REFRIGERATION CONTROL APPARATUS

Filed Oct. 24, 1935 3 Sheets-Sheet 1

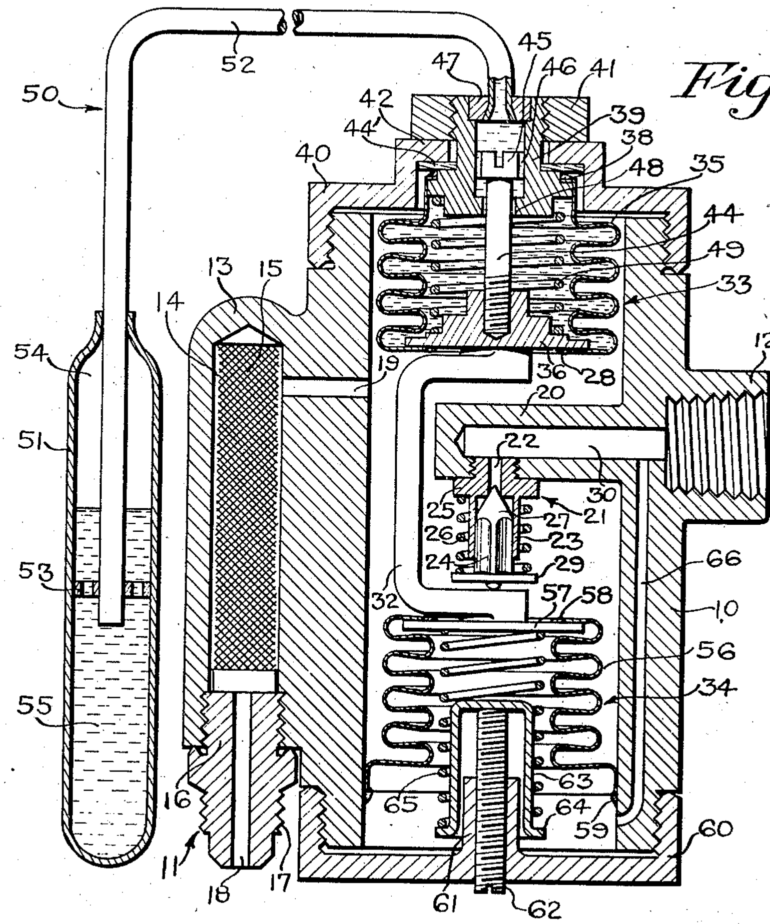

Fig. 1

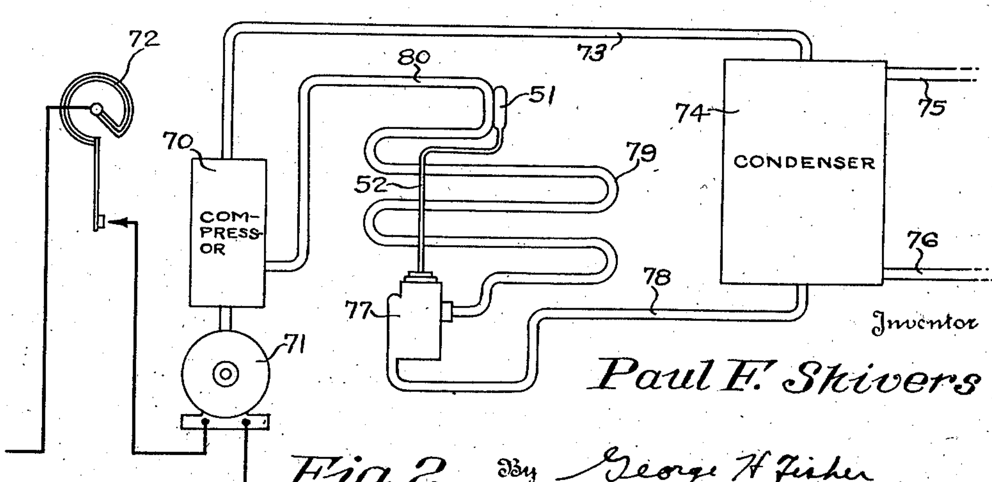

Fig. 2

Inventor

Paul F. Shivers

By George H Fisher

Attorney

May 10, 1938. P. F. SHIVERS 2,116,802

REFRIGERATION CONTROL APPARATUS

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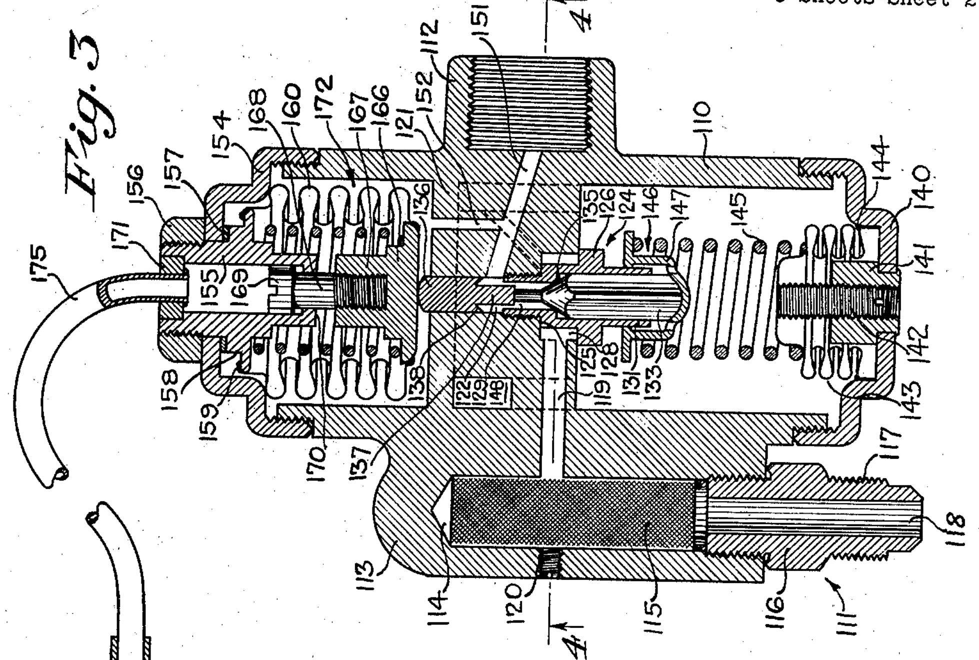

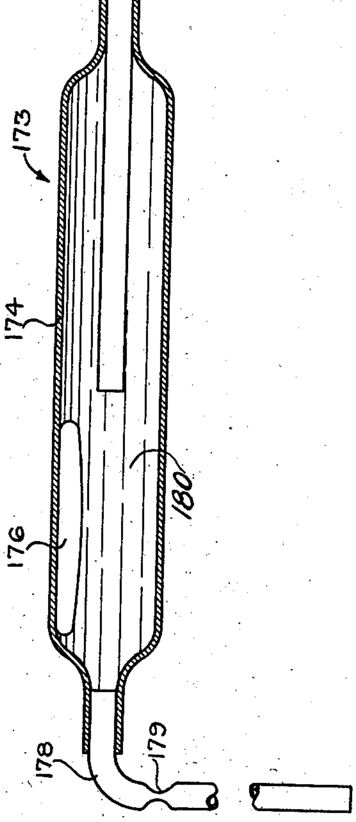

Fig. 3

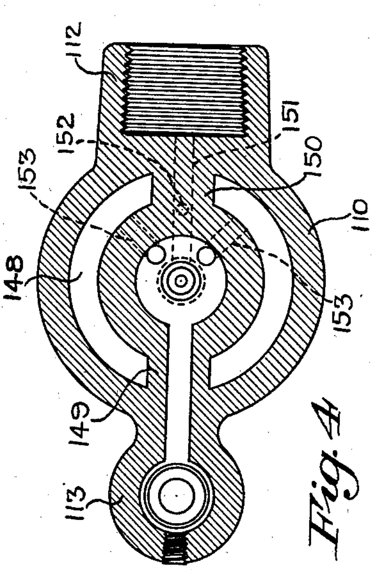

Fig. 4

Inventor

Paul F. Shivers

By George H Fisher

Attorney

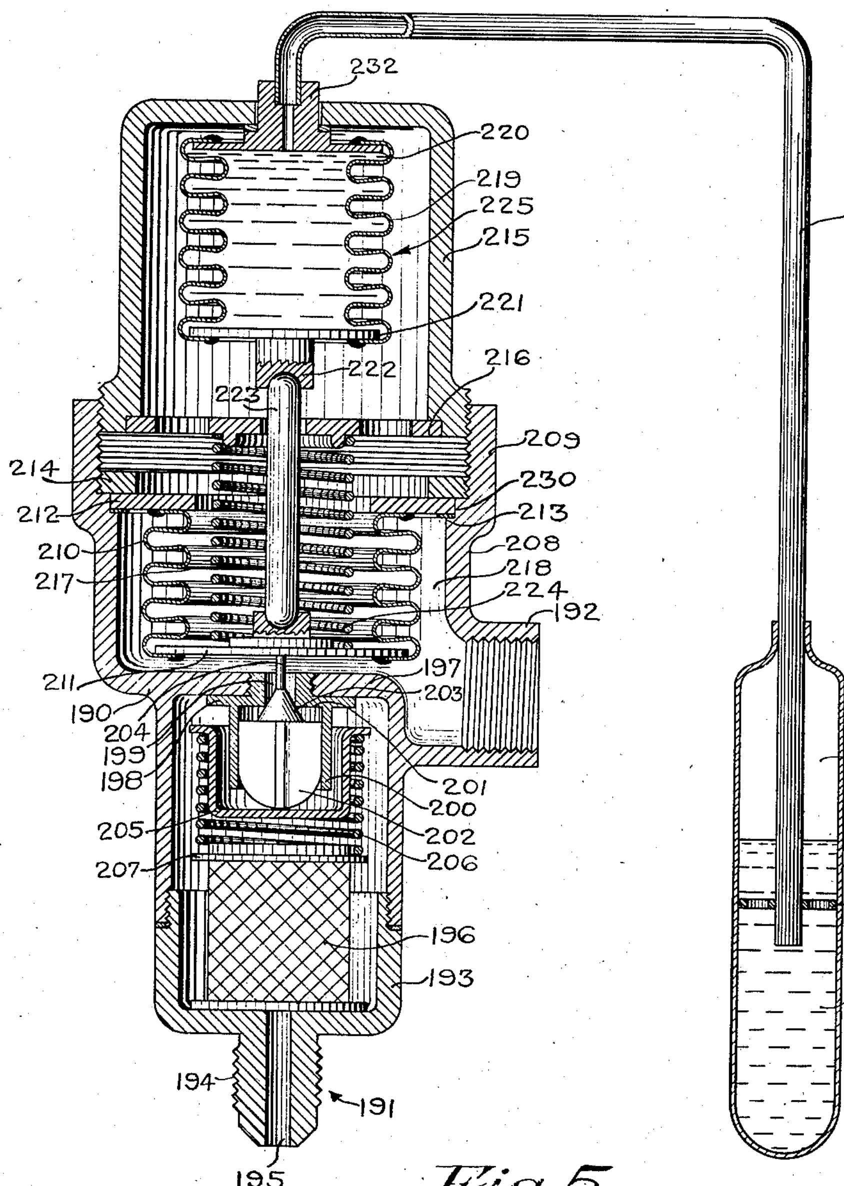

Fig. 5

Inventor

Paul F. Shivers

By George H Fisher

Attorney

Patented May 10, 1938

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UNITED STATES PATENT OFFICE

2,116,802

REFRIGERATION CONTROL APPARATUS

Paul F. Shivers, Wabash, Ind., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application October 24, 1935, Serial No. 46,527

21 Claims. (Cl. 62—8)

My invention relates to improvements in refrigeration control apparatus and more particularly to such apparatus employing a thermostatically controlled expansion valve mechanism.

It is the usual practice to employ an expansion valve between the condenser coil and the evaporator coil of a refrigerating apparatus. This valve serves to reduce the pressure of the refrigerant in passing from the condenser to the evaporator. In passing through the expansion valve from the high pressure side to the low pressure side of this system there is a tendency for the refrigerant to form a certain amount of gas in the valve drawing heat from the walls of the valve in so doing. In other words, a similar action but on a much smaller scale as that which takes place in the evaporator takes place in the valve itself. The result of this is that there is a tendency for frost to form on the outside of the expansion valve. The formation of this frost so lowers the temperature of the valve as to endanger the smooth operation of the same. Moreover, where thermostatic control means are employed, a lowering of the temperature at the valve results in the temperature at the valve being lower than the temperature at the control point. Where a thermostatic control means based upon the variation in vapor tension of a fluid is employed, this cooling of the valve below the temperature of the control point tends to shift the control point to the valve itself thus giving an inaccurate temperature control.

An object of the present invention is to provide a refrigeration control system in which the control of the flow of refrigeration through the expansion valve is not dependent upon the temperature of the valve being higher than that of the desired control point.

A further object of the present invention is to provide a thermostatically controlled expansion valve mechanism in which the thermostatically controlled means is based on the variation of vapor tension with temperature, and in which said control means responds only to the temperature at the desired control point.

A further object of the invention is to provide a refrigeration expansion valve mechanism in which the valve will be maintained sufficiently warm to prevent "frosting" thereof.

A further object of the invention is to provide a refrigeration expansion valve mechanism in which provision is made not only for the usual control of the flow of refrigerant in accordance with the outlet pressure but in which provision is made to prevent variations in the inlet pressure from causing a variation in the flow of refrigerant through the valve.

Other objects of the invention will become apparent from the accompanying specification, claims and drawings, of which:

Figure 1 is a sectional view of one form of my expansion valve;

Figure 2 is a schematic showing of a refrigeration system embodying my expansion valve;

Figure 3 is a sectional view of a modified form of my expansion valve;

Figure 4 is a section taken on the line 4—4 of Figure 3 in the direction indicated by the arrows, and

Figure 5 is a sectional view of a further modification of my expansion valve.

Referring to Figure 1, the expansion valve mechanism comprises a valve housing 10 having inlet connection 11 and outlet connection 12. The inlet connection 11 comprises a longitudinally extending projection 13 of the valve body which is provided with an elongated cylindrical chamber 14 therein. A screen 15 is located in said chamber and is retained in place by a screw-threaded nipple 16 which is provided with a threaded lower end 17 to facilitate connection with any suitable conduit. The nipple 16 is provided with a central passage 18 which is in communication with a passage 19 in the wall of the valve body 10 through the screen 15.

The valve body is provided with an inwardly extending portion 20. This portion 20 is provided with an aperture in which is screw-threadedly mounted a valve seat and guide member 21. The member 21 is provided with a central aperture 22 which communicates with the interior of the guide 23. A shoulder is provided by the junction of aperture 22 with the interior of the guide 23 and forms the valve seat proper. The member 21 is further provided with an external flange 25 which provides an abutment shoulder for a spring 26. The valve proper comprises a cylindrical member 24 having a conical end 27 which forms a valve head. The member 24 is fluted to allow the passage of fluid to the valve seat between the valve stem and the wall of guide 23. At its lower end the valve is provided with a circular disc 29 which forms an abutment shoulder for the other end of spring 26. As will be readily seen, the valve is biased to an open position by the action of the spring 26. The inwardly projecting portion 20 is provided with a passage 30 communicating with aperture 22 and with the outlet 12.

The valve flange 29 is in engagement with a yoke 32, which yoke serves to hold in spaced relationship two opposed expansible chambers 33 and 34. The expansible chamber 33 comprises a corrugated element 35 whose lower end is soldered at 28 to a disc 36. At the opposite end, the corrugated diaphragm 35 is soldered at 38 to the flange of a nipple 39. The nipple 39 is secured to a threaded collar 40 forming the upper closure member of the valve body 10 through a nut 41 which clamps said nipple against a flange 42 of collar 40. A washer 44' of any suitable material is provided between the nipple 39 and flange 42 to prevent escape of fluid from the interior of the valve body. A bolt member 44 is threadedly engaged at its lower end with the disc 36 and is provided at its upper end with a head 45 having grooves 46 therein to permit the passage of fluid between the head 45 and the internal wall of nipple 39. The internal passage of the nipple 39 is partially closed at its outer end by a cylindrical disc 47 which is secured to the nipple 39 in any suitable manner such as being sweated thereto. The nipple 39 is provided with an inwardly directed flange 48. The disc 36 which constitutes a movable wall of the expansible chamber 33 is limited in its downward movement by the engagement of the head 45 of bolt 44 with flange 48 of nipple 39. A spring 49 is located within the bellows element and serves to urge the same to expanded position.

Connected through the disc 47 and nipple 39 with the interior of chamber 33 is my novel thermostatic means generally indicated by the reference numeral 50. This means comprises a bulb 51 into which extends a tube 52. The tube 52 extends slightly more than half-way into the bulb 51 and is held in a central position by means of an apertured disc 53. Tube 52 is connected at its opposite end with the disc 47 extending through the aperture thereof and secured thereto by any suitable means shown for purposes of illustration in the drawings as a flared connection. In the upper portion of the bulb 51, there is located a substance 54 which is normally in a vaporous state. While the particular substance which I employ is not of importance, it being well known in the art to employ such vaporous materials, I have found it satisfactory to employ a substance similar to that used for the refrigerant. Thus, where sulphur dioxide is employed as a refrigerant, I have found it satisfactory to employ this substance for the vaporous substance in the bulb. Filling the rest of the space in the bulb, the interior of the tube 52 and the interior of the expansible chamber 33 is a substance 55 which remains liquid throughout the range of temperatures to which it will be subjected and which has a relatively low co-efficient of temperature expansion. Any suitable substance which has the above properties is satisfactory. I have found a mixture of ethylene glycol, alcohol and water to be satisfactory for this purpose, although this is merely one of any number of substances which will immediately suggest themselves to one skilled in the art as suitable for the purpose. Since the only vapor is located in the bulb and since the liquid 55 has a comparatively low co-efficient of temperature expansion, changes in temperature occurring at some other point than adjacent the bulb 51 will have no effect upon the controlling action of the thermostatic means 50.

The expansible chamber 34 comprises a corrugated diagram element 56 which is soldered to a circular plate 57 at its upper end at 58. The lower end of the diaphragm member 56 is soldered at 59 to the interior of the valve body 10. The valve body 10 is closed at its lower end with a threaded cap 60 having an upwardly extending internally threaded stud 61. A screw 62 is threaded through said stud and abuts a cup-shaped member 63 having a flange 64 at its lower end which flange serves as an abutment member for a spring 65. The spring bears at its other end against the movable plate 57 and serves to urge the expansible chamber 34 towards its expanded position. The screw 62 serves as a means for adjusting the tension of spring 65. A passage 66 extends downwardly through the wall of the valve body 10 and serves to establish communication between the interior of expansible chamber 34 and aperture 30 of stud 20 adjacent the valve outlet. This passage results in the interior of chamber 34 being subjected to the outlet pressure.

It will be noted that the incoming refrigerant passes into a chamber which completely surrounds the inwardly projecting portion 20 and the valve seat and guide member 21 and which extends substantially the full length of the valve body. Since the refrigerant entering the expansion valve is still comparatively warm, the provision of this large chamber in the valve body in direct communication with the inlet results in the presence of a large body of relatively warm fluid completely surrounding the valve seat, the valve and valve guide on all sides and of sufficient size so as to serve to prevent the temperature of the valve body from falling unduly. In this manner the tendency of my valve to "frost over" is negligible.

The diameter of diaphragm 35 is slightly greater than that of diaphragm 56 as indicated in the drawings. The result of this is that any increase in inlet pressure will have a slightly greater effect upon the chamber 33 than upon chamber 34. Thus if the inlet pressure rises both diaphragms will tend to be compressed against the action of the respective springs associated therewith. Since, however, the diaphragm 33 has a larger area exposed to the inlet pressure than diaphragm 34 the tendency towards compression of chamber 33 will be greater than that of diaphragm 34 with the result that the yoke 32 will be moved upwardly thus moving the valve towards its seat. In this manner, the increase in inlet pressure tends to reduce the opening of the valve and hence the flow of refrigerant through the valve is maintained constant in spite of such change in inlet pressure. It will be obvious that the opposite action takes place when the inlet pressure decreases and that in this case also the movement of the valve is such as to tend to maintain the flow of refrigerant constant in spite of such decrease in inlet pressure.

Referring to Figure 2, I have shown my expansion valve mechanism embodied in a more or less conventional refrigeration system. The system comprises a compressor 70 operated by a motor 71, whose action is controlled by a thermostat 72 which is located in a space to be cooled. A conduit 73 serves to convey the compressed refrigerant from the compressor to a condenser 74. The condenser 74 may be of any suitable conventional construction and is provided with inlet and outlet pipes 75 and 76, respectively, for the circulation of a cooling medium therethrough. The expansion valve is designated by the reference numeral 77 and is connected through a conduit 78 with the outlet of condenser 74. The outlet of expansion valve 77 is connected with the evaporator coil 79 which in turn is connected through a conduit 80 with the inlet of compressor 70. The thermostatic bulb 51 of my expansion valve is shown located adjacent the outlet of the evaporator 79.

In operation the refrigerant is compressed through the action of compressor 70 and the compressed refrigerant is passed through condenser 74 to lower the temperature and liquefy the refrigerant. It is then passed in its liquid condition to the expansion valve 77 through which it passes to the evaporator 79, the interior of which is at a relatively low pressure. Upon entering the evaporator the refrigerant is evaporated and in so doing absorbs heat from the walls and surrounding atmosphere of coils 79, thus serving to lower the temperature adjacent the same. Due to the connection between the outlet 12 and the interior of expansible chamber 34 when the compressor starts operation thus lowering the pressure in the evaporator 79, the pressure within the expansible chamber 34 is decreased with the result that the expanding effect of chamber 33 becomes greater than that of 34 so that yoke 32 is moved downwardly thus moving the valve away from the valve seat permitting the passage of refrigerant thereto. As soon as the pressure at the inlet of the evaporator begins to rise, the pressure in chamber 34 will likewise begin to rise and the valve will be moved towards a closed position. In this way my valve serves to control the flow of refrigerant in accordance with the outlet pressure which is equivalent to the pressure at the inlet of the evaporator 79. The outlet pressure maintained by the valve may be adjusted by varying the tension of spring 65 through adjusting screw 62.

As the temperature surrounding the evaporator 79 decreases due to the evaporation of the refrigerant, the temperature surrounding bulb 51 will likewise decrease with the result that the vapor tension in bulb 54 is decreased. Through the liquid 55, this decrease in pressure is transmitted to the interior of bellows 33, causing an upward movement of yoke 32 and a corresponding upward movement of valve 27 towards closed position. In this manner my valve serves to maintain a constant temperature at the outlet of the evaporator coil and since the pressure is dependent upon the temperature, to tend to maintain a constant pressure at the outlet of the evaporator.

In the event that for any reason the pressure in the inlet of valve 77 changes my valve will act to prevent such change in inlet pressure from affecting the flow of refrigerant, in the manner previously discussed.

Since the valve body is maintained comparatively warm by reason of the large body of warm refrigerant therein, there is no tendency for the valve to "frost" as previously explained. This in itself decreases the liability of the thermostatic control means 50 being rendered inaccurate by reason of a low temperature in the expansion valve. In addition, the use of a substance which remains in liquid state in the tube, in the bulb and in the expansion chamber within the valve eliminates the possibility of the operation of the thermostatic means being affected if for any reason the temperature of the valve should become lower than that surrounding the bulb.

It will be seen that my valve automatically compensates for any variation in inlet pressure and automatically controls the flow of refrigerant in accordance with variations in the pressure in the evaporator and the temperature at the outlet side of said evaporator. I, moreover, have provided a valve with which one does not experience the usual difficulty of "frosting" encountered with valves of this type. This, together with my novel filling for the thermostatic bulb assembly results in the valve being provided with thermostatic control means which is responsive to the temperature only at the desired control point.

In Figures 3 and 4 of my drawings, I have illustrated a modified form of my device. Referring to Figure 3, the valve body is designated by the reference numeral 110 and is provided with an inlet 111 and an outlet 112. The valve body 110 is provided with a longitudinally extending projection 113 which is provided with a chamber 114 therein housing a screen 115. The screen 115 is retained in place by a nipple 116 threadedly engaged to the member 113. The nipple 116 is provided at its lower end with a threaded portion 117 which serves to facilitate the connection of said nipple to a suitable conduit. The nipple 116 is further provided with a central aperture 118 which is in communication with an inlet aperture 119 in the valve body proper, through the screen 115. A set screw 120 closes off an entrance to the passage 119 which entrance is provided for the purpose of facilitating the removing of any obstruction which may enter the passage 119 in spite of the presence of screen 115.

The valve body 110 is divided into two portions by a central partition 121. The partition is provided with a central aperture 122 into the lower end of which is threaded a valve seat and guide member 124. Member 124 is provided exteriorly with shoulders 125 and 126 which engage with corresponding shoulders in the partition 121. The aperture 122 of the partition 121 is provided with an enlarged portion at its lower end which is of greater diameter than the exterior diameter of the member 124 between shoulder 125 and shoulder 126, thus providing an annular passage 128 between the enlarged portion of passage 122 and the valve seat and guide member 124. Member 124 is provided with an aperture 129 which communicates at its lower end with the interior of a cylindrical portion 131 of the member, which constitutes the valve guide. The shoulder formed by the junction of aperture 129 with the interior of the guide 131 serves as a valve seat. The valve proper comprises a stem portion 133 which is fluted to permit the passage of fluid between said stem and the interior of guide 131. The upper end of said stem is conical in form as indicated at 135 to provide a valve head. Attached to the valve stem at its upper end is a plunger extension 136 which is connected to said stem through a reduced portion 137. At the junction of the reduced portion 137 with the main body portion of the plunger 136, the shoulder located at said junction is recessed slightly as indicated at 138 for a purpose to be presently described.

The lower end of casing 110 is closed by means of a screw cap 140 which is provided with a central aperture in which is mounted an internally threaded plug 141. Mounted in said plug 141 is a screw 142 the end of which is in engagement with the upper end of a diaphragm 143. The lower end of the diaphragm is soldered to the cap 140 at 144. This diaphragm constitutes a seal to prevent fluid from escaping through the adjusting means constituted by the screw 142 and the plug 141. A spring 145 bears at its lower end against the upper end of the diaphragm and bears at its upper end against a spring guide 146 which spring guide is provided with a perforated, cup-shaped aperture portion 147 which abuts against the end of the valve stem. The spring 145 thus serves to bias the valve towards a closed position.

The partition 121 comprises an annular passage 148 which is shown in full lines in Figure 4 and partly in dotted lines in Figure 3. As will be evident from the showing in these two figures, this annular passage 148 extends downwardly to the lower edge of the partition 121 except for two portions 149 and 150 of the partition 121 which portions contain the inlet passage 119 and passages 151 and 152 leading to the outlet 112 and to the upper portion of the valve, respectively. This annular passage 148, as shown in Figures 3 and 4, is connected by diagonal passages 153 with the annular chamber 128.

The upper end of the valve body 110 is closed by a screw cap 154. This cap 154 is provided with a central aperture through which extends a nipple 155 which is in threaded engagement at its upper end with a nut 156 which serves to clamp the nipple 155 against the inner surface of collar 154. A washer 157 of any suitable material is interposed between the nipple and collar to prevent escape of fluid from the valve housing. Nipple 155 has a central flange 158 to which is soldered at 159 a corrugated diaphragm 160. This diaphragm is soldered at its lower end to a disc 166 which bears against the upper end of plunger 136. The disc 166 is provided with an internally threaded stud 167. A bolt 168 is in threaded engagement with said stud at its lower end and is provided at its upper end with a head 169 grooved to permit the passage of fluid between the head and the interior of nipple 155. The nipple 155 is provided with an internally extending flange 170 which is adapted to engage a head of bolt 168 and limit the downward movement thereof. The upper end of the aperture through the nipple 155 is partially closed by means of a collar 171 which is secured to the nipple 155 in any suitable manner such as by being sweated thereto. It will thus be seen that disc 166 constitutes a movable wall of a chamber 172, the expansion of which is limited by the engagement of the head of bolt 168 with flange 170.

The thermostatic means 173 comprises a bulb 174 connected by a tube 175 to the interior of chamber 172. As in the preceding case, the tube 175 extends slightly more than half-way into the bulb. Similarly, as in the preceding case, the bulb contains a substance 176 in vaporous condition and the remaining portion of the bulb, the tube 175 and the interior of the expansible chamber 172 are filled with a fluid 180 which remains in a liquid state throughout the temperature range to which it is subjected and which has a relatively low co-efficient of temperature expansion. These substances employed may be the same as those suggested in connection with the previously described form of my device. The bulb 174 is shown as provided with a means for initially filling the bulb with liquid and vapor which comprises a section of tubing which is crimped as at 179 after the assembly has been filled to prevent escape of the fluid substances.

The refrigerant flowing to the valve seat enters through the aperture 118 passing therethrough into the screen 115 and through the screen and aperture 119 to the annular chamber 128. It will be noted that this chamber immediately surrounds the valve seat so that the valve seat is directly surrounded with the incoming refrigerant which is relatively warm. From the annular passage 128 the refrigerant passes through the diagonal passages 153 to the annular passage 148 and from there to the lower portion of the interior of the valve body 110 where it has access to the valve seat through the apertures in spring guide 147 and the flutes in the valve stem 133. If the valve is open, the refrigerant passes through the valve and the valve seat with considerable force due to the high pressure in the inlet side thereof and is thrown against the shoulder 138 and from there passes through aperture 151 to the outlet. As previously explained, the shoulder 138 is recessed slightly. The object of this recessing of said shoulder is to prevent the refrigerant issuing through the valve from passing between the plunger 136 and the surrounding partition 121 into the upper portion of the valve chamber. By recessing the shoulder in this manner the liquid is deflected towards the central portion of the plunger assembly and from there passes through aperture 151 as previously explained. The upper portion of the valve casing is in communication with the outlet through passage 152 and the pressure maintained therein tends to correspond to the outlet pressure. Since the exterior of diaphragm 160 is subjected to a pressure corresponding to the outlet pressure any decrease in said outlet pressure, such as by the starting of the compressor, will result in the expansion of said chamber thus urging the valve further away from its seat. Conversely, upon the outlet pressure rising the chamber will contract and the valve will be urged closer towards its seat by the action of the spring 145. Thus the valve, in a manner similar to that described in the previously described embodiment, tends to maintain a constant outlet pressure, the value of which may be adjusted through spring adjusting screw 142. If some means such as a recessed shoulder 138 were not provided to prevent the refrigerant from being forced between plunger 136 and the partition 121, the pressure in the upper portion of the valve body acting on the exterior of diaphragm 160 would tend to be higher than the outlet pressure due to the force with which the refrigerant issues from the valve seat. This would result in the valve being controlled as though a higher outlet pressure existed than was actually the case.

The action of the thermostatic means 173 is substantially the same as that in the case of my previously described species. Upon the temperature at the control point, which is preferably the outlet of the evaporator, rising, the vapor tension within the bulb will be increased and the increase in pressure caused thereby will be transmitted to the liquid in the interior of the expansible chamber 172. This will cause plunger 136 to be moved downwardly thus moving the valve in the direction of an open position and permitting more refrigerant to flow through the valve. Similarly, when the temperature adjacent the outlet of the evaporator decreases, an opposite action takes place.

Thus, as in my preceding form, I have provided a valve wherein the flow of refrigerant is controlled in accordance with the outlet pressure which corresponds to the pressure in the evaporator coil. I have, moreover, provided a valve in which means is provided for controlling the position of the valve in accordance with the temperature at the outlet of the evaporator. This form of my valve is likewise designed to prevent "frosting" thereof and is, moreover, provided with a temperature control means which is effective even if such "frosting" should take place.

In Figure 5, I have shown a third modification of my expansion valve mechanism. In this figure, the valve body is indicated by the reference character 190 and is provided with an inlet 191 and an outlet 192. The inlet 191 is constituted by a cap 193 provided at its lower end with a nipple 194. The cap 193 has a central aperture 195 through the nipple portion thereof which communicates with the interior of a screen 196.

The valve body 190 is separated by a transverse partition 197 into upper and lower portions. In the center of the partition 197 an aperture is provided in which is mounted a member 198 which functions as a valve seat and guide member. The member 198 is provided with a central aperture 199 which communicates with the interior of a cylindrical portion 200 which constitutes a valve guide. At the junction of said aperture 199 with the interior of the guide 200, a shoulder is provided which constitutes a valve seat. Slidably mounted within the guide 200 is a valve which comprises a ribbed stem portion 202 and a conical valve portion 203. The valve portion 203 is provided with an integral pin extension 204 at its upper end. Bearing against the lower end of the valve stem is a cup-shaped spring guide 205. A spring 206 bears at its upper end against the flange of spring guide 205 and at its lower end against the shoulder of a lower spring guide 207 which is mounted on the upper end of screen 196. Thus spring 206 serves to bias the valve towards a closed position and to simultaneously hold the screen 196 in position.

The upper end of the valve body 190 is enlarged as at 208 and terminates in a screw-threaded flange 209. A diaphragm 210 is soldered at its lower end to a disc 211, and at its upper end to an annular plate 212. This diaphragm is secured in position through the annular plate 212 which is in engagement with a sealing washer 230 on an internal shoulder 213 of the valve body and is clamped to said shoulder by an internal annular member 214 in threaded engagement with the interior of flange 209 of the valve body. The plate 211 attached to the lower end of the diaphragm 210 bears against the upper end of a pin 204. A cap 215 is in loose-threaded engagement with the interior of flange 209 and is provided at its lower end with a perforated central apertured plate 216 which is secured thereto in any suitable manner such as by being sweated thereto. A spring 217 bears at its upper end against the plate 216 and at its lower end against the plate 211 thus serving to expand the diaphragm and to hence contract a chamber 218 which is constituted by the upper portion of the valve housing by the diaphragm 210, and by the upper and lower plates 211 and 212. The cap 215, by reason of the loose-threaded engagement with flange 209, constitutes a means for adjusting the tension of spring 217.

An expansible chamber 225 is located in the cap 215 and comprises a corrugated diaphragm member 219 soldered at its upper and lower ends to plates 220 and 221. The lower plate 221 is provided with a recessed downwardly extending boss 222 and a pin 223 has one end thereof seated in the recess of said boss. The lower end of pin 223 is seated in a recess of a box 224 and on the plate 211. In this manner, a connection is provided between the movable plate 221 and the movable disc 211 whereby expansion and contraction of chamber 225 will cause corresponding movement of disc 211. The upper plate 220 is provided with a nipple 232 which extends upwardly through cap 215 and loosely engages the same so as to form a swivel connection therebetween. The interior of the expansible chamber 225 is connected through nipple 232 with a tube 226 which communicates with the interior of a bulb 227. This bulb corresponds to the similar bulbs described in connection with the other embodiments of my invention. As in a preceding embodiment, the tube extends slightly more than half-way into the bulb and is held therein by a perforated supporting member 228. The upper portion of the bulb contains a substance 229 in vaporous condition and the remaining portion of the tube 226 and the interior of the chamber 225 are filled with a substance 231 which remains liquid throughout the range of temperatures encountered during the use of the apparatus, as in the other forms of my invention.

The refrigerant, in passing through the valve, enters through aperture 195 and passes therethrough into the screen 196 and from there into the main portion of the interior of the valve body. From there it passes between the exterior of the valve guide 200 and the interior of the cup-shaped spring guide 205 between the ribs of the valve guide 202 to the valve seat. When the valve is opened the refrigerant passes between the valve and the valve seat through aperture 199 and out through the outlet 192. It will be seen that the chamber 218 is exposed to the outlet pressure so that upon the outlet pressure decreasing the plate 211 is moved downwardly and upon the outlet pressure increasing the opposite action takes place. Thus, when the outlet pressure decreases due to the compressor being put into operation, plate 211 is moved downwardly by spring 217 and moves the valve toward open position in opposition to spring 206 and hence tends to increase the flow of refrigerant so as to maintain the outlet pressure constant.

When there is an increase in the temperature adjacent the point at which bulb 227 is located, which point will usually be in the vicinity of the outlet of the evaporator, the vapor tension will increase and the increase in pressure caused thereby will be transmitted to the interior of chamber 225 thus causing a downward movement of plate 211. This will result in the valve being moved to an open position causing increase in the flow of refrigerant to the evaporator. Since, as in the preceding forms, no vaporizable substance is present in the control means except at the control bulb, the thermostatic control means will not be affected by the presence of a lower temperature in the vicinity of the valve than at the control point, thus even though no means is provided for preventing "frosting" as in this species, an accurate thermostatic control is nevertheless obtained. Also, as in the preceding cases, the flow of refrigerant through the valve is controlled in such a manner as to tend to maintain the pressure in the evaporator more or less constant.

While I have shown and described certain detailed embodiments of my invention, it will be understood that these are for purposes of illustration only and that my invention is to be limited only by the scope of the appended claims.

I claim as my invention:

1. In apparatus for cooling a space, pressure

actuated means for varying the cooling effect of said apparatus, temperature responsive means for controlling said first named means, said temperature responsive means comprising a vapor containing member located at a point remote from said first named means, the temperature adjacent said first named means being lower than the temperature adjacent said vapor containing member, and hydraulic means for transmitting a variation in pressure in said vapor containing member due to a variation in vapor tension caused by a change in the temperature adjacent thereto to said pressure actuated means to cause the same to vary the cooling effect of said apparatus, said hydraulic transmitting means comprising a fluid having such characteristics that it remains in a liquid condition within the temperature range to which the apparatus is subjected, and having a low coefficient of expansion, whereby the temperature at the pressure actuated means has substantially no effect upon the pressure exerted against the pressure actuated means.

2. In apparatus for cooling a space, pressure actuated means for varying the cooling effect of said apparatus, temperature responsive means for controlling said first named means, said temperature responsive means comprising a vapor containing bulb located at a point remote from said first named means, and conduit means connecting said bulb with said pressure actuated first mentioned means, the temperature adjacent said first named means being lower than the temperature adjacent said vapor containing bulb, the portion of said bulb not occupied by said vapor and said conduit means being completely filled with a substance having such characteristics that it remains in the liquid state throughout the range of temperatures to which the same is subjected in use, said substance serving as a hydraulic means for transmitting variations in pressure caused by variations in the vapor tension due to changes in the temperature adjacent the bulb to said pressure actuated means to cause the same to vary the cooling effect of said apparatus.

3. In refrigerating apparatus, an expansion valve mechanism controlling the flow of refrigerant, said valve mechanism comprising a valve seat, a valve, means urging said valve into engagement with said seat, an expansible chamber having a movable wall, and means operatively associated with said movable wall and with said valve to vary the extent to which said valve is urged into engagement with said seat, temperature responsive means for varying the operation of said valve mechanism, said means comprising a vapor containing bulb located at a point spaced from said valve mechanism and a conduit connecting said bulb with the interior of said expansible chamber, the temperature within said valve adjacent said chamber tending to be lower than the temperature adjacent said bulb, the portion of the bulb not occupied by said vapor, said conduit and said expansible chamber being filled with a substance having such characteristics that it remains in the liquid state throughout the range of temperatures to which it is subjected in use, said substance serving as a hydraulic means for transmitting variations in pressure caused by variations in the vapor tension in said bulb due to changes in the temperature adjacent thereto to said expansible chamber to vary the extent to which the valve is urged into engagement with the valve seat.

4. A thermostatically controlled expansion valve mechanism for use in refrigerating apparatus comprising a valve body, a valve seat, a valve movable into engagement therewith, an inlet for said valve, a passage for refrigerant extending from said inlet around said valve seat on all sides thereof and terminating at the valve seat, an expansible chamber in said valve body having a movable wall, means operatively connected with said valve and with said wall for causing movement of said wall to effect movement of said valve, a bulb adapted to be located at a point spaced from said valve mechanism, tubing connecting said bulb with said chamber, a vaporous substance in a portion of said bulb and a substance having such characteristics that it remains in the liquid state throughout the range of temperatures encountered in the refrigerating apparatus with which the valve mechanism is to be employed, filling the portion of the bulb not occupied by said vapor, said tubing, and said expansible chamber.

5. A thermostatically controlled expansion valve mechanism for use in refrigerating apparatus comprising a valve body, a valve seat, a valve movable into engagement therewith, an inlet for said valve, a passage for refrigerant extending from said inlet to said valve seat and comprising an enlarged chamber extending around the valve seat on all sides thereof, an expansible chamber in said valve body having a movable wall, means operatively connected with said valve and with said wall for causing movement of said wall to effect movement of said valve, a bulb adapted to be located at a point spaced from said valve mechanism, tubing connecting said bulb with said chamber, a vaporous substance in a portion of said bulb and a substance having such characteristics that it remains in the liquid state throughout the range of temperatures encountered in the refrigerating apparatus with which the valve mechanism is to be employed, filling the portion of the bulb not occupied by said vapor, said tubing, and said expansible chamber.

6. A thermostatically controlled expansion valve mechanism for use in refrigerating apparatus comprising a valve body, a valve seat, a valve movable into engagement therewith, an inlet for said valve, a passage for refrigerant extending from said inlet to said valve seat and comprising an annular passage closely surrounding said valve seat, a second annular passage above said seat in communication with said first annular passage, and a third annular passage beneath said valve seat in communiction with said second annular passage and with said valve seat, an expansible chamber in said valve body having a movable wall, means operatively connected with said valve and with said wall for causing movement of said wall to effect movement of said valve, a bulb adapted to be located in a space spaced from said valve mechanism, tubing connecting said bulb with said chamber, a vaporous substance in a portion of said bulb and a substance having such characteristics that it remains in the liquid state throughout the range of temperatures encountered in the refrigerating apparatus with which the valve mechnism is to be employed, filling the portion of the bulb not occupied by said vapor, said tubing, and said expansible chamber.

7. A thermostatically controlled expansion

valve mechanism for use in refrigerating apparatus comprising a valve body, a valve seat, a valve movable into engagement therewith, an inlet for said valve, an outlet for said valve, a passage for refrigerant extending from said inlet around said valve seat on all sides thereof and terminating at the valve seat, a passage of relatively short length between said valve seat and said outlet, an expansible chamber in said valve body having a movable wall, means operatively connected with said valve and with said wall for causing movement of said wall to effect movement of said valve, a bulb adapted to be located at a point spaced from said valve mechanism, tubing connecting said bulb with said chamber, a vaporous substance in a portion of said bulb and a substance having such characteristics that it remains in the liquid state throughout the range of temperatures encountered in the refrigerating apparatus with which the valve mechanism is to be employed, filling the portion of the bulb not occupied by said vapor, said tubing, and said expansible chamber.

8. An expansion valve mechanism comprising a valve body, an inlet and an outlet in said valve body, a valve seat, a valve, a plurality of opposed expansible and contractible chambers, each having a movable wall, means operatively associated with said movable wall and with said valve to cause movement of said valve upon expansion and contraction of said chambers, the contraction of one of said chambers causing a movement of the valve towards a closed position and the contraction of the other chamber causing a movement of the valve towards an open position, and means for subjecting the movable walls of both of said chambers to the inlet pressure of the fluid whose flow is controlled by said valve mechanism, and the movable wall of said first mentioned chamber having a larger effective area than the movable wall of said second mentioned chamber so that upon an increase in said inlet pressure, said valve will be moved towards a closed position so as to maintain the flow of fluid constant in spite of said increase in inlet pressure.

9. An expansion valve mechanism comprising a valve body, an inlet and an outlet in said valve body, a valve seat, a valve, a plurality of opposed expansible and contractible chambers, each having a movable wall, means in said chambers yieldably urging the same towards expanded position and said movable walls in the direction of the valve seat, a member operatively associated with said valve and with said movable walls to maintain said movable walls in a definitely spaced relationship in spite of said yieldable means, said member being so associated with said valve that movement of said member produces a corresponding movement of said valve, the contraction of one of said chambers causing movement of said member so as to move said valve towards said valve seat, and means for subjecting the exterior of both of said chambers to the inlet pressure of the fluid whose flow is to be controlled, the effective area of the movable wall of the chamber whose contraction causes the valve to move to closed position being larger than that of the movable wall of the other chamber so that upon an increase in said inlet pressure, said valve will be moved towards a closed position so as to maintain the flow of liquid constant in spite of said increase in inlet pressure.

10. An expansion valve mechanism comprising a valve body, an inlet and an outlet in said valve body, a valve seat, a valve, a plurality of opposed expansible and contractible chambers, each having a movable wall, means operatively associated with said movable walls and with said valve to cause movement of said valve upon expansion and contraction of said chambers, the contraction of one of said chambers causing a movement of the valve towards a closed position and the contraction of the other chamber causing a movement of the valve towards an open position, means for subjecting the movable walls of both of said chambers to the inlet pressure of the fluid whose flow is controlled by said valve, and the movable wall of said first mentioned chamber having a larger effective area than the movable wall of said second mentioned chamber so that upon an increase in said inlet pressure, said valve will be moved towards a closed position so as to maintain the flow of fluid constant in spite of said increase in inlet pressure, and temperature responsive means for further controlling the position of said valve relative to said seat comprising a bulb containing a vaporous substance and means for connecting said bulb with the interior of one of said chambers so that variation in the vapor tension in said bulb will act on the movable wall of said chamber to vary the position of the valve.

11. An expansion valve mechanism comprising a valve body, an inlet and an outlet in said valve body, a valve seat, a valve, a plurality of opposed expansible and contractible chambers, each having a movable wall, means operatively associated with said movable walls and with said valve to cause movement of said valve upon expansion and contraction of said chambers, the contraction of one of said chambers causing a movement of the valve towards a closed position and the contraction of the other chamber causing a movement of the valve towards an open position, means for subjecting the movable walls of both of said chambers to the inlet pressure of the fluid whose flow is controlled by said valve, and the movable wall of said first mentioned chamber having a larger effective area than the movable wall of said second mentioned chamber so that upon an increase in said inlet pressure, said valve will be moved towards a closed position so as to maintain the flow of fluid constant in spite of said increase in inlet pressure, and temperature responsive means for further controlling the position of said valve relative to said seat comprising a bulb containing a vaporous substance and conduit means for connecting said bulb to the interior of one of said chambers, and a substance having such characteristics that it remains in the liquid state within the range of temperatures to which the same will be subjected in use in filling the said chamber, said conduit means and the portion of the bulb not occupied by the vapor.

12. In a refrigerating system, a thermostatically controlled expansion valve mechanism, comprising a valve seat, a valve, means for controlling the position of said valve with respect to the valve seat in accordance with the inlet pressure of liquid refrigerant so as to compensate for variations in said inlet pressure, further means for varying the position of said valve in accordance with the outlet pressure and tending to move said valve towards closed position upon an increase in said outlet pressure, and thermostatic means for controlling the position of said valve in accordance with temperature at a point spaced from said valve mechanism, said last

named means comprising a pressure responsive device for actuating the valve, and a bulb connected thereto and spaced from the valve mechanism, said bulb containing in part a vaporous substance, the space in said bulb not occupied by the vaporous substance, and the pressure responsive device, being completely filled with a fluid having such characteristics that it remains in the liquid state throughout the temperature range to which it is subjected.

13. An expansion valve mechanism comprising a valve body, an inlet and an outlet in said valve body, a valve seat, a valve, a plurality of opposed expansible and contractible chambers, each having a movable wall, means operatively associated with said movable walls and with said valve to cause movement of said valve upon expansion and contraction of said chambers the contraction of one of said chambers causing a movement of the valve towards a closed position and the contraction of the other chamber causing a movement of the valve towards an open position, means for subjecting the movable walls of both of said chambers to the inlet pressure of the fluid whose flow is controlled by said valve and the movable wall of said first mentioned chamber having a larger effective area than the movable wall of said second mentioned chamber so that upon an increase in said inlet pressure, said valve will be moved towards a closed position so as to maintain the flow of fluid constant in spite of said increase in inlet pressure, and means subjecting the interior of the second chamber to a pressure corresponding to the outlet pressure so as to move the valve towards an open position upon a decrease in said outlet pressure so as to maintain said outlet pressure constant.

14. In a thermostatically controlled expansion valve mechanism, a valve body having inlet and outlet openings, a plurality of opposed expansible chambers, having movable walls opposed to each other, a valve seat and a valve located in said valve body between said two movable walls, a member holding said walls in spaced relation to prevent relative movement thereof, said member being associated with said valve so as to cause movement of said valve upon movement of said member so that upon expansion of one of said chambers and the contraction of the other of said chambers said valve is moved towards an open position and upon the opposite movement of said chambers taking place, said valve is moved towards a closed position, the interior of the first mentioned of said chambers being hydraulically connected with a vapor containing bulb so that upon an increase in the vapor tension in said bulb due to an increase in temperature adjacent said bulb said valve will be moved towards an open position, and the interior of the other of said chambers being subjected to the outlet pressure of the fluid being valved, so that upon an increase in the outlet pressure, said valve will be moved toward a closed position so as to tend to maintain said outlet pressure constant, and means to subject the exterior of both of said chambers to the inlet pressure of the fluid being valved, the movable wall of the first mentioned of said chambers having a larger diameter than the movable wall of the other of said chambers so that upon an increase in inlet pressure said valve will be moved to a closed position so as to tend to maintain the flow of fluid through said valve constant.

15. In an expansion valve mechanism, a valve body including a passage having a valve port therein, an inlet conduit communicating with one side of the valve port, an outlet conduit intersecting said passage at the other side of the valve port, a diaphragm chamber into which said passage opens, a diaphragm in said chamber, a valve cooperating with the valve port, and a valve plunger for moving said valve in response to movements of said diaphragm, said plunger completely filling the passage between the diaphragm chamber and outlet conduit and being of reduced dimensions between the outlet conduit and valve member, the point of transition in dimensions being flared towards the valve member to reverse the direction of the fluid and deflect it into the outlet conduit.

16. In an expansion valve mechanism, a valve body including a passage having a valve port therein, an inlet conduit communicating with one side of the valve port, an outlet conduit intersecting said passage at the other side of the valve port, a diaphragm chamber into which said passage opens, a diaphragm in said chamber, a valve cooperating with the valve port, and a valve plunger for moving said valve in response to movements of said diaphragm, said plunger completely filling the passage for a portion of its length to prevent flow of fluid being valved into said diaphragm chamber and being of reduced dimensions for another portion of its length to permit flow of said fluid to said outlet passage, the zone of transition in dimensions of said plunger being recessed.

17. In an expansion valve mechanism for refrigeration systems, in combination, a valve casing, valve means in said casing for reducing the pressure of refrigerant flowing therethrough, said valve means comprising a valve port and a cooperating valve member, temperature responsive means for adjusting said valve means, said temperature responsive means comprising an actuating device for said valve means, a temperature responsive bulb, and means connecting said bulb to said actuating device, said bulb containing a vaporous substance for exerting different vapor pressures for different temperatures to which said bulb is subjected, said connecting means including a hydraulic pressure transmitting fluid having such characteristics that it remains in the liquid state within the temperature range to which said expansion valve mechanism is subjected.

18. In an expansion valve mechanism for refrigeration systems, in combination, a valve casing, a valve means in said casing for reducing the pressure of refrigerant flowing therethrough, said valve means comprising a valve port and a cooperating valve member, and means for adjusting said valve means in a manner to compensate for variations in inlet pressure on said valve means so as to maintain a substantially constant flow of fluid through said valve means regardless of changes in inlet pressure, said adjusting means comprising a pressure responsive device responsive to inlet pressure and arranged to adjust said valve means in a manner to vary the valve opening just sufficiently to counteract a variation in flow through the valve due to a change in inlet pressure.

19. In an expansion valve mechanism for refrigeration systems, in combination, a valve casing, a valve means in said casing for reducing the pressure of refrigerant flowing therethrough, said valve means comprising a valve port and a cooperating valve member, means responsive to the outlet pressure of said valve means for con-

trolling said valve means in a manner to decrease the valve opening upon increase in outlet pressure, and means for adjusting said valve means in a manner to compensate for variations in inlet pressure on said valve means so as to maintain a substantially constant flow of fluid through said valve means regardless of changes in inlet pressure, said adjusting means comprising a pressure responsive device responsive to inlet pressure and arranged to adjust said valve means in a manner to vary the valve opening just sufficiently to counteract a variation in flow through the valve due to a change in inlet pressure.

20. In an expansion valve mechanism for refrigeration systems, in combination, a valve casing, a valve means in said casing for reducing the pressure of refrigerant flowing therethrough, said valve means comprising a valve port and a cooperating valve member, temperature responsive means for positioning said valve means, and means for adjusting said valve means in a manner to compensate for variations in inlet pressure on said valve means so as to maintain a substantially constant flow of fluid through said valve means regardless of changes in inlet pressure, said adjusting means comprising a pressure responsive device responsive to inlet pressure and arranged to adjust said valve means in a manner to vary the valve opening just sufficiently to counteract a variation in flow through the valve due to a change in inlet pressure.

21. In an expansion valve mechanism for refrigeration systems, in combination, a valve casing formed to provided an inlet chamber and an outlet chamber, means for supplying liquid refrigerant to said inlet chamber, a valve port for placing said inlet and outlet chambers in communication, a valve member cooperating with said valve port for controlling the flow of said liquid refrigerant from said inlet chamber to said outlet chamber, and a diaphragm structure subjected to the liquid refrigerant on the inlet side of the valve for positioning said valve member, said diaphragm structure being formed to provide two separate diaphragm chambers, one of said diaphragm chambers being arranged to be subjected to the pressure of the low pressure refrigerant and arranged in a manner tending to urge said valve member towards flow restricting position upon an increase in pressure of said low pressure refrigerant, and said other diaphragm chamber being subjected to a pressure varying with the temperature at a thermostatic device to which said last mentioned chamber is operatively connected.

PAUL F. SHIVERS.