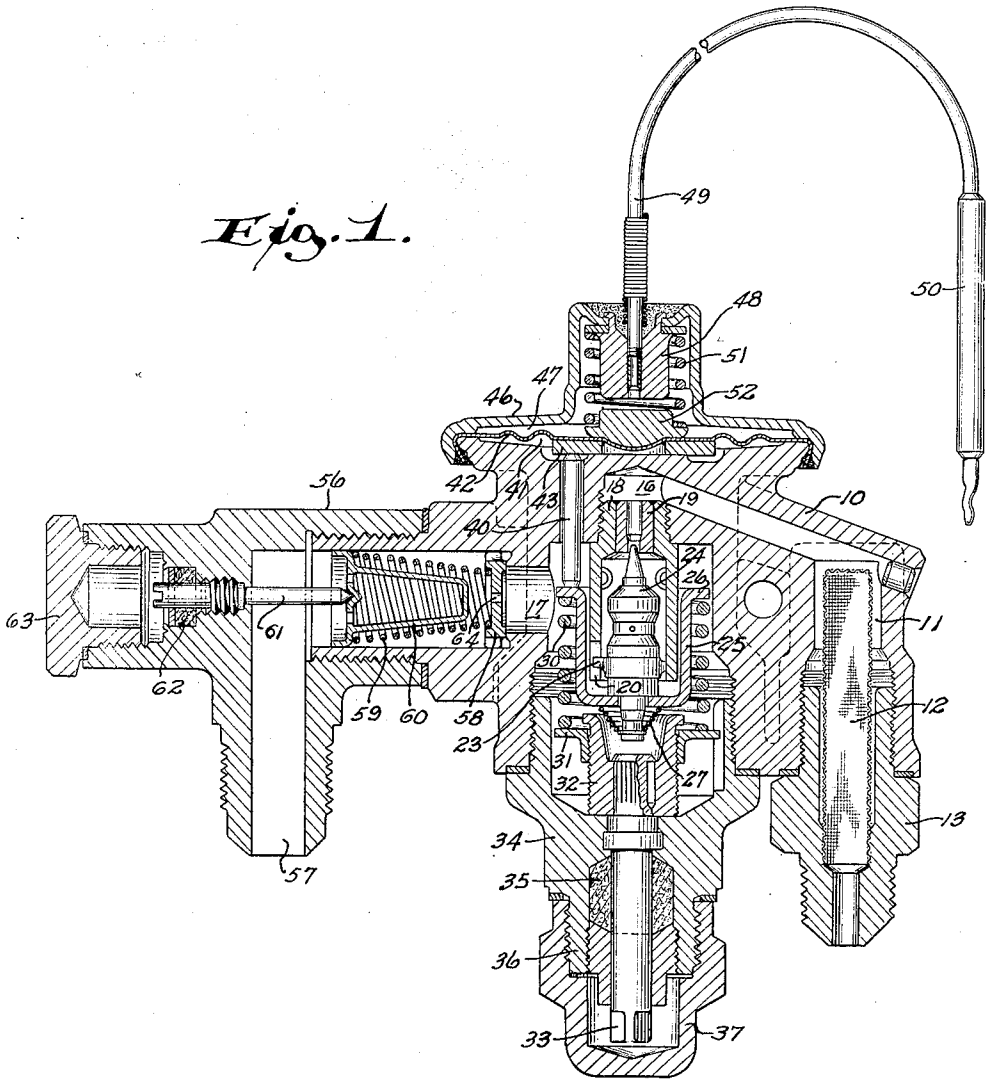
April 3, 1951 C. L. AUGHEY ET AL 2,547,070

THERMOSTATIC EXPANSION VALVE

Filed March 26, 1947 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

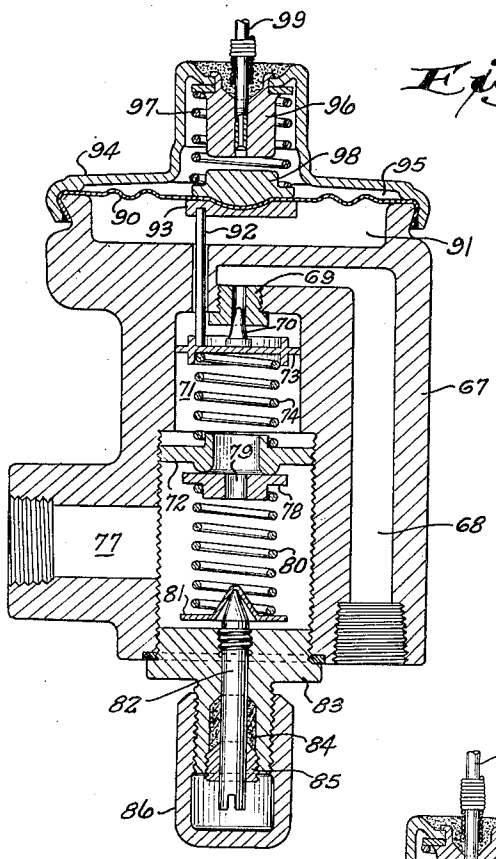
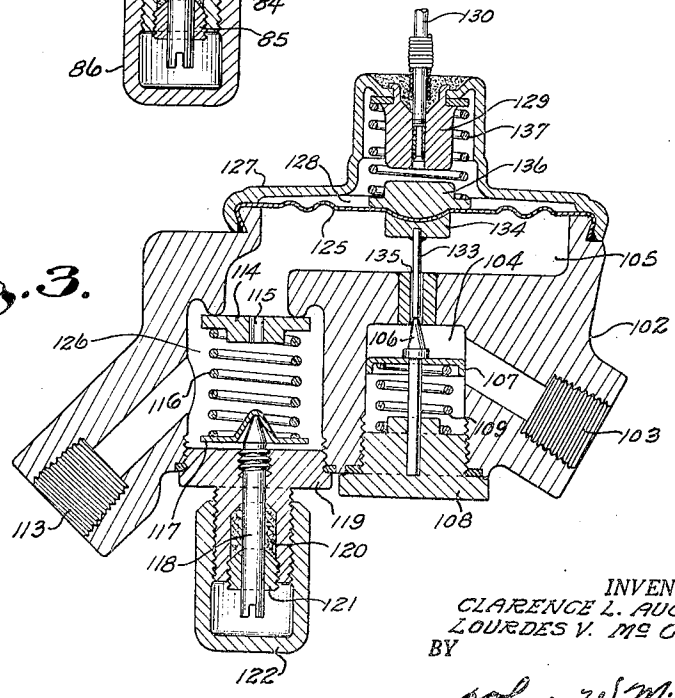


Fig. 3.



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THERMOSTATIC EXPANSION VALVE

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10 Claims. (Cl. 62—127)

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This invention relates to improvements in expansion valves for refrigerating systems of the compressor-condenser-evaporator type employing a liquefiable and vaporizable refrigerant and particularly to a valve actuated by a limit pressure charge in thermally responsive means actuating the valve.

The phrase "pressure limit charge" designates such charge in the thermal element of an expansion valve that the pressure in the element remains substantially constant when the temperature of the charge (and of the space to which the element is responsive) reaches a given value. Hence increase in the temperature of the refrigerated space, even above the pre-determined limit, does not cause opening of the expansion valve. Therefore, the evaporator pressure cannot exceed a pre-determined value and the compressor motor cannot be overloaded. In the use of limit charged expansion valves, the coldest spot to which the limit charge is subjected, is the spot controlling the action of the valve. Such spot, heretofore, was in the valve itself where the liquid refrigerant expands into vapor and is a considerable distance from the thermal element bulb which should be in the cold spot. Hence it was heretofore necessary to insulate the expansion chamber within the valve from any adjacent chamber forming a part of the thermal element.

A further problem in the use of refrigerating systems with an expansion valve is the so-called unloading of the compressor which is the condition in which the valve bypasses the refrigerant on the "off" cycle until the pressure in the condenser is approximately equal to that in the evaporator, thus avoiding overloading the compressor during pull-down of the system and permitting the use of a low-starting torque motor. Both the initial and the operating costs of a refrigerator are thus decreased. Another difficulty with the usual expansion valve is the adjustment of the superheat value of the valve which requires the variation by small increments, of a relatively large and heavy spring. The term "super-heat" defines the increase of temperature of the vapor at a given pressure, above the temperature at the same pressure when the vapor is in contact with the liquid.

It is therefore one object of the present invention to provide an expansion valve which will avoid development therein and adjacent a portion of the thermal element actuating the valve, of a lower temperature than the space about the portions of the thermal element.

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Another object of the invention is to provide an expansion valve in which the refrigerant expansion is divided into two steps to reduce the cooling resulting from expansion to such extent as will have no effect on any of the thermal element portions adjacent the locations at which either of the expansion steps take place.

Another object of the invention is to provide a multi-chamber expansion valve with means for equalizing the pressures in the several chambers in which expansion occurs, with the evaporator pressure thereby unloading the valve during the "off" portion of the system cycle.

A further object of the invention is to provide a refrigerant expansion valve in which expansion is divided into a relatively large pressure drop and a relatively small pressure drop which makes it possible to unload the system compressor.

Another object of the invention is to provide an expansion valve with a superheat adjustment which will be more sensitive and variable by smaller increments than is possible in valves used heretofore.

And a further object of the invention is to employ a spring for determining the super-heat setting of a refrigerant expansion valve, other than the spring urging a first or main valve closed in opposition to the action of a thermally responsive element, and which is more accurately adjustable than was heretofore possible by adjustment of the valve spring.

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 is a cross-sectional view taken substantially on a central plane through the longitudinal axis of one embodiment of the present invention;

Fig. 2 is a view similar to Fig. 1 of another embodiment of the invention; and

Fig. 3 is a view similar to Fig. 1 of a third embodiment of the invention.

Generally, the present invention provides an expansion valve for a compression type refrigerating system, the valve receiving liquefied refrigerant and partially expanding the refrigerant in a first step through a first valve into a first chamber adjacent a portion of a thermal element controlling valve operation. The partially expanded refrigerant is held in such chamber under pressure until the refrigerant is further expanded in a second step through a second valve into a second chamber which forms

a part of the passage to the evaporator. A bypass is provided in connection with one of the valves to unload the system by equalizing the pressures in the chambers. The second valve is a pressure-reducing valve and is under the action of a spring which is more accurately adjustable to vary the superheat setting of the valve than was possible heretofore.

Referring particularly to the drawing, number 10 designates a casing having an inlet passage 11 in which a strainer 12 is held by a nut 13. The passage 11 terminates in an enlarged portion 16 connectible with a chamber 17 by an opening in a valve seat member including a mounting 18 threaded into the opening and supporting a valve seat member 19. The valve seat mounting 18 extends into chamber 17 as a hollow cylinder with holes through the wall thereof and with a slot 20 in the end of the cylinder wall. The slot 20 receives one of two ears 23 extending from a valve body 24, the other ear sliding on the wall of the mounting, and the ears guide such valve body in its movement in the valve seat mounting 18 to bring the needle point of the valve 24 into and out of seating position in the valve seat 19.

The valve 24 is mounted in a cup-shaped carrier 25 with a lip flange 26 and is movably supported therein by a spring 27. The valve carrier is adjustably supported on a spring 30 seated at one end under the carrier lip flange and seated at the other end on a ring 31 threaded on a cylindrical block 32 secured against relative rotation on a stem 33 and extending through a closure member 34 threaded into the casing 11. The stem 33 is sealed into the closure 34 by packing 35 compressed by a nut 36, and the end of the stem protruding beyond the nut is protected by a cap 37.

The valve carrier supports a plurality of pushpins 40 extending from chamber 17 through the end of the casing into a chamber 41 defined by a flexible diaphragm 42 fixed on the casing 11, the pushpins bearing on a pad 43 held in contact with the diaphragm by the pushpins. The passages in which the pushpins slide, are materially larger than the pushpins so that the pressures in chambers 17 and 41 are always substantially equalized. An apertured cap 46 encloses the diaphragm 42 and coacts therewith to form a chamber 47, the cap also serving to hold the diaphragm on the casing in gas-tight relation. Chamber 47 is closed by a plug 48 in which is fixed a conduit 49 connected with a bulb 50 which is to be located adjacent the evaporator in the space to be refrigerated. A spring 51 acts between the cap 46 and a pad 52 bearing on the diaphragm 42. Chamber 47, conduit 49 and bulb 50 are "limit charged" with a liquid (such as methyl chloride when the system is charged e. g. with difluoro dichloro methane) which is partially evaporated at a given temperature and which produces such pressure, at the given temperature, as will raise the vaporization point of the liquid sufficiently to prevent further vaporization thereof and further increase in pressure so long as the space to be refrigerated is at the given temperature.

The casing 11 has connected therewith an outlet fitting 56 of substantially T shape, which provides an outlet chamber and passage 57 to an evaporator (not shown) and receives means guiding and adjusting a valve 58 which separates the chamber 17 from the chamber 57. Such valve seats on a portion of the casing wall defining the chamber 17 and is movably held in seated position by a spring 59 acting between the valve and a thimble-like guide 60 forming a seat for one end of the spring. The position of the guide 60 is adjusted by movement of a stem 61 threaded into the outlet fitting and sealed therein by packing 62 through which the stem extends for adjustment, the protruding end of the stem being protected by a cap 63.

The action of the described structure can best be understood by consideration of the temperature values prevailing in the several chambers. It is assumed that the temperature at the evaporator inlet is to be 0° F. and that the refrigerant will absorb sufficient heat in the evaporator to raise the refrigerant temperature to 10° F. The coldest spot in the usual refrigerating system employing an expansion valve, is the chamber 17 of the valve and it is accordingly usually necessary to insulate such chamber from the chamber 47 (and the bulb 50) which should be responsive only to the evaporator temperature. But in the present construction the temperature in chambers 17 and 41 can be made higher than the evaporator temperature because the usual refrigerant expansion is divided into two steps between chambers 17 and 57. The temperature in chamber 17 may be made 15° F. which is 5° higher than the desired temperature of the evaporator and the bulb 50 (rather than lower than such bulb temperature). But chambers 17 and 41 are connected by the pushpin passages and chamber 41 is also at the temperature of 15°. Hence it is no longer necessary to insulate chamber 47 from chamber 17 to avoid a cold space in the valve itself.

At the above temperatures, the pressure relations in the several valve chambers are such as to produce another useful result. At the above temperatures, the absolute pressure in chamber 17 is 32.44 and in chamber 57 is 23.87, all pressures being in lbs. per sq. in. absolute. There being a difference of only 8.57 lbs. pressure between the first chamber 17 and the second chamber 57, a small bypass may now be provided in or around valve 58 to equalize the pressures in such chambers during the "off" portion of the system cycle. Such bypass is shown herein as a small opening 64 through valve 58. Even when valve 58 is closed, the pressure in chamber 17 causes flow of partially expanded refrigerant into chamber 57 (and into the evaporator) until the pressure in the several chambers is equalized thus unloading the valve. The opening 64 is sufficiently small (of the order of a .008–.02 inch in diameter per ton of refrigeration) so as not to interfere with the pressure-reducing or second expansion step of valve 58. The small opening is, however, non-clogging and has such characteristic only because of the low pressure difference between the first and second expansion chambers. At the inlet pressure of 131.6 lbs. of liquid refrigerant and the evaporator pressure of 23.87 lbs. encountered in the usual single stage expansion valve, due to the high pressure drop on the two ends of the opening, such opening would be too small and would clog quickly.

The temperatures of chambers 17 and 41 are controlled by valve 58 which is under a pressure difference of only 8.57 lbs. and the spring 59 urging the valve to seat the position need exert only that force. Hence such spring may be made with a relatively small diameter and is more accurately adjustable by small increments than was possible with the relatively large and heavy spring

30 heretofore used for the super-heat adjustment.

At 10° F. the pressure in chamber 47 is 23.60 lbs. and the pressure in chamber 17 at 15° is 32.44 lbs. These pressures require a spring 51 to exert a force of 8.44 lbs. per sq. in. of diaphragm area plus spring 30. Spring 30 which is now used only as a valve-closing spring can accordingly be made much softer. It is obvious that by selecting the proper charge and temperature relations, spring 51 may be eliminated.

In the several modifications shown the structures are generally similar to those above described but are materially simplified. In Fig. 2, a casing 67 provides an inlet passage 68. A valve seat member 69 receives a valve 70 controlling flow of refrigerant into a first chamber 71, such chamber being partially defined by a partition 72 with an opening therethrough and a bead about the opening to form a valve seat.

The first valve 70 is mounted on a plate 73 movable in contact with the walls of the first chamber 71 and is supported on a spring 74 seating on the partition 72. A second chamber 77 also forming the passage to the evaporator, receives refrigerant from chamber 71 under the control of a second valve 78 with an opening 79 therethrough and supported on a spring 80, the other end of the spring being seated on a plate 81 supported on a stem 82 for adjustment of the spring force. The stem 82 is mounted in a gland 83 threaded into the valve housing and sealed therein by a packing 84 with a follower 85. The stem projects beyond the follower 85 for adjustment and such projecting stem portion is enclosed by a cap 86.

A diaphragm 90 is mounted on the casing 67 to define a chamber 91 into which pushpins 92 extend from their support on the valve plate 73, the pushpin passages again connecting chambers 71 and 91. The pushpins engage with a pad 93 and hold such pad in contact with the diaphragm 90. A cover 94 is fixed on the valve casing and coacts with the diaphragm 90 to provide a chamber 95 with the diaphragm serving as a flexible wall thereof, the chamber being closed by a plug 96. The diaphragm is held in contact with the pad 93 by a spring 97 seating between the cover and a pad 98 resting on the diaphragm. A tube 99 extends through the cover 94 in gas-tight relation and is connected with a bulb similar to bulb 50 and also located in the space to be refrigerated. Flexure of the diaphragm is under the action of the limit charge in such chamber, tube and bulb as is wellknown.

In Fig. 3, a casing 102 is provided with an inlet passageway 103 culminating in an enlarged portion 104 having an opening through a wall thereof communicating with a first chamber 105, flow of liquid between inlet 103, 104 and chamber 105 being controlled by a valve 106. The stem of valve 106 has a plate 107 mounted thereon and the end of the stem extends into a passage in a cap 108 threaded into the valve casing, the plate and the stem guiding movement of the valve which is urged toward closed position by a spring 109 acting between the plate and the cap.

The chamber 105 is separated from a second chamber 113 also forming the outlet passage to an evaporator (not shown), by a valve 114 having an opening 115 therethrough and urged toward seated position by a spring 116 acting between the valve and a plate 117. The plate 117 is adjustably positioned by a stem 118 threaded in a gland 119 which is itself threaded into the valve casing. The stem is sealed in the gland by packing 120 which is compressed by a packing follower 121 and the end of the stem 118 extending beyond the packing follower is enclosed by a cap 122.

A diaphragm 125 closes one end of casing 102 to define a first expansion chamber 105 from which partially expanded refrigerant may pass to a second expansion chamber through valve 114 and the passage 115 therein. The diaphragm is enclosed in a cover 127 coacting with such diaphragm to define a chamber 128 having an opening therein closed by a plug 129 into which is set a tube 130 connecting the chamber 128 with the interior of the tube and with a bulb similar to bulb 50 of Fig. 1. The chamber 128, the tube 129 and the bulb of the present modification are charged as above described, and the bulb is so placed as to be responsive to the temperature of the evaporator in the space to be refrigerated.

A pushpin 133 bears on valve 106, through the aperture in valve seat member 135 for such valve, and is connected with a pad 134 bearing on the under side of the diaphragm 125 under the pressure of the spring 109. A pad 136 rests on diaphragm 125 to provide a seat for a spring 137 acting between plug 129 and the pad to aid the pressure of the charge in the thermal element in keeping the diaphragm thereof under pressure in the direction for opening valve 106.

It will thus be seen that the present invention provides a structure in which a limit charged valve does not require heat insulation of the thermal element from the refrigerant expansion chamber in the valve, in which the valve is made unloading in a simple and practical manner and in which the super-heat adjustment is made on a spring more readily adjusted than the usual valve supporting spring.

The present structure provides a casing receiving an expansible refrigerant which is liquefied under pressure. The liquid refrigerant is expanded and vaporized in a plurality of chambers in the casing and connectible in series. Vaporization of the refrigerant into the several chambers is under the control of a valve for each chamber thereby dividing the expansion into a plurality of stages or steps of which the first stage results in a large decrease in pressure from the compressor discharge pressure at which the liquid refrigerant is held in the condenser receiver and of which the second stage provides a relatively small decrease in pressure. The valve controlling the first expansion stage is urged toward seated position by a spring which may be adjustable either at the factory only or may be adjustable in the field also. Such spring is opposed by the pressure in a chamber forming a portion of a thermal element carrying a limit charge responsive to the temperature of the space to be refrigerated and usually associated with the evaporator. The valve controlling the second expansion stage is also urged toward seated position by a spring which is however relatively small and easily adjustable and such spring acts only against the pressure in the first expansion stage. The thermally responsive element includes a diaphragm subjected on the one side to the pressure of the thermal element charge varying as the evaporator pressure varies and subjected on the other side to the pressure of the partially expanded refrigerant in the first expansion chamber. The pressure relations in the several expansion chambers may accordingly be readily so adjusted that the temperature

in the first expansion chamber is higher than evaporator temperature thereby making the limit charge of the thermal element responsive only to the evaporator temperature.

With pressure relations in the several chambers adjusted to obtain the result above described, the first and second expansion chambers may be interconnected by an uncontrolled passage so that the pressure in such chambers will equalize when the first valve is closed and thereby permit unloading of the compressor. Such continuous connection of the expansion chambers is practical because the difference in pressure between the first and second chambers is relatively small and such difference in pressure does not clog the relatively small passage. The unloading passage is herein shown as an aperture through the second valve but may of course be a passage through the casing itself.

In the present construction, the bias spring for the first valve is required only to be adjusted to coact with the pressure of the thermal element limit charge at a given temperature and need not be as large as heretofore. Such spring may now be adjusted in the factory and a relatively small spring which is easily adjusted by relatively small increments and opposes only the pressure in the first expansion chamber, may now be employed for any field adjustments necessary to set the degree of expansion in the first chamber for obtaining the temperature therein, determined by particular system conditions in the field, which will be higher than the evaporator temperature of a given system.

The division of the expansion action into a plurality of steps, the provision of an unloading passage and the adjustment of superheat by use of the spring acting on the second valve, are each separate features which may be separately incorporated in a valve, or any two or more of such features may be combined in the same valve.

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 valve controlling expansion of a liquid refrigerant under pressure in a refrigerating system of the compression type, a casing receiving the refrigerant and defining a first chamber in series with a second chamber, a first and a second valve, the first and second valves serially controlling expansion of refrigerant into the first and the second chamber and dividing expansion of the refrigerant into a plurality of steps, means responsive to the temperature of the space to be refrigerated and controlling opening of the first valve, and means responsive to pressure in the first chamber and controlling opening of the second valve, the second valve having an aperture therethrough for equalizing pressure in the chambers upon closing of the first valve.

2. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, means biasing said valves to their seated positions, a variable volume chamber including a diaphragm flexing in response to pressure variations in the chamber, a feeler bulb connected to said chamber and subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in said chamber with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said chamber, means operably connecting said diaphragm and one of said valves, said one valve being regulated by said diaphram to allow partial expansion of the refrigerant to a temperature higher than that in said space, the partially expanded refrigerant acting in opposition to the pressure in said chamber and in opposition to the biasing means acting on the other valve to open said other valve and allow final expansion of the refrigerant.

3. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, means biasing said valves to their seated positions, a varible volume chamber including a diaphragm flexing in response to pressure variations in the chamber, a feeler bulb connected to said chamber and subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a varporizable liquid which varies the pressure in said chamber with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said chamber, means operably connecting said diaphragm and one of said valves, said one valve being regulated by said diaphragm to allow partial expansion of the refrigerant to a temperature higher than that in said space, the partially expanded refrigerant acting in opposition to the pressure in said chamber and in opposition to the means acting on the other valve to open said other valve and allow final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of said feeler bulb.

4. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, adjustable means biasing said valves to their seated positions, a variable volume chamber including a diaphragm flexing in response to pressure variations in the chamber, a feeler bulb connected to said chamber and subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in said chamber with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said chamber, means operably connecting said diaphragm and one of said valves, said one valve being regulated by said diaphragm to allow partial expansion of the refrigerant to a temperature higher than that in said space, the partially expanded refrigerant acting in opposition to the pressure in said chamber and in opposition to the adjustable means acting on the other valve to open said other valve and allow final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of said feeler bulb.

5. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed

refrigerant through the expansion valve, adjustable means biasing said valves to their seated positions, control means including a limit pressure charged bulb subjected to the temperature of the space to be refrigerated, one of the valves being actuated by said control means to allow partial expansion of the refrigerant to a temperature higher than that in said space, the partially expanded refrigerant acting in opposition to said control means and in opposition to the adjustable means acting on the other valve to open said other valve and allow final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of said bulb, and an orifice communicating with both sides of said other valve to reduce the pressure of said partially expanded refrigerant when said one valve is closed.

6. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, means actuating one of the valves to partially expand the refrigerant, said metans including a feeler bulb subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in the bulb with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said bulb, said actuating means being controlled by said partially expanded refrigerant and by pressure variations in said bulb, the other of the valves being actuated by the partially expanded refrigerant to control the pressure of the partially expanded refrigerant and to allow final expansion of the refrigerant.

7. In an expansion valve for refrigerating systems employing a compressed vaporizable refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, means actuating one of the valves to partially expand the refrigerant, said means including a feeler bulb subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in the bulb with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said bulb, said actuating means being controlled by said partially expanded refrigerant and by pressure variations in said bulb, the other of the valves being actuated by the partially expanded refrigerant to control the pressure of the partially expanded refrigerant and to allow final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of said bulb.

8. In an expansion valve for compression type refrigerating systems employing an expansible refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, thermally responsive control means including a feeler bulb subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in the bulb with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said bulb, one of the valves being actuated by said control means to partially expand the refrigerant, the other of the valves being actuated by the partially expanded refrigerant to control and complete the final expansion of the refrigerant.

9. In an expansion valve for compression type refrigerating systems employing an expansible refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, thermally responsive control means including a feeler bulb subjected to the temperature of the space to be refrigerated, a charge in said bulb comprising a vaporizable liquid which varies the pressure in the bulb with temperature variations in said space and which is completely vaporized at a predetermined temperature to limit the pressure in said bulb, one of the valves being actuated by said control means to partially expand the refrigerant, the other of the valves being actuated by the partially expanded refrigerant to control and complete the final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of the charge in said bulb.

10. In an expansion valve for compression type refrigerating systems employing an expansible refrigerant, the combination of, a pair of valves controlling the expansion and flow of the compressed refrigerant through the expansion valve, limit pressure charged thermally responsive control means, one of the valves being actuated by said control means to partially expand the refrigerant, the other of the valves being actuated by the partially expanded refrigerant to control and complete the final expansion of the refrigerant, the temperature of said partially expanded refrigerant being higher than the temperature of the limit pressure charge in said control means, and an orifice communicating with both sides of said other valve to reduce the pressure of said partially expanded refrigerant when said one valve is closed.

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