EXPANSION VALVE FOR REFRIGERATING APPARATUS

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This invention relates to refrigerating apparatus and more particularly to an expansion valve or control for operating 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 it. These automatic 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. To prevent this, limiting devices for the thermostatic expansion valves have been introduced further complicating the drawing and adjustment and they are apt to cause difficulties in this field.

It is an object of this invention to provide a thermostatic expansion valve in which the thermostatic bulb responsive 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 thermostatically operating back pressure diaphragm as a protector to protect the motor compressor against excessive and continued high back pressures.

Another object of this invention is 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 has reached a predetermined temperature.

It is another object of this 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 with a diaphragm which is adjustable by an adjusting screw accessible by removing a cap from the valve body. According to this invention there is provided a thermostatic 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 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 thermostatically responsive diaphragm with the valve is made only when the liquid refrigerant approaches or reaches the outlet of the evaporator causing the thermostatically 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 such circumstances the lost motion connection is uncoupled and there is no other connection between the thermostatically 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 drawings 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 liquified. The operation of the motor-compressor unit may be controlled by a switch 127 operated in accordance with the temperature of the 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 port 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 a diaphragm 48 cooperating with the seat 18 carried by a stem 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.

If 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 upper end 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 valve 16 to close. 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 a force tending to move the valve 16 out of 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 against the bottom of the diaphragm 48 equals 48 force due to 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, the diaphragm 48 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 a minimum force 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 overexpansion 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 unaffected by the spring 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 an ordinary bulb 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 139. This thermostatic chamber 139 is connected to a thermostat bulb 145 which is clamped in metal-to-metal contact with the outlet portion of the evaporator 123. The operation of this bulb 145 is included in 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 is not important and it may be changed with changes in the temperature 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 used in the refrigerating system such as diethyolodichloro-methane (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 tending the diaphragm 133 to move towards the diaphragm 48 in the direction to open the valve 16. If the diaphragm 133 were to have an 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 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 and arranged in such a way that there is no connection between the diaphragms when 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 dash the valve 16 out of the way to allow 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 133. When the pressure in the evaporator 123 equals 48 force due to the spring 16, the pin 147 extends through a centrally located aperture in the spring support 51 and also through an inverted cup member 155 which is normally sealed by a 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 to the pressure at the head 149. The pin 147 extends through a centrally located aperture in the spring support 51 and also through an inverted cup member 151 which 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 normally urge the diaphragm 33 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 a traditional expanding 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 141a through which the spring 155 is adjustable. This aperture 141a is fitted with 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 to the pressure at the 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 141a in cap 141 may be omitted and the bellows 157 and the spring 155 and the screw 161 may be omitted.

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 sufficient to move the diaphragm 133 forward 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 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 pressure in the bulb 145 may be varied.

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 back pressure of the spring 155 and unsealing the inverted cup member from the head 149 so that the thermally responsive diaphragm will be always normally uncoupled from the refrigerant inlet orifice 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 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 moving independently of any operating pressures other than that acting on the bulb 145. 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 bulb 145. 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 means for 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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