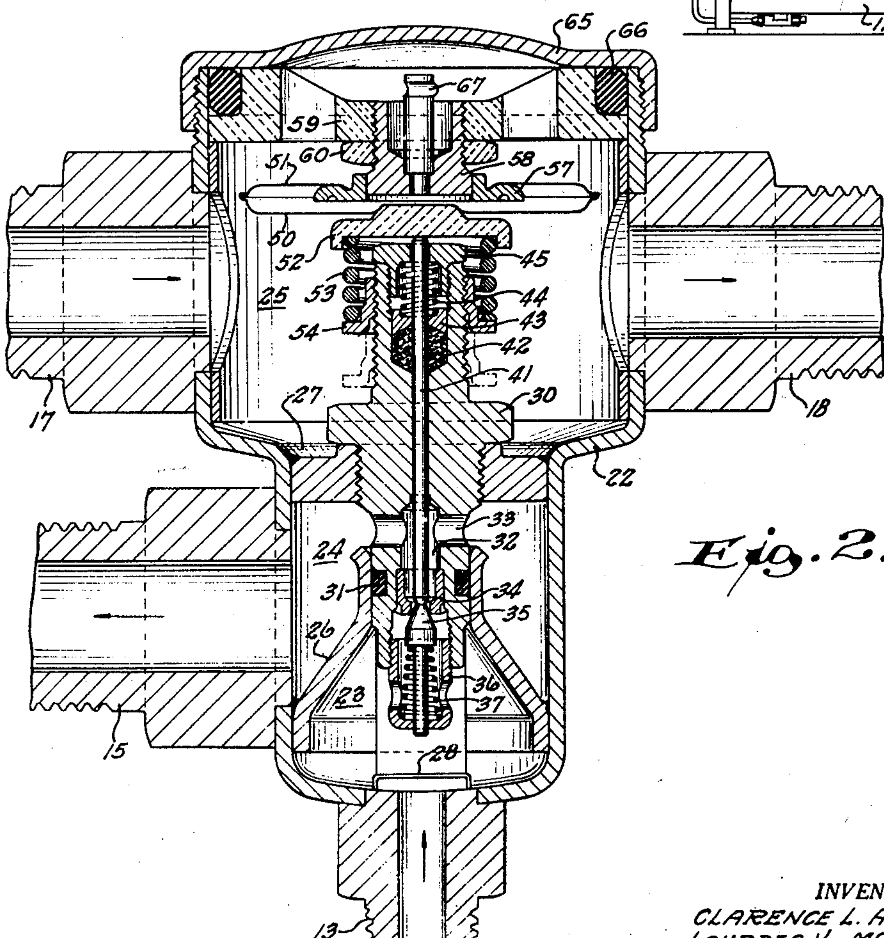

Fig. 2.

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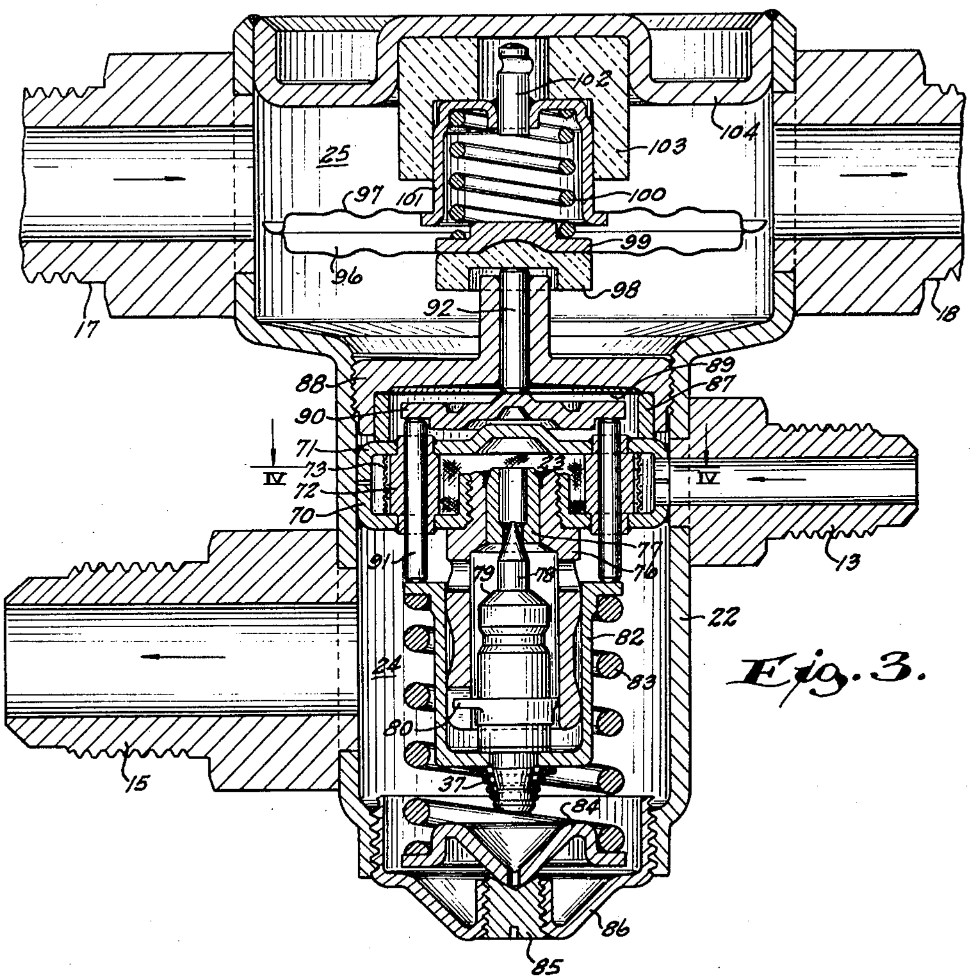

Fig. 3.

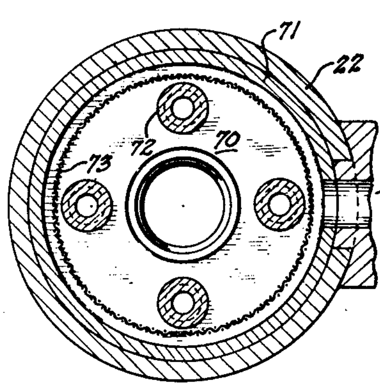

Fig. 4.

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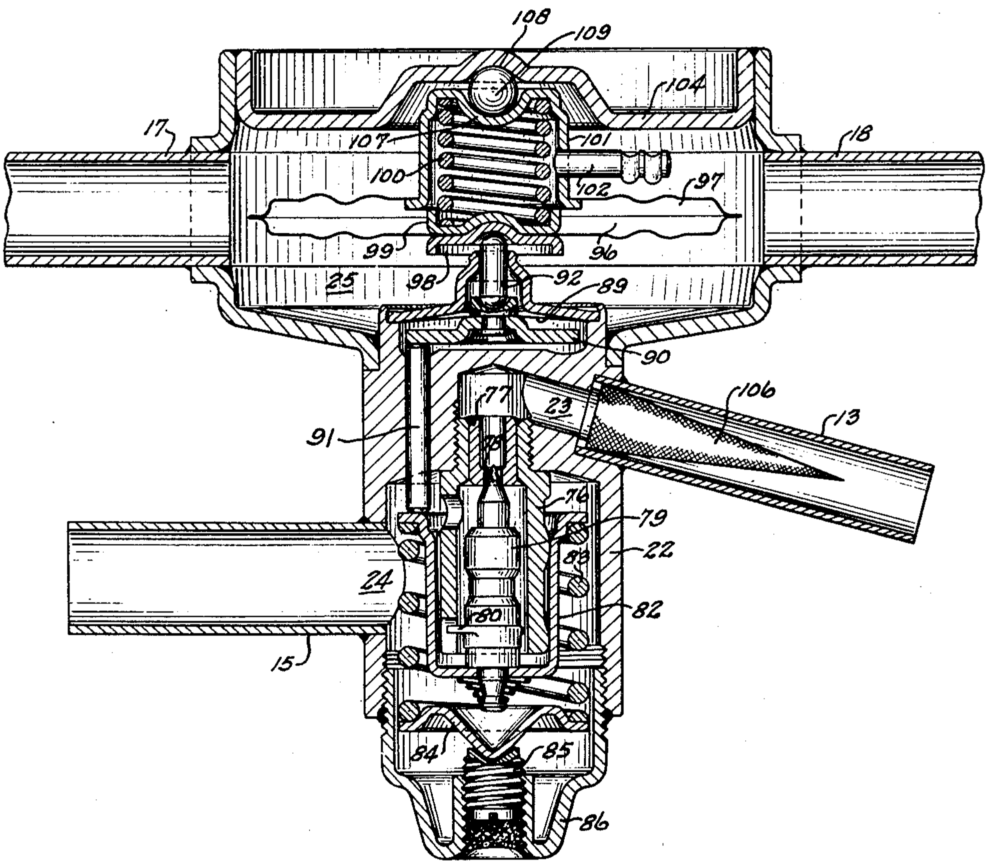
Fig. 5.



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REFRIGERANT EXPANSION VALVE

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7 Claims. (Cl. 62—8)

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This invention relates to improvements in valves for regulating the flow of refrigerant in a compression-type refrigerating system from a source of liquid refrigerant under pressure to an evaporator for the refrigerant in a space to be cooled.

One object of the invention is to provide a pressure-regulating valve in a refrigerating system of the compression-condensation type in which operation of the valve is directly responsive to the conditions of the refrigerant returning to the compressor from the evaporator.

Another object of the invention is to provide a pressure-regulating valve for a refrigerating system in which the valve is closed responsive to the pressure in the evaporator whenever such pressure exceeds a predetermined value.

Another object of the invention is to provide a pressure-regulating valve for a refrigerating system in which the valve is closed responsive to the pressure in the evaporator whenever the evaporator pressure exceeds the initial pressure in a thermostatic element in the stream of gas flowing from the evaporator and regardless of the temperature of the valve itself.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 diagrammatically represents a refrigerating system of the compressor-condenser-evaporator type showing the relation of the valve of the present invention to the several parts of such system;

Fig. 2 is a vertical sectional view taken substantially on a central plane through one modification of the valve with some of the parts thereof shown in elevation;

Fig. 3 is a vertical sectional view of another modification of the valve with some of the parts thereof shown in elevation;

Fig. 4 is a fragmentary enlarged view taken looking down on the plane of line IV—IV of Fig. 3; and

Fig. 5 is a vertical sectional view taken on substantially a central plane with some of the parts shown in elevation, of a third modification of the present invention.

Referring to the drawings by characters of reference, the reference numeral 10 designates a compressor from which compressed gaseous refrigerant is discharged into a condenser 11 for cooling. Cooling of the compressed refrigerant in the condenser 11 liquefies the refrigerant which flows into a receiver 12 connected by way

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of a conduit 13, with a chamber in a regulating valve generally indicated at 14, and a conduit 15 with an evaporator 16. Liquid refrigerant from the receiver 12 is partially vaporized in the valve 14 by reduction in pressure and is completely vaporized in the evaporator 16 by absorption of heat from the space to be cooled. The completely gasified refrigerant leaves the evaporator 16 by a conduit 17 and flows through another chamber in the valve 14 and a conduit 18 to the inlet side of the compressor 10.

The expansion valve comprises a casing 22 which is divided into a liquid refrigerant inlet chamber 23, a vaporized refrigerant outlet chamber 24, and a gaseous refrigerant return chamber 25, the separation between chambers 23 and 24 being attained (see Fig. 2) by a partition 26, and the separation between chambers 24 and 25 being produced by a partition 27. The partition between chambers 24 and 25 must be made gastight to prevent leakage from chamber 24 into chamber 25 which is at lower pressure due to the pressure drop through evaporator 16. A shield 28 over the inlet into the valve casing prevents interference of the incoming liquid refrigerant with the valve to be described. The partitions 26 and 27 are both formed with ports into which is fitted a filler piece 30. The filler piece is formed to fit into the ported partition 26 with a close fit and leakage between the partition 26 and the filler piece 30 is prevented by a resilient gasket 31 which is put under pressure upon insertion of the filler piece into the port of the partition 26. And the filler piece is retained in a predetermined position and is sealed into the partition 27 by screwing into the port therein. The filler piece is formed with a substantially central passageway therethrough having a portion designated 32 connected with transverse passages 33, the passages 32 and 33 forming a conduit for the flow of gas from the inlet chamber 23 to the outlet chamber 24.

The filler piece passage 31 is provided with a shoulder on which is supported a valve seat member 34 having an orifice therein which is closed by a needle valve 35. The valve 35 is positioned adjacent its seat by a retainer 36 screw-threaded into the end of the filler piece 30 and by a spring 37 acting between a wall of the retainer 36 and a surface of the valve 35. The pressure at which the valve is actuated may be readily adjusted by changing the position of retainer 36 in filler piece 30. The valve 35 is actuated by way of a push pin 41 extending from chamber 25 through the axial passage in the filler piece 30 and into contact with the end of the needle valve 34. Leakage of refrigerant between the chambers 24 and 25 along the push pin 41 is prevented by sealing the push pin into the filler piece 30 by means of a packing gland including a packing 42 compressed by a follower 43 under the action of a spring 44 which is compressible as desired by a cap 45 threaded into the interior of the filler piece 30 and capable of adjusting the degree of compression of the spring 44.

A variable volume means which is temperature and pressure responsive is provided for actuating the push pin and the valve and includes a pressure-responsive element shown as being formed from a plurality of diaphragms 50 and 51 which are spaced and joined at their peripheral edges, it being understood that other expansible means such as bellows may be used in place of the diaphragms. The lower diaphragm 50 of the pressure-responsive element is formed with a seat therein for receiving a pressure plate 52 of heat insulating material which is adapted to press on the push pin 41 upon expansion of the pressure-responsive element and is adjustably held in the diaphragm seat by varying the degree of compression of a spring 53 acting against a seat 54 screw-threaded on the filler piece 30. The upper diaphragm 51 is formed with an aperture therein in which is mounted a ring 57. The ring 57 has fixed therein a boss 58 which is screw-threaded into a heat-insulating supporting member 59 and is held in place therein by a lock nut 60. Member 59 is sealed against the cover 65 of the casing by a resilient gasket 66. The boss 58 has a hole therethrough into which is fitted a tube 67 for charging the space between the diaphragms 50, 51 with a suitable fluid as is well known. After the charge has been supplied, the tube is pinched off and suitably sealed.

The pressure and temperature-responsive element 50, 51 is in the flow of refrigerant which has been gasified in the evaporator and is therefore directly subjected to the temperature and pressure changes in such gas. And, being heat-insulated from the valve and the casing, such element is not subject to temperature changes of the valve itself. If the pressure of the gas stream exceeds the internal pressure of the element, the element cannot hold the valve open against the action of the springs tending to close the valve either directly or indirectly. The element 50—51 is partially filled with a vaporizable fluid at a predetermined pressure and temperature. The use of the same fluid as is used in the refrigerating system has been found satisfactory. The vaporizable fluid, however, completely vaporizes above a predetermined temperature and the pressure within the element then reaches its maximum. This condition is termed a limit charge. At the time of starting the system the pressure of the gaseous refrigerant as it leaves the evaporator 16 is well above that in the element 50—51; consequently the valve 35 is closed and the load on the compressor is greatly reduced permitting the use of lower power operating motors.

In the use of the above structure, the compression springs 37 and 53 are so adjusted that expansion and contraction of the temperature and pressure responsive element 50, 51 controls opening of the valve 55 to admit that quantity of refrigerant to the evaporator which will maintain the space to be cooled at the desired temperature so long as the system is operating normally. The usual variations in temperature in the space to be cooled cause changes in the temperature and

pressure of the gas flowing from the evaporator to the suction inlet of the compressor, which changes act on the expansible element 50, 51 in the gasified refrigerant stream to vary its actuation of the valve as necessary to maintain the predetermined temperature. However, if some abnormal condition occurs which increases the pressure of the gas in the evaporator beyond the initial pressure of the element 50, 51, such element is partially collapsed. The spring 53 then raises the pressure plate 52 off the end of the push pin 41 and the spring 37 closes the valve 35 to cut off further flow of refrigerant until the evaporator pressure is again reduced to the value at which the expansible element 50, 51 may respond to temperature and pressure changes.

In the modified form of the invention shown in Figs. 3 and 4, the space 23 in the valve casing 22 is defined by the partition walls 70 and 71, the chamber 23 being within the chamber 24. The walls 70 and 71 are spaced from each other by spacers 72 which are secured to the walls in gas-tight relation and are formed with passages therethrough and provide a supporting framework for a screen 73 through which all of the refrigerant coming from the condenser must flow. The partition wall 70 is formed with a flanged port in which is threaded a retainer 76 for a valve seat 77. The retainer 76 also forms a guide for the valve which comprises a needle 78 and a holder 79, the holder having an ear 80 extending into a slot in retainer 76 which prevents rotation of the valve and holder and limits its movement relative to the seat. The valve holder 79 is seated in a cup-shaped member 82 mounted on a compression spring 83 extending between a flange on the cup-shaped member and a seat 84 which is adjustable from exteriorly of the valve casing by reason of its mounting on a screw 85 threaded into a flanged aperture in the casing closure 86.

A spacer 87, resting on partition wall 71, determines the location of a third partition 88 extending across the casing 22 above the chamber 23 and screwed into the casing to define chamber 24 and the chamber 25. The spacer 87 and partition 88 act as a clamp holding the periphery of a flexible diaphragm 89 which forms a gas-tight partition between chambers 24 and 25. The diaphragm rests on a pressure plate 90 and is carried by and supported on push pins 91 extending through the passages in the spacers 72 and resting on the upper flanged edge of the spring guide 82.

A flanged hole in partition 88 receives and guides a push pin 92 of heat insulating material which actuates the valve by transmitting movement thereto from a pressure-temperature responsive means mounted in the chamber 25 and under the pressure of the gas flowing from the evaporator to the condenser. The pressure-responsive means includes a plurality of diaphragms 96 and 97 joined at their outer edges to define a space of variable volume partially filled with a vaporizable material at a predetermined pressure and temperature. The lower diaphragm 96 of the pressure-responsive element rests on a pressure plate 98 in contact with the upper end of the push pin 92. A pressure pad 99 is placed on the lower diaphragm 96 to transmit to the variable volume means 96, 97 the pressure of a spring 100 acting between the pad 99 and the end of a cup-shaped member 101 forming a closure for a hole in the upper diaphragm 97. The end of the cup-shaped member 101 itself has a hole therethrough for the purpose of receiving a tube 102 for charging the space within the diaphragm 96, 97 with a suitable expansible fluid, the tube being suitably sealed after charging of the space defined by the diaphragms. The diaphragm closure 101 is set into a socket member 103 of insulating material which is secured to the cover 104 of the valve casing.

The embodiment of the invention shown in Fig. 5 is similar to that shown in Fig. 3 excepting for the provision of a screen 106 in the liquid inlet 13 to the valve casing 22 and for the manner in which the pressure and temperature-responsive element is mounted in heat-insulated relation with the casing. The diaphragm closure 101 is formed with a socket 107 in the wall thereof adjacent a portion of the casing cover 102 which is provided with a similar and opposed socket 108. The sockets are shown as being substantially semi-spherical to receive a ball 109 which is made of suitable heat-insulating material capable of withstanding the action of the refrigerant and the pressure exerted thereon and which spaces the diaphragm closure from the cover and prevents the transmission of heat therebetween. The use of ball and socket suspensions or mountings for the expansible element facilitate the assembly of the element in the casing and allow the free positioning of such element during operation.

In the use of the modified structures described particularly above, the actions are similar to those described with respect to Fig. 2. The variable volume means 96, 97 expands and contracts responsive to changes in the pressure and temperature of the gasified refrigerant flowing from the evaporator 16 through the valve chamber 25 as a result of the suction of the compressor 10. A decrease in the pressure and temperature of the gasified refrigerant stream allows the variable volume means to expand which acts against spring 83 to open the valve 35 and admit the refrigerant necessary to bring the pressure and temperature of the gas stream back to the predetermined value. Increase in the gasified refrigerant temperature and pressure partially collapses the means 96, 97 so that the springs 83 and 37 expand to close the valve until the conditions in the gasified refrigerant stream have come back to their desired values.

It will be seen that the above structures provide a pressure-regulating or expansion valve for a compression type of refrigerating system in which means having a volume variable responsive to pressure changes in a stream of refrigerant is located in such stream flowing from the evaporator to the compressor. Such means is therefore directly responsive to changes in the refrigerant conditions in the evaporator. The valve being spring-biased toward closing position, the pressure which may be produced under any conditions is limited to the pressure obtainable from the vaporized material in the variable volume means. Being heat-insulated from the valve casing and the valve, the variable volume means is unaffected by the temperature of the valve casing parts or the valve itself. The means transmitting the action of the variable volume means to the valve includes push pins extending from one valve casing chamber to the other in sealed relation or in such relation that leakage between the chambers connected by the push pins is without effect on the operation of the variable volume means.

One important advantage of the valve of the present construction is that the load on the compressor motor may be largely reduced when the system is started while at a high temperature. If the temperature and pressure responsive element is charged with a fluid which completely vaporizes above a predetermined temperature, the pressure in the element and the expansion thereof reaches a maximum at such temperature. If the system temperature rises above the predetermined value, the pressure in the refrigerant return chamber of the casing exceeds the maximum pressure in the element and the element is partially collapsed thus allowing the spring to close the valve. No more refrigerant can then flow into the evaporator until the compressor has pumped the pressure in the evaporator below the maximum pressure of the responsive element. Upon such reduction in pressure the valve will again be opened by the pressure responsive element until the pressure in the evaporator again exceeds the maximum pressure obtainable in such element. It will thus be seen that the above operation provides for the cooling of a space by increments or steps with a definite limit on the amount of refrigerant which may be evaporated in any one step and thus limits the load which may be imposed at any one time on the compressor motor. The temperature at which the above cycle takes place is of course dependent on the fluid used in charging the pressure-responsive element and on the pressure to which the element is charged as is well known.

Although but a few embodiments of the present invention have been illustrated and described it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. In a device for controlling the flow of refrigerant in a compression-evaporation type refrigerating system, a casing having a plurality of chambers separately receiving the supply of refrigerant from the compressor to the evaporator and the return of refrigerant from the evapoator to the compressor, a valve in the casing controlling the flow of refrigerant through the supply chamber, a flexible walled chamber in the return chamber charged with a fluid completely vaporizable at a predetermined temperature to establish a maximum pressure therein, said chamber being variable in volume responsive to changes in temperature of the refrigerant flowing through the return chamber provided said refrigerant pressure is not in excess of said maximum, means mounting the flexible walled chamber in heat insulated relation to the casing and to the valve, and means transmitting movements of the flexible walled chamber to the valve.

2. In a control device for a refrigeration system of the type including a compressor and an evaporator, a valve casing, a valve controlling the flow of refrigerant from the compressor to the evaporator, and pressure limit charged means mounted in said casing in heat exchange relation with the refrigerant flowing from the evaporator and operatively connected to said valve to regulate same, said means being insulated from said casing and from said valve and being operative to regulate said valve in accordance with the temperature of the refrigerant flowing from the evaporator to the compressor so long as the pressure of the refrigerant flowing from the evapo-

rator is below the pressure limit of said charged means but unable to effect movement of said valve when the pressure of the refrigerant flowing from the evaporator to the compressor exceeds the pressure limit of said means.

3. In a control device for a refrigeration system of the type including a compressor and an evaporator, a casing having a plurality of chambers, the flow of refrigerant from the compressor to the evaporator passing through one of said chambers and the return flow of refrigerant from the evaporator to the compressor passing through another of said chambers, a valve in said one chamber for controlling the flow of refrigerant therethrough, a diaphragm chamber mounted in said another chamber and responsive to pressure and temperature of the refrigerant flowing from the evaporator to the compressor, and means transmitting the action of said diaphragm chamber to the valve, a charge in said diaphragm chamber comprising a vaporizable liquid which is completely vaporized at a predetermined temperature to establish a pressure limit within the diaphragm chamber so that said diaphragm chamber is inoperative to actuate the valve when the refrigerant pressure in said another chamber exceeds said pressure limit and is operative to control said valve in accordance with the temperature of the refrigerant in said another chamber when the refrigerant pressure in said another chamber is below said pressure limit.

4. In a control device for a refrigeration system of the type including a compressor and an evaporator, a casing having a plurality of chambers individually subjected to the supply of refrigerant from the compressor to the evaporator and the return of refrigerant from the evaporator to the compressor, a valve in the casing controlling the flow of refrigerant through the supply chamber, a spring urging the valve toward closed position, a diaphragm chamber mounted in the return chamber in heat exchange relation with the refrigerant flowing from the evaporator, means operatively connecting the diaphragm chamber and said valve for regulating the valve in opposition to said spring, a charge in said diaphragm chamber comprising a vaporizable liquid which is completely vaporized at a predetermined temperature to establish a pressure limit within the diaphragm chamber so that said diaphragm chamber is inoperative to actuate said valve when the refrigerant pressure in the refrigerant return chamber exceeds said pressure limit and is operative to control said valve in accordance with the temperature of the refrigerant in said refrigerant return chamber when the refrigerant pressure in said refrigerant return chamber is below said pressure limit.

5. In a control device for a refrigeration system of the type including a compressor and an evaporator, a casing having a supply chamber through which refrigerant flows from the compressor to the evaporator and a return chamber through which refrigerant flows from the evaporator to the compressor, a valve in said supply chamber controlling the flow of refrigerant to the evaporator, a pressure limit charged element mounted in the return chamber and insulated from the casing, and insulating means for transmitting the action of said element to the valve, said element being operative to increase in volume and

increase the opening of said valve in response to an increase in refrigerant temperature in said return chamber when the refrigerant pressure in said return chamber is below the limit charge of said element and being unable to open said valve when the refrigerant pressure in the return chamber exceeds the pressure limit of said element.

6. In a control device for a refrigeration system of the type including a compressor and an evaporator, a valve casing having a chamber therein, an inlet and outlet in said chamber respectively adapted for connection to the compressor and the evaporator, a valve in said chamber adapted to control flow of refrigerant from the compressor to the evaporator, a diaphragm chamber in heat exchange relation with the refrigerant flowing from said evaporator and directly responsive to the temperature and pressure of said return refrigerant to regulate said valve, a charge in said diaphragm chamber comprising a vaporizable liquid which is completely vaporized at a predetermined temperature to establish a pressure limit within the diaphragm chamber so that said diaphragm chamber is inoperative to actuate said valve when the return refrigerant pressure exceeds said pressure limit and is operative to control said valve in accordance with the temperature of the return refrigerant when the return refrigerant pressure is below said pressure limit.

7. In a control device for a refrigeration system of the type including a compressor and an evaporator, a valve casing having two chambers, the supply refrigerant flowing from the compressor to the evaporator passing through one of said chambers and the return refrigerant flowing from the evaporator to the compressor passing through the other of said chambers, a valve in said one chamber adapted to regulate flow of refrigerant through the chamber, a variable volume diaphragm chamber in said other chamber, and means for transmitting movement of said diaphragm chamber to said valve, a charge in said diaphragm chamber comprising a vaporizable liquid which is completely vaporized at a predetermined temperature to establish a pressure limit within the diaphragm chamber so that said diaphragm chamber is inoperative to actuate said valve when the refrigerant pressure in said other chamber exceeds said pressure limit and is operative to control said valve in accordance with the temperature of the refrigerant in said other chamber when the refrigerant pressure in said other chamber is below said pressure limit.

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