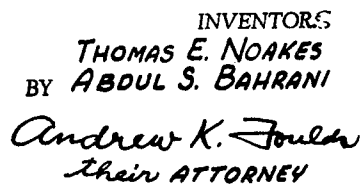


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THERMOSTATIC REFRIGERANT EXPANSION VALVE

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This invention relates to refrigerant expansion valves. In certain respects it may be considered as an improvement on the structures disclosed and claimed in copending patent application Serial No. 55,225, filed September 12, 1960, now abandoned.

It is old in refrigerant expansion valves to operate the valve element by means of a thermostatic power element responsive to evaporator outlet temperature, and to regulate the superheat in the evaporator by arranging an adjustable superheat spring in opposition to the action of the thermostatic power element. It is also old to subject the thermostatic power element to the pressure existing in the evaporator outlet, as by extending an equalizer line from the evaporator outlet to the portion of the expansion valve occupied by the power element.

In expansion valves of this type the superheat spring is intended to be the only adjustable force member in the system so that it can control the amount of superheat at a desired value. However, under conventional practice variations in refrigerant supply pressures cause variable forces to be exerted on the valve element, which forces are transmitted to the power element with consequent adverse effect on the value of the superheat which is intended to be controlled by the spring.

With the above in view, it is a primary object of the present invention to provide a refrigerant expansion valve in which the refrigerant supply pressures have substantially no biasing effect on the valve element so that the superheat spring can under varying operational conditions control the superheat without interference from the refrigerant pressure.

A further object of the present invention is to provide a refrigerant expansion valve with a pressure balancing means therein so that the thermostatic power element can operate the valve element with a lessened force and with an improved time response.

An additional object of the invention is to provide a pressure balancing bellows or diaphragm wherein rupture thereof causes the valve element to be biased to a substantially closed or fail-safe position.

A still further object of the invention is to provide a refrigerant expansion valve having an improved pressure balancing-valve element assembly therein, said assembly being so related to the valve seat that a line of expansion valves having substantially different flow capacities can be provided without changing valve bodies or other major components.

Other objects of this invention will appear from the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIGURE 1 is a sectional view taken through a valve of this invention, and showing same arranged in a refrigerant circuit; and

FIG. 2 is a sectional view taken on line 2—2 in FIG. 1.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and ar-

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range of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to the drawings, particularly FIG. 1, there is shown an improved expansion valve 10 arranged in a refrigerant circuit which comprises a conventional evaporator 12, conventional compressor 14 and conventional condenser 16. The valve comprises a major body member 18 and a minor body member or cap 20. A partition 22 is located within body member 18 for defining an inlet chamber 24, an outlet chamber 26 and an intervening valve seat 28. As shown in the drawing valve seat 28 takes the form of an annular sharp-edged wall structure located upstream from a cylindrical opening 30 in partition 22.

Cooperating with valve seat 28 is a valve element 32 which comprises a valve poppet portion 33 having a generally frusto-conical surface 34 seatable against seat 28 and having a guide portion 36 slidably engaging the annular surface defined by opening 30. In the illustrated embodiment guide portion 36 comprises three upstanding arms 40 spaced circumferentially from one another to define three peripheral flow spaces or apertures 42.

In the FIG. 1 position valve element 32 is seated against valve seat 28 so that no refrigerant can flow from the inlet chamber 24 to the outlet chamber 26. Downward movement of the valve element allows refrigerant to flow past valve seat 28, thence through the flow apertures 42, and thence into the outlet chamber 26. In the illustrated embodiment the arms 40 have their upper ends unconnected, but if desired these arm upper ends could be connected to form a ring-like structure, in which event guide portion 36 would structurally take the form of an apertured tube. In the illustrated arrangement arms 40 are radially thickened in their base areas for reinforcement purposes, but such thickening would not be required in an apertured tube configuration.

As shown in FIG. 1, valve element 32 is screw-threaded into an annular head element 44 which is sealed to the upper end of a conventional metal bellows 46. The lower end of bellows 46 is sealingly secured to an annular plate or ring 48 which is suitably fixed in the valve body. Valve element 32 is provided with a series of passages 50 so that the interior of the bellows is at all times subjected to the pressure existing in outlet chamber 26; the exterior of the bellows is at all times subjected to the pressure existing within inlet chamber 24.

It will be noted that the effective area of the bellows, as defined by dimension 52, is substantially the same as that of valve seat 28. In a valve arrangement of the illustrated type the bellows effective area multiplied by the pressure drop across the bellows opposes the valve element effective area multiplied by the pressure drop thereacross. By making the bellows and valve element with the same effective area we accomplish a pressure-balancing action which materially improved the performance of the valve. Thus, when the effective area of the bellows is made substantially the same as the effective area of the valve seat the inlet pressure in chamber 24 acts equally on the bellows exterior surfaces and on the valve poppet so that the inlet pressure exerts substantially no biasing action tending to move the bellows-poppet assembly either up or down. The outlet pressure acts equally on the valve element and the bellows interior surfaces so that varying outlet chamber pressures have no net biasing action on the bellows-valve element assembly. Since neither the outlet pressures nor the inlet pressures exert a biasing action on the bellows-valve element as-

sembly it follows that pressure differential between the inlet and outlet chambers has no biasing effect on said assembly. The bellows-valve element assembly is in essence substantially freely floatably mounted so that it can be moved with the application of a comparatively small operating force.

In order to operate the valve element from its closed position to its full open position there is provided a conventional removably mounted thermostatic power element 54 which comprises a tubular thermal spacer 56, two rigid discs 58 and 60, and a corrugated metal diaphragm 62. As is conventional the power element also comprises a thermal bulb 64 arranged at the evaporator outlet and a capillary 66 for applying an operating force to the upper face of diaphragm 62, which force is transmitted to the valve element 32 by a conventional stem 68.

The illustrative valve is an externally equalized valve, and is equipped with an equalizer line 70 which extends from the evaporator outlet duct into communication with a chamber 72 located below diaphragm 62. In this manner the thermostatic valve is made responsive to the suction pressure as is conventional with externally equalized valves. If desired, the invention could be practiced with an internally equalized construction, in which event chamber 72 would communicate with the outlet chamber 26, as by omitting line 70 and stem packing 74.

In order to control the superheat of the evaporator there is provided a conventional superheat spring 76 having its lower end engaged with a nut 78 and having its upper end engaged with a ring-shaped retainer 80 abutting against the valve element. The loading on the spring can be varied by turning threaded rod 82, as in the conventional manner. Nut 78 has a hexagonal or other non-circular outer surface which keys the nut for slidable movement on the correspondingly shaped internal surface of cap 20. In order that rod 82 be precluded from axial movement the rod is provided with an enlarged portion 79 which abuts against the internal end surface 81 of the cap. Thus, turning movement of rod 82 causes nut 78 to travel upwardly to load spring 76, with rod portion 79 reacting against surface 81 to maintain the rod in its illustrated position.

In operation of the illustrated valve the temperature of bulb 64 determines the pressure on the upper face of diaphragm 62 and therefore determines the position of valve element 32. Thus, as the evaporator outlet temperature rises the valve element opens, and as the evaporator outlet temperature falls the valve element closes. As is conventional the amount of superheat is controlled by spring 76 which exerts a force on the valve element and diaphragm in opposition to the force developed by bulb 64.

Considering the balance of forces on valve element 32, it will be seen that the downwardly acting forces consist of the pressure on the upper face of diaphragm 62; the upwardly acting forces include the pressure in chamber 72 and the force of spring 76. By varying the loading of spring 76 we can thus vary the superheat. This superheat regulating action can be satisfactorily accomplished because the pressures in chambers 24 and 26 have substantially no biasing effect on the valve element, as heretofore explained.

Under usual conditions the pressure in inlet chamber 24 may vary considerably, for example from 100 p.s.i. to 300 p.s.i. If we now assume a conventional construction not having the bellows 46 or the passages 50, it will be seen that variation in the inlet pressure would considerably vary the upward force on the valve element, for example, by one hundred pounds or more, so that spring 76 would not under all conditions satisfactorily set the superheat at the desired value. Thus, it will be seen that by using the illustrated pressure balancing bellows 46 we are able to considerably improve the superheat setting of the valve over conventional arrangements.

Bellows 46 is further advantageous in that it better

enables the manufacturer to produce a line of expansion valves of different refrigerant flow capacities, as for example capacities ranging from as little as fifteen tons to as much as ninety tons. To aid in accomplishing the capacity-varying feature it is necessary under our invention to vary the circumferential extent of the segmental flow apertures 42, as by utilizing a series of valve elements 32 which are interchangeable one with another except for the sizes of the flow apertures 42.

FIG. 2 illustrates a valve in which guide arms 36 are relatively thick circumferentially so that the segmental flow spaces 42 have relatively small circumferential dimensions. The valve as shown has a relatively small flow capacity of about fifteen tons when used with F-12 refrigerant and a short stroke power element 54.

The FIG. 2 valve construction, modified only by slimming guide arms 40 to about half their illustrated circumferential widths, provides relatively large segmental flow spaces 42 which enable the valve to have a flow capacity in excess of twenty-five tons.

By utilizing a longer stroke power element 54, in combination with the FIG. 2 dimensioning, the capacity of the valve can be increased to a capacity of thirty-five tons. Additional capacity increase to fifty-five tons can be accomplished by using a longer stroke power element in combination with a valve element having the aforementioned slim guide arms. Further capacity increase can be achieved by changing the type of refrigerant, but of course that expedient is conventional and expected. As respects capacity variation our invention concerns particularly the use of interchangeable valve elements 32.

To facilitate interchangeable use of different valve elements 32 and power elements 54 the assembly is constructed so that element 32 has a detachable threaded connection 35 with bellows head 44, and element 54 has a detachable connection 57 with the valve body. The employment of detachable power elements is old in the art, but it is believed novel to employ detachable sized valve elements for capacity variation purposes.

In connection with the valve element configuration it is realized that we are not the first in the art to propose the use of a slidable valve element having an apertured guide portion slidably arranged within a valve seat opening. It is believed, however, that the prior art arrangements have generally utilized the guide portion apertures as means for controlling the rate at which the valve element flow path changes during the valve element stroke, and not as means for varying the maximum flow capacity from valve to valve. Thus our concept of varying the circumferential dimensions of the guide arms 36 from one valve assembly to another is believed to be new in the art. It should also be noted that this concept is used with the pressure balancing means 46 for improving the performance characteristics of the entire line of expansion valves.

One feature of the illustrated embodiment which is of note is that the balancing bellows 46 is located in the inlet chamber of the valve body. Within the broader aspects of our invention the bellows could be located in the outlet chamber, as by merely reversing the valve position in the line; however when the bellows is located in the inlet chamber any rupture of the bellows allows the inlet pressure to force the valve element to a substantially closed fail-safe position in which only a small flow of refrigerant takes place through the passages 50. When the bellows is disposed in the outlet chamber any bellows failure forces the valve to the full open position which is a disadvantage.

FIG. 1 shows the pressure-balancing means as a radially-rigid, axially-extensible bellows 46. It is contemplated that within the broader aspects of our invention other pressure-balancing devices such as diaphragms could be employed. In utilizing a diaphragm the valve body would be modified to mount the diaphragm below the valve element. The diaphragm could be connected to the valve element by a hollow stem so that the outlet chamber was

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applied on the diaphragm lower face. The diaphragm would have its upper face exposed to the inlet chamber to achieve the desired pressure-balancing action.

As noted previously, the invention is concerned principally with the construction of valve element 32 and its employment with the pressure-balancing means for superheat regulation, improved operating response, and valve capacity variation. The features of the invention are more particularly specified in the following claims.

We claim:

1. In combination: a refrigerant expansion valve having a valve body which is provided with a partition for defining a refrigerant inlet chamber, a refrigerant outlet chamber, and a valve seat therebetween; a valve element disposed within one of the chambers for closing against the seat to throttle refrigerant flow therethrough; a thermostatic power element disposed adjacent one end of the valve body and adapted to be responsive to evaporator outlet temperature for opening the valve element; said power element comprising a stem extending through the valve body into unattached abutting engagement with the valve element; an adjustable superheat spring disposed within said one chamber adjacent the other end of the valve body for opposing the action of the power element on the valve element; said valve body having an opening registering with the valve seat; a removable cap structure sealing said opening;

a pressure-balancing bellows located within said one chamber in surrounding relation to the superheat spring;

means sealing one end of the bellows to the valve element, and means sealing the other end of the bellows to the cap structure so that the exterior surface of the bellows is at all times subjected to the one chamber pressure;

means defining a passage between the bellows interior and the other chamber so that the interior surface of the bellows is at all times subjected to the other chamber pressure;

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said bellows having substantially the same effective area as the valve seat so that said bellows is substantially uninfluenced by the absolute pressures in the individual chambers or by the pressure differential between chambers; said bellows, superheat spring and valve element being installable in the valve body by insertion thereof through the aforementioned valve body opening.

2. The combination of claim 1 wherein the bellows is provided with an internally threaded annular head; said valve element comprising an externally threaded portion engaged with the threads of said head, a poppet portion engageable with the valve seat, and spaced guide arms extending from the poppet portion into the opening defined by the valve seat; said guide arms being slidably engaged with the annular surface defined by the valve seat opening so that refrigerant flow takes place through the spaces between the guide arms; the construction and arrangement of said valve element permitting valve elements having differently dimensioned flow spaces to be interchangeably mounted on the aforementioned head whereby to permit variation in the flow capacity of the valve.

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