This invention relates to novel and useful improvements in expansion valves for refrigeration systems, and it is particularly concerned with the devising of a valve which may be economically manufactured and which is highly effective under the various service conditions which may be encountered.

In the customary refrigeration expansion valve which is subject to automatic control, flow of refrigerant from the inlet to discharge ports, through the valve seat, is regulated in part by the pressure on the discharge side of the valve which is transmitted to a pressure-responsive element working in opposition to the valve spring. The pressure-responsive element itself may be manually adjusted by changing the loading of a spring applied thereto, or the pressure-responsive element loading may be modulated by superimposing a "power element," or second pressure member in which the pressure changes are governed through the temperature existing in the expansion coil of the system. Again, the main valve spring may be made adjustable, so that the pressure differential between the main spring and the force exerted through the pressure-responsive element may be controlled within reasonable limits.

While a number of such valves have been made commercially, there still remain for solution the problems of providing a valve which will not stick or bind, which will have a wider range of operation, to which the power element may be applied without danger of the action becoming erratic at the ends of the operating range, and which, withal, will not be unduly complicated or expensive. For example, one manifest difficulty with valves of this class has been the tendency of the valve needle to become canted or dislodged during operation, due to faulty pressure applications from both the main spring and the pressure pins.

As hereinafter more fully set forth, we propose to eliminate this trouble by providing a substantially frictionless but fully positive means for actuating the valve toward and away from its seat. As another example, some valves which function in a satisfactory manner over a limited high-temperature range become erratic when adjusted for low-temperature work, due to the formation of frost over the valve body which offsets the intended functioning of the power element. We propose to correct this defect in a simple manner by bringing the refrigerant through the valve in such fashion as to minimize the extreme temperature changes to which prior valves have been subject.

Various other objects and features of the invention will be apparent from a perusal of the following detailed description of a typical embodiment of an improved valve, reference being made throughout to the accompanying drawing, wherein:

Fig. 1 is a longitudinal section through a refrigeration expansion valve including a thermally actuated power element;

Fig. 2 is a section on the line 2—2 of Fig. 1, showing in clearer detail the path taken by the incoming refrigerant; and

Fig. 3 is a fragmentary side elevation of a further embodiment of the invention, portions thereof being drawn in section to show the sealing and locking means of the power element.

The valve comprises a main body member 10 formed on one side with an offset portion 11 to provide for the necessary inlet passages, and on one end with an extended cylindrical flange 12 adapted to receive a sealing bellows 13. A boss 14 formed on the main body 10 in spaced relation to the inlet port 11 is drilled and tapped to provide a discharge port 18. The main portion of the body is drilled from one end to the other with a centrally disposed longitudinal bore 16, which is counterbored on the flanged end to provide a shoulder 17, and which is internally threaded on the opposite end, as indicated by the reference numeral 19, to receive a closure member. The drilling of the main body in this manner eliminates an integral partition wall within the valve, as has heretofore been customary, and with it the necessity for complicated port and passage arrangements which have interfered with the free flow of the refrigerant, and have thus tended to reduce the valve capacity.

The offset portion 11 of the valve body is formed with a drilled and tapped passage 21 terminating in a recess 22, and which is closed by a fitting 23 which connects the valve to the receiver of the refrigeration system (not shown).

The fitting 23 is also counterbored to receive a conical filter screen 24, the tip of which seats in the recess 22. This expedient serves to keep the filter from becoming distorted or lost, and thus assures the admission of clear refrigerant at all times. The inlet passage 21 communicates with the bore 16 of the main body through a diagonal drilled passage 25, which, as will be noted, if it is projected, clears the end of the flange portion 12. There are two noticeable ad-
vantages in providing an inlet passage of such angularity. The passage may be drilled from the exterior of the valve body without use of special tools or cross-drilling operations, and the refrigerant is brought into the valve body in a path of less frictional resistance, and therefore less energy loss in the refrigerant.

It will moreover be noted that the diagonal passage 25 communicates with the bore 16 above the shoulder 17, and that this enlarged portion of the bore is occupied by a cylindrical insert or plug 26, which, after being pressed into the bore, may be secured by solder, as indicated by the reference numeral 27. The plug 26 is formed externally with a circumferential groove 28 which aligns itself with the passage 25. On the opposite side of the plug 26, the groove is drilled with a substantially radial duct 29, which in turn communicates with an axial passage 31 extending downward to the limit of the chamber defined by the bore 16. Thus, refrigerant entering the passage 25 is caused to flow around the groove 28 in contact with the wall of the main body 10, thence through the duct 29 and through the passage 31, before entering the discharge port 15. This bypassing provides a relatively warm zone of liquid refrigerant within the main valve body which shields the sealing bellows and power element from the low temperature effects of the expanded refrigerant, and moreover brings the liquid refrigerant through the valve seat 31 with a minimum of pre-expansion.

The lower end of the main body 10 is closed by a threaded cap member 33 engaging the internal threads 18 of the bore 16. The threaded portion of the cap is integrally formed with diometrically opposed slots 34 which serve as keyways for lugs 35 formed on a spring-supporting washer 36. This washer is threaded on a post 37 formed with a threaded enlarged portion disposed in the bore 16, and an adjustment portion extending through a central aperture in the cap 33. The cap 33 also receives a gland nut 38 for packing the projecting portion of the post 37, and a cover cap 39 which protects the parts from accidental setting, thus making the bore 16 perfectly gas-tight. It will be apparent that, with these parts assembled as shown, the cap 38 may be removed and the projecting portion of the post 37 turned with a wrench, thus causing the washer 36 to move linearly in the bore 16. This motion is utilized to change the setting of the main valve spring, and hence the operating range of the valve.

Surrounding the threaded section of the post 37, and abutting the washer 36, is a coiled spring 41, which engages, at its opposite end, a valve-supporting washer 42 formed with a longitudinal bore 43 which is made conical or tapered at its lower end. A valve needle 45, of less diameter than the bore 43, is mounted within the bore 43, and the needle is formed with conical or tapered ends 46 and 47, the lower of which seats on the conical portion of the bore 45, while the upper end passes through the valve member 40 in a manner to restrict the passage therethrough. The needle 45 is also formed with a shouldered portion 48 on which is disposed a washer 49, and through which movement of the needle, in response to movement of the sealing bellows 13, may be effected.

It will be particularly observed that the needle 45 may rock or tilt within the bore 43, or rather, with respect to the washer 42. Heretofore, difficulties in proper closing of needle valves have been encountered, because of misalignments of the spring 41. By providing a somewhat universal or adjustable seat for the needle within the washer 42, any such misalignments are automatically compensated for, thus permitting the needle point 46 to enter the seat 31 correctly under all conditions of operation.

Further in accordance with the present invention, the connection between the sealing bellows 13 and the valve needle, and through which the opening and closing of the valve is made responsive automatically to the evaporator pressure, is effected in a positive manner. The bellows 13 is soldered within the cavity formed by the flange 12, and the bottom wall 51 of the bellows is drilled to receive the ends of three equi-angularly disposed push pins 52 which are soldered in place. The pins extend within the bore 16 through enlarged bores 53 formed longitudinally in the plug 26—these holes also permitting the refrigerant pressure existing at the discharge port 15 to act against the bellows 13 in the customary manner of automatic expansion valves.

Each pin 52 is drilled and tapped on its projecting portion 54. Then a through hole is bored in the numeral 54, to receive a screw 55 for supporting an annular washer 56 whose inner marginal portion overlaps the needle washer 43. It is of course apparent that, with the rocking bearing provided between the needle 45 and the cone washer 42, it would be inexpedient to have the pins 52 abut the cone end. Accordingly, the washer 43, which is in effect integral with the needle 45, is contacted by the washer 56, which in turn is actuated by the simultaneous movement of the bellows 13. The bottom of the pins 52 thus acts through the plane surface of the washer 56 directly against the needle, and serves to maintain the needle in correct alignment with respect to the seat 31. It will moreover be noted that the securing of the pins 52 to the bellows 13 and washer 56 prevents the pins from rubbing the walls of the holes 53, thus eliminating a source of friction herefore encountered.

When the valve is to be employed as a simple automatic valve, the flanged end 12 of the body is closed by a flange 14 and a cover 15, and the bellows 13 is loaded with a spring. As herein illustrated, however, the valve is also provided with a thermally actuated power element for varying the loading in response to the temperature in the expansion coil. The flanged end 12 of the valve body is provided with external threads for engagement with internal threads 61 formed in a cap 62 having an internal shoulder 63. A partition plate 64, formed with a flanged aperture 65, abuts the shoulder 63, and serves as a stop member for a coiled spring 66 whose opposite end presses against the bottom wall 51 of the sealing bellows 13. The cap 62 contains a power element bellows 67 in the form of a closed expansible casing which is soldered to the upper end of the cap 62, so that, as the power bellows expands and contracts, the lower wall 68 thereof moves 69 to close the inlet refrigerant passage therethrough. A tube 69, passing through the cap 62, terminates in a bulb 71 which may be located on the suction end of the evaporator, or other desired point, in accordance with usual practice. The tube and bellows is charged with a remote refrigerant, such as methyl chloride, and as the temperature of the charging medium changes, the pressure within the bellows 67, and hence the force which it exerts, is proportionally modified.

The bottom walls 68 and 51 of the bellows 67
and 13 are automatically interconnected for conjoint movement when the cap 62 is screwed onto the body. The walls 56 and 51 carry complementary fittings comprising threaded studs 72 and 73, which are interconnected by an internally threaded sleeve 75, which sleeve is formed of an insulating material. To effect the assembly, the threads for the studs and sleeve are made the same pitch as the threads for the cap 62 and flange 12. A baffle plate 76 is also position just below the lower wall 51, to minimize admission of slugs of refrigerant to the bellows 13. It will also be seen that the stud 73 carries a flanged washer 74 in which is seated the spring 66.

To assemble the valve, the plug 26 is first tightly seated in the large end of the bore 16, with the duct 29 remote from the inlet passage 25. The sealing bellows 13, with the stud 73 and the pins 52 secured in the base thereof, and the baffle 76 positioned on the pins, is then dropped into position, with the free ends of the pins passing through the apertures 53 of the plug 26. Assembly of the valve parts may then be effected through the open end of the bore 16, and the cap 62, with the remaining parts of the bellows assembly, may be screwed into place in the manner just described.

It will be observed that the power bellows 67 and sealing bellows 13 are positively interconnected through the sleeve 75, and hence any motion of the power bellows is transmitted through the sealing bellows irrespective of the internal pressure conditions in the valve. The sealing bellows, in turn, is positively connected to the valve actuating washer 56, and therefore contractive, as well as expansive movements of the bellows are positively transmitted to the valve needle. While these parts are all interlinked for positive action, the motions, as applied to the needle 45, are substantially frictionless. As has heretofore been explained, this action is obtained without creating any tendency to bind the needle 45 with respect to its valve seat 31.

Adjustment of the valve is normally effected through the post 37 to vary the loading on the spring 44, and thereby the effective pressure differential between the spring and the variable force exerted by the power bellows 67. It may here be noted that the spring 66 may be replaced by a like spring of different rate to render the valve effective when used with various refrigerants without changing the refrigerant used to charge the power bellows. Likewise, some adjustment may be effected by rotating the cap 62, although for most service conditions, it is preferred to give the cap a fixed position with respect to the valve body, and then secure it in position by soldering.

In Fig. 3, the valve is slightly modified so that the cap 62a thereof may be utilized as a service adjustment to supplement the adjustment of the post 37, or, if desired, to act as a substitute therefor. In this embodiment, the power bellows 67a and 72, which are rigidly interconnected to the cap 62a, but rather is provided with a shouldered and threaded stem 80 which projects loosely through the hole 81 in the cap. Washers 82 and 83 of insulating material are disposed on opposite sides of the hole, and the stem and the washers may be clamped tightly to the cap by means of a lower end of the cap 62a is formed with a circular seat portion 85 which receives an annular rubber gasket 86, which gasket may be clamped by a threaded lock ring 87 disposed on the external threads of the flanged end 12a of the valve body. When the ring 87 is drawn up, the lower extremity of the cap is sealed against the entrance of air and moisture, which otherwise might enter the bellows chamber with damaging effects. The remainder of the structure may be similar to that of Fig. 1.

In adjusting the valve of Fig. 3, the nut 84 and ring 81 are loosened, and with the stem 80 held against movement, the cap 62a is rotated to vary the loading effect of the spring 66 to the desired degree. It will be observed that during this adjustment the sleeve and stud connections between the bellows are unaffected, and the only reaction thereto is the extension or compression of the spring 66 and the power bellows 67. After this operation, the nut 84 and ring 81 are again tightened to lock and seal the assembly.

While we have described our invention with reference to several specific embodiments, it will be understood by those skilled in the art that numerous modifications may be resorted to without departing from the principles thereof, and accordingly it is not intended to limit the invention to the precise forms illustrated, but to encompass such combinations and parts as may be comprehended by the following claims.

We claim:

1. In a refrigerant expansion valve, a valve body formed with a valve-receiving portion, a cylindrical flange contiguous therewith and having a chamber formed therein, and an offset inlet passage portion, said valve-receiving portion being formed with a longitudinal bore communicating with said chamber, a valve seat formed in said bore, a spring means for actuating the valve, and a closure means for closing the end of the bore and holding said spring and valve in operating position, a discharge port formed in the valve body in communication with said bore, a separate insert disposed at the opposite end of the bore to divide the bore from said chamber, a sealing bellows secured within said chamber, a plurality of longitudinally disposed apertures formed in said insert, push pin members freely extending through said apertures and connecting said sealing bellows and said valve, a valve seat formed in said insert, against which the valve may contact, a diagonal passage formed in the body and connecting said inlet passage portion and said bore at a portion thereof covered by said insert, said diagonal passage, as projected, extending beyond the end of said cylindrical flange, and a tortuous passage extending around said insert for connecting said diagonal passage and said valve seat.

2. In a refrigeration expansion valve, a valve body formed at one end with an extended cylindrical flange defining a sealing bellows chamber, a sealing bellows mounted in the chamber, a threaded stud secured to the bottom of the sealing bellows and projecting upwardly therefrom, an internally threaded screw cap engaging the exterior of said cylindrical flange and covering said sealing bellows, a manually actuated power element mounted within the cap and having an end wall movable with respect thereto, a threaded stud secured to said end wall and aligned with the stud secured to said sealing bellows, and a threaded sleeve connecting said studs, the thread on said cap and the sleeve being of the same pitch whereby the cap may be applied to the bellows positively interconnected in one rotary operation.

3. A refrigeration expansion valve comprising
a valve body having an extended end defined by a cylindrical flange, a chamber formed within the
chamber, an internally threaded cap engaging over said flange, said cap containing a thermally
actuated power element and a transversely disposed partition plate formed with a central aperture,
threaded and aligned studs secured to the sealing bellows and the power element, a threaded
eave interconnecting said studs and passing through the aperture in said partition plate, the
cap and sleeve threads being of the same pitch, a spring disposed between the sealing bellows and
the partition plate, a plurality of push pins positively secured to said sealing bellows and ex-
tending to within said valve body, said valve body being formed with a longitudinal bore, a cylin-
drical insert pressed into said bore and the end thereof adjacent said sealing bellows, said insert
being formed with passages through which said pins freely extend, a valve seat in said insert, in-
let and outlet ports formed in said body and communicating with said bore on opposite sides of
the valve seat, a circumferential diaphragm groove in the insert in fluid communication with the inlet
port, a passage in the insert connecting said groove and seat at a point remote from the inlet port, a
valve needle in the bore for engagement with the seat, a circular plate connected to the ends of
the push pins and formed with a central aperture through which the needle extends in abut-
ting relation, spring means for urging the needle toward its seat, and closure means for the op-
posite end of the bore for maintaining the spring under compression.

In a thermostatic expansion valve including a body having a sealing bellows affixed thereto,
a threaded cap adapted to be screwed onto the body to enclose the sealing bellows, a power bel-
loos disposed within the cap, a rigid connection between the two bellows, a stem on the power
bellows extending through the cap, means sealing and locking the stem to the cap, said means be-
ing releasable to permit adjustment of the cap, resilient means associated with the bellows as-
sembly and operatively engaged for adjustment by the cap, and releasable gasket means for seal-
ing the connection between the cap and body.

5. A refrigeration expansion valve comprising a body formed with a longitudinal bore extend-
ing therethrough, said body being formed on one end with an outwardly flanged portion in com-
munication with the bore, a sealing bellows mounted in the flanged portion and extending toward said bore, a shoulder formed in the bore adjacent the inner end of the bellows, a separate
insert plug snugly mounted in the bore and abut-
ting the shoulder, said plug having a circumfer-
ential groove, a radial passage communicating with the groove, and an axial passage extending
from one end face of the plug to said radial passage, said plug being also formed with longi-
tudinal and circumferentially spaced clearance holes, an inlet port formed in the body and com-
municating with said circumferential groove at a point remote from the radial passage, a discharge port formed in the body and communicating with the bore below the plug
whereby the path of travel of refrigerant through the body is from the inlet port to the groove, ra-
dial passage, axial passage, and discharge port.

A valve mounted in the bore below the plug and in alignment with the axial passage thereof,
means in the bore for resiliently urging the valve to seat in said axial passage, means at the op-
posite end of the body for closing the bore and holding the resilient means, a thrust plate en-
circling the valve, and push pins extending through the spaced circumferential clearance
holes in the plug and engaging the sealing bellows on one end and the thrust plate on the other end, said circumferential clearance holes being of greater diameter than the pins to pro-
vide for free movement and for fluid communi-
cation between the bellows and flange portion
of the body and the discharge port.

6. A refrigeration expansion valve comprising a body formed with a longitudinal bore terminat-
ing at one end in a flanged portion of the body, a sealing bellows mounted in said flanged portion,
inlet and outlet ports formed in the body in spaced relation, a plug disposed in the body be-
tween the flanged portion and the bore, a valve seat formed in the plug below the flanged portion,
a fluid passage formed in the plug between the inlet and outlet ports of the body and extending through said seat, said plug being formed with a plurality of circumferentially spaced, longitudi-
nally disposed push pins positively secured at one end to the sealing bellows and freely extending through the apertures, an annular plate disposed in the body below the plug and
freely secured to the opposite ends of the pins, a valve for the valve seat, said valve extending freely through the plate, shoulder means on the
valve for engagement with the plate, a cup mem-
ber formed with a bore in which said needle is mounted, said needle being of less diameter than the cup bore and formed with a tapered end engaging in said bore to provide a free rocking
bearing for the needle, and spring means dis-
posed in the bore and engaging the cup member

to urge the needle towards its seat.

7. A refrigeration expansion valve comprising a body formed with a longitudinal bore, said body
having a flanged portion at one end, a sealing bellows secured to said flanged portion, a trans-
verse wall member positioned in the body and the bore to separate the sealing bellows from the
bore, a valve seat in the wall member, a plu-
rality of circumferentially spaced clearance holes
formed in the wall member in spaced relation to
the valve seat, a plurality of push pins securely fixed to the sealing bellows and each extending
through one of the clearance holes, said pins being of less diameter than the cup bore, inlet and
outlet ports formed in the body and communica-
ting with each other through the seal, said outlet port being in fluid communication with the
bore below the wall and with the sealing bellows through said clearance holes, a plate se-
cured to the ends of the push pins extending through the wall, said sealing bellows, pins, and
plate thereby being integrated into a substanc-
ially rigid and unitarily movable assembly, a valve needle in the bore below the seat, a spring
for pressing the needle towards its seat, closure means for the bore formed in the body and
in the bore and against the needle, and a rocking
bearing connection between the plate and the
needle, whereby the needle may adjust itself to
the seat concurrently with linear movement only
of the integrated assembly of bellows, pins, and
plate.

8. The structure of the preceding claim 7, wherein the flanged portion of the body is pro-
vided with a cap, a power bellows in the cap, and a fixed connection extending between the seal-
ing bellows and the power bellows.

9. A thermostatic expansion valve comprising
a body having a sealing bellows affixed thereto, a cap for the body, said cap having a power bellows disposed therein, said cap and said body being formed with means for connecting the cap to the body whereby the sealing bellows is enclosed when the cap and body are connected through said means, connection fittings on both the sealing bellows and the power bellows, said connection fittings including means adapted to interengage each other to connect said bellows concurrently with the connecting of the cap to the body.

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