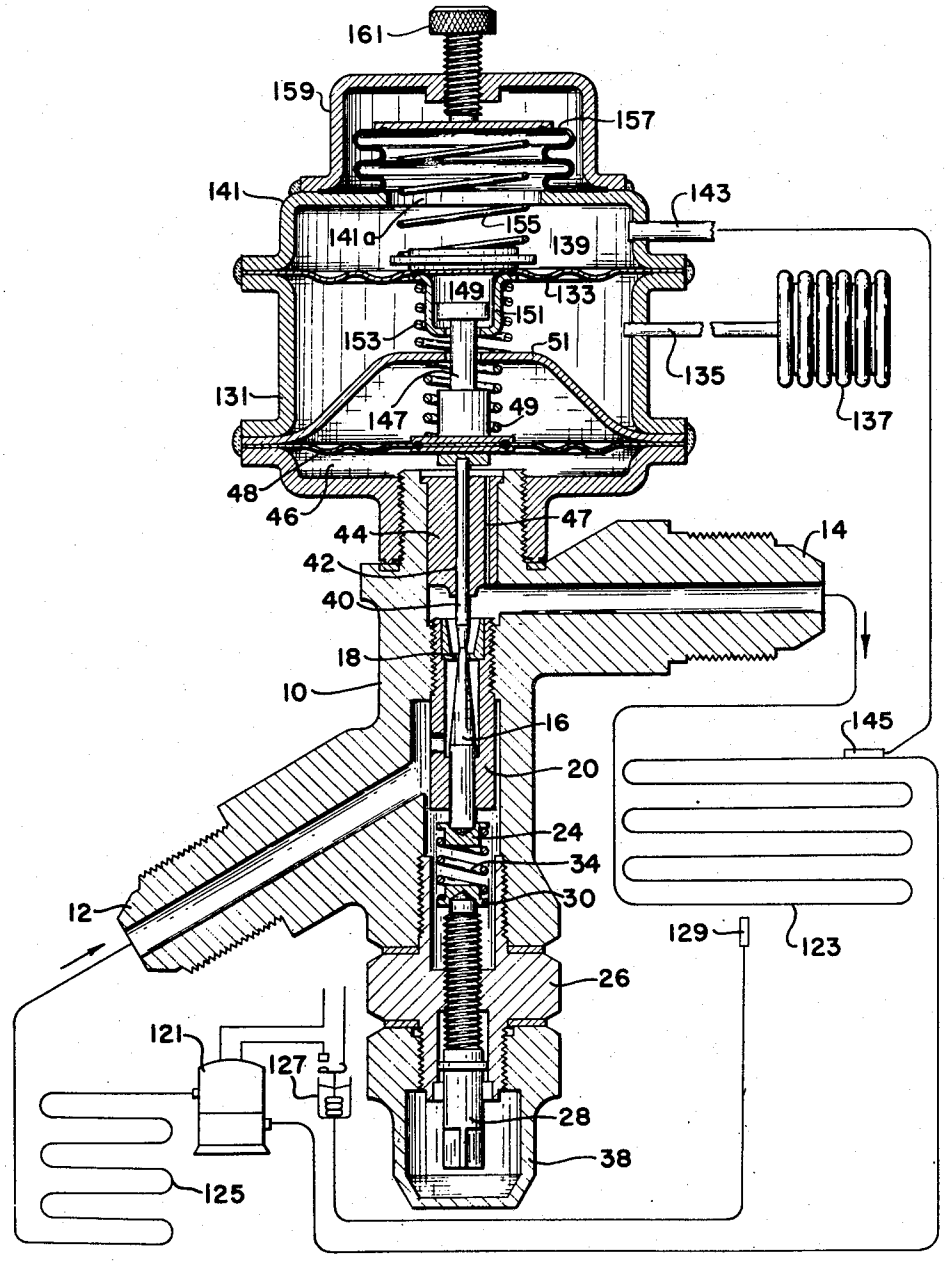
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EXPANSION VALVE FOR REFRIGERATING APPARATUS

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EXPANSION VALVE FOR REFRIGERATING APPARATUS

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This invention relates to refrigerating apparatus and more particularly to refrigerant expansion valves for controlling the flow of liquid refrigerant from the condenser to the evaporator.

Originally, refrigerating systems had hand valves for controlling the flow of liquid refrigerant from the condenser to the evaporator. Such hand valves had to be adjusted from time to time to accommodate changing conditions. Automatic expansion valves were introduced to provide better performance and to make it unnecessary to have an attendant to adjust the hand valves. These automatic expansion valves provided an increased flow of refrigerant as the pressure within the evaporator was reduced below a selected back pressure setting. Automatic expansion valves are used for substantially uniform evaporator loads when it is satisfactory to operate at a constant back pressure. Where loads are not uniform it cannot handle heavy loads efficiently and there is a possibility that liquid refrigerant will flow out of the evaporator into the compressor and damage the compressor.

Thermostatic expansion valves were introduced to overcome such difficulties with the automatic expansion valves. The thermostatic expansion valves provide a thermostatic bulb at the outlet of the evaporator which throttles the valve before the liquid refrigerant flows out of the evaporator. At all other times the thermostatic system exerts a force tending to hold open the valve. While it provides improvement in such respects the thermostatic expansion valves introduced a problem not encountered with the automatic expansion valves, since under heavy loads the back pressure sometimes rose high enough to overload the compressor. Attempts have been made to provide limiting devices for the thermostatic expansion valves to prevent such overloading of the compressor. However, these limiting devices have introduced further complications in regard to adjustment and they are apt to cause difficulties in the field.

It is an object of this invention to provide a thermostatic expansion valve in which the back pressure diaphragm operates independently of the thermostatic bulb responsive diaphragm during normal refrigeration and high back pressure conditions, and in which the thermostatic bulb responsive diaphragm becomes effective solely to throttle the refrigerant flow and this only when the evaporator has become charged with liquid refrigerant to the maximum desired amount. This arrangement thus uses the independently operating back pressure diaphragm as a protector to protect the motor compressor against excessive and continued high back pressures.

It is another object of this invention to provide an expansion valve which operates as an automatic expansion valve directly responsive to refrigerant pressures in the evaporator at all times except when liquid refrigerant approaches the evaporator outlet.

It is another object of this invention to provide an expansion valve in which the thermostatic element is coupled to the valve only when the temperature at the evaporator outlet drops below a predetermined temperature.

It is another object of my invention to provide a thermostatic expansion valve in which the upper limit of back pressure can be adjusted in the same manner as an automatic expansion valve is adjusted.

These objects are attained in the form of the invention illustrated in which there is provided a pressure operated expansion valve responsive to back pressure which is adjustable by an adjusting screw accessible by removing a cap from the valve body. According to this invention

there is provided a thermostat bulb to be clamped in metal-to-metal contact with the evaporator outlet. This bulb is connected to a diaphragm chamber. But the diaphragm of this chamber is not connected to operate the valve under normal circumstances. This temperature responsive diaphragm is normally disconnected from the valve and normally has no influence upon the valve so that the valve normally operates as an automatic expansion valve in which the valve closes when a predetermined back pressure is reached to limit the pressure within the evaporator and the suction line when the system is in operation.

The connection of this thermally responsive diaphragm with the valve is made only when the liquid refrigerant approaches or reaches the outlet of the evaporator causing the thermally responsive diaphragm to move in the closing direction of the valve. Under such circumstances, a lost motion connection becomes coupled and assists in moving the valve to closed position. Under normal circumstances the lost motion connection is uncoupled and there is no other connection between the thermally responsive diaphragm and the valve so that this diaphragm cannot raise the back pressure above the back pressure for which the valve is set. This prevents overloading of the compressor.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawing:

The figure is a diagrammatic representation of one form of the refrigerating system including a sectional view of a valve embodying one form of my invention.

Referring now to the drawing there is shown a sealed motor-compressor unit **121** for withdrawing evaporated refrigerant from an evaporator **123** and pumping the compressed refrigerant into a condenser **125** where the compressed refrigerant is liquefied. The operation of the motor-compressor unit may be controlled by a switch **127** operated in accordance with the temperature of its thermostatic bulb **129** which for example may be located in the medium cooled by the evaporator **123**.

The flow of refrigerant from the condenser **125** to the evaporator **123** is controlled by my improved expansion valve including a valve body **10** having an inlet **12** connected to the outlet of the condenser **125** and an outlet **14** connected to the inlet of the evaporator **123**. The flow of liquid refrigerant through the valve body **10** from the inlet **12** to the outlet **14** is regulated by the valve **16** cooperating with the seat **18** carried by a stem guide **20** which is threaded into the valve body **10** as shown. The lower end of the valve **16** seats in a spring seat **24**. A gland member **26** is threaded into the bottom of the valve body **10** and has an adjusting screw **28** threaded therein. The upper end of this adjusting screw **28** extends into supporting arrangement with the spring seat **30** provided at the lower end of the coil spring **34**. The squared end of the screw **28** may be turned to vary the compression of the spring **34** so as to vary the force required to open the valve **16** and in that way to vary the refrigerant evaporator pressure at which the valve **16** will move to closed position at all times, as will be described later. The lower end of the gland **26** is sealed by a cap **38**.

The valve **16** may be moved off its seat by means of a downward movement of the pin **40** acting on the tip of the valve **16** from the outlet or evaporator pressure side of the valve seat **18**. The proper relationship of the point of the pin **40** with respect to the point of the valve **16** is maintained by bore **42** in the guide **44** positioned in the upper end of the valve body **10**. The bore **42** may be also used to allow pressure variations in the outlet side of the valve **16** to be transmitted to the chamber **46**. But to insure this I have provided an additional passage **47** connecting the valve outlet **14** with the diaphragm chamber **46**.

The upper side of the chamber **46** is formed by a diaphragm **48** which is lifted by increasing pressure in the chamber **46** and the outlet **14** of the valve to permit the spring **34** to move the valve **16** to closed position. To keep the diaphragm **48** in engagement with the pin **40** and to keep the pin **40** in engagement with the valve **16**

there is provided a spring 49 the upper end of which is supported by the spring support 51 while the lower end rests on top of the diaphragm 48. This spring 49 provides an opening force tending to push the valve 16 to the open position to allow refrigerant to flow from the inlet 12 to the outlet 14.

The force of this spring 49 is opposed by the pressure in the chamber 46 against the bottom of the diaphragm 48 and the force of the spring 34. Therefore, whenever the pressure in the chamber 46 rises high enough that its force plus the force of the spring 34 equals the force of the spring 49, then the valve 16 will be closed. When the motor-compressor unit 121 operates to reduce the pressure in the evaporator 123 and the chamber 46, then the valve 16 will open to allow refrigerant to flow into the evaporator 123. The pressure at which the valve 16 opens and closes is adjusted by the screw 28. Preferably, this screw is adjusted to provide sufficient force to close the valve when the evaporator pressure is as high as the motor-compressor unit can pump continuously without overloading. However, to secure a lower evaporator temperature or for other reasons, the force of the spring 34 may be raised to provide a lower back pressure if desired.

The valve as so far described will operate as an ordinary automatic expansion valve. To prevent the overflow of liquid refrigerant from the evaporator 123 into the motor-compressor unit 121 where it might damage the compressor, I provide a novel thermostatic control arrangement which is normally uncoupled from the valve 16 and the diaphragm 48. The purpose of this uncoupling is to prevent the disturbance of the operation of the valve 16 in accordance with the pressure in the chamber 46 so that the motor-compressor unit 121 will never be overloaded.

Mounted above the pressure chamber 46 and the diaphragm 48 is a cylindrical support 131 the upper end of which supports a thermostatic diaphragm 133. The cylindrical support 131 is sealed to the diaphragms 48 and 133 providing a sealed chamber between the diaphragms. Preferably this sealed chamber is evacuated so that pressure changes therein are minimized. However, if desired, the interior of this chamber between the diaphragms may be connected by a tube 135 to a resilient bellows 137 located outside the chamber so that the pressure within the chamber will be substantially the same as atmospheric pressure or at a substantially fixed differential from atmospheric pressure.

The thermostatic chamber 139 is located above the diaphragm 133 and is formed by an upper inverted cup member 141, the rim of which is sealed to the diaphragm 133. This chamber 139 is connected by a small tube 143 to a thermostat bulb 145 which is clamped in metal-to-metal contact with the outlet portion of the evaporator 123. The location of this bulb 145 may be varied to obtain the best results. For example, it may be placed at some point in the last pass of the evaporator or it may be placed on an adjacent portion of the suction line. Its position may be changed with changes in the back pressure adjustment screw 28. The bulb 145, the capillary tube 143 and the chamber 139 are charged with a volatile liquid which preferably is the same refrigerant which is used in the refrigerating system such as difluorodichloromethane (F–12).

With this arrangement, when liquid refrigerant approaches the bulb 143, the pressure within the chamber 139 will fall. However, when there is less liquid refrigerant in the evaporator 123 and considerable superheat in the portion of the evaporator nearest the bulb 145 the pressure within the chamber 139 will increase causing the diaphragm 133 to move towards the diaphragm 48 in the direction to open the valve 16. If the diaphragm 133 were to have any solid connection with the valve 16 under such circumstances, it would increase the pressure within the evaporator 123 by allowing liquid refrigerant to flow into the evaporator 123 more rapidly. It would also tend to increase the pressure required in the chamber 46 to move the valve 16 to closed position. Under such circumstances it would be possible to overload the motor compressor unit.

To prevent this from occurring, I provide a lost motion connection between the diaphragms 133 and 48 arranged in such a way that there is no connection between the diaphragms whenever the pressure in the chamber 139 is sufficient to move the diaphragm 133 toward the diaphragm 48 and the valve 16. This lost motion connection is a one way only connection which can only operate in the direction to move the diaphragm 48 and the valve 16 to closed position. Therefore it never can increase the back pressure or the evaporator pressure, but can only serve to decrease this pressure by reducing the flow of liquid refrigerant into the evaporator when the evaporator outlet becomes cold enough to indicate that liquid refrigerant is dangerously close to flowing out of the evaporator.

To provide this lost motion there is a pin 147 located in the cylindrical housing 131 with its lower end attached to the diaphragm 48 and its upper end provided with a head 149. The pin 147 extends through a centrally located aperture in the spring support 51 and also through an inverted cup member 151. The rim of this inverted cup member 151 is attached to the central portion of the diaphragm 133. A coil spring 153 has its lower end seated upon the spring support 51 and its upper end pressing to the end of the inverted cup 151 so as to normally urge the diaphragm 133 away from the diaphragm 48 and the valve 16. The force of the spring 153 is normally opposed by the pressure within the chamber 139 whenever superheated refrigerant is adjacent the bulb 145.

To adjust the pressure within the chamber 139 which will cause the valve 16 to be moved toward the closed position, I have shown an additional spring 155 acting upon the upper face of the diaphragm 133. To provide an external adjustment for this spring 155 the cap member 141 is provided with an aperture 141*a* through which the spring 155 extends. This aperture is covered and sealed by a sealing bellows 157. The sealing bellows 157 is covered by a cap member 159 provided with an adjusting screw 161 which may be turned to adjust the closed end of the bellows 157 which supports the upper end of the spring 155. In this way a convenient arrangement is provided for adjusting the pressure at which the diaphragm 133 will operate to close the valve 16. If no adjustment for the thermostatic system is required, the opening 141*a* in cap 141 may be omitted and the bellows 157 and the spring 155 and the screw 161 may be omitted also.

When the superheat adjacent the bulb 145 is at a minimum indicating the approach of liquid refrigerant, the pressure within the chamber 139 will be reduced sufficiently that the spring 153 will move the diaphragm 133 upwardly against the opposing force of the spring 155 to cause the bottom of the inverted cup member 155 to engage the head 149 and pull the diaphragm 48 toward closing position. The pin 42 and the valve 16 by the force of the spring 34 will follow the diaphragm 48 in the movement toward closed position thereby reducing or stopping the flow of refrigerant into the evaporator 123. If a constant amount of superheat is desired, this may be obtained by properly adjusting the screw 161 whenever the back pressure screw 28 is adjusted.

As soon as this occurs the bulb 145 will begin to warm up again and the pressure within the chamber 139 will increase thereby moving the diaphragm 133 downwardly against the force of the spring 153. This will uncouple the inverted cup member from the head 149 so that the thermally responsive diaphragm will be always normally uncoupled from the pressure responsive diaphragm 48 and the valve 16. It should be observed that the spring support 51 is rigid and prevents any transmission of force from the diaphragm 133 through the springs 153 and 49, to the diaphragm 48. Thus by this particular one way only lost motion arrangement which normally uncouples the thermostatic diaphragm 133 from the valve 16 and at all times prevents the diaphragm 133 from applying any opening force to the valve 16. I have provided an arrangement whereby the flow of refrigerant through the valve is always stopped when the pressure in the evaporator 123 rises above the setting of the valve as controlled by the spring 34. This prevents the compressor from being overloaded.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. Refrigerating apparatus including evaporating means, a pressure responsive valve means connected to the inlet of said evaporating means for controlling the flow of refrigerant thereto, temperature responsive means responsive to temperatures adjacent the outlet portion of said evaporating means, and a one way only connect-

ing means for operably connecting said temperature responsive means upon a predetermined reduction in temperature to move said pressure responsive valve means toward closed position only and completely disconnecting said temperature responsive means from said valve means upon movement in the opposite direction.

2. A refrigerant expansion control including a valve for controlling the flow of refrigerant, a pressure responsive means responsive to a rise to a predetermined pressure for closing said valve and responsive to a fall below said pressure for opening the valve, a one way only connection operably connected to the valve for movement only in the valve closing direction and disconnecting completely from said valve in the opposite direction, and a temperature responsive means connected to said one way only connection for moving said valve only to closed position upon a reduction in temperature, said one way only connection completely disconnecting said temperature responsive means from said valve upon a rise in pressure.

3. A refrigerant expansion control including a valve body having an inlet and an outlet, a diaphragm means exposed to the pressure at the valve outlet, a valve in said valve body for controlling the flow of refrigerant from the inlet to the outlet and connected to said diaphragm means in such a direction as to close the valve upon an increase in outlet pressure and to open the valve upon a decrease in outlet pressure, spring means having one portion connected to the body and another portion connected to the diaphragm means acting in the direction to move the valve toward open position, a second spring means acting upon the valve in the direction to move the valve toward closed position, an adjustment means extending between the body and said second spring means for adjusting the second spring means, a thermostatic means including a second diaphragm means connected to the valve body movable in the direction of valve opening upon an increase in temperature of the thermostatic means, a third spring means having one portion in connection with the valve body and another portion in connection with the second diaphragm means acting in a direction to oppose the movement of said second diaphragm means in the direction of valve opening, and a one way only connecting means for operably

connecting said thermostatic means with the valve upon a predetermined temperature reduction to bias the valve toward the closed position and completely disconnecting said thermostatic means from the valve upon a temperature increase.

4. A refrigerant expansion control including a valve body having an inlet and an outlet, a diaphragm means exposed to the pressure at the valve outlet, a valve in said valve body for controlling the flow of refrigerant from the inlet to the outlet and connected to said diaphragm means in such a direction as to close the valve upon an increase in outlet pressure and to open the valve upon a decrease in outlet pressure, spring means having one portion connected to the body and another portion connected to the diaphragm means acting in the direction to move the valve toward open position, a second spring means acting upon the valve in the direction to move the valve toward closed position, an adjustment means extending between the body and said second spring means for adjusting the second spring means, a thermostatic means including a second diaphragm means connected to the valve body movable in the direction of valve opening upon an increase in temperature of the thermostatic means, a third spring means having one portion in connection with the valve body and another portion in connection with the second diaphragm means acting in a direction to oppose the movement of said second diaphragm means in the direction of valve opening, and a one way only connecting means for operably connecting said thermostatic means with the valve upon a predetermined temperature reduction to bias the valve toward the closed position and completely disconnecting said thermostatic means from the valve upon a temperature increase, and a positive stop means for preventing said thermostatic means from moving said valve to open position.

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