Aug. 8, 1939. E. J. DILLMAN ET AL 2,168,564

CONTROL DEVICE

Filed April 24, 1935 2 Sheets-Sheet 1

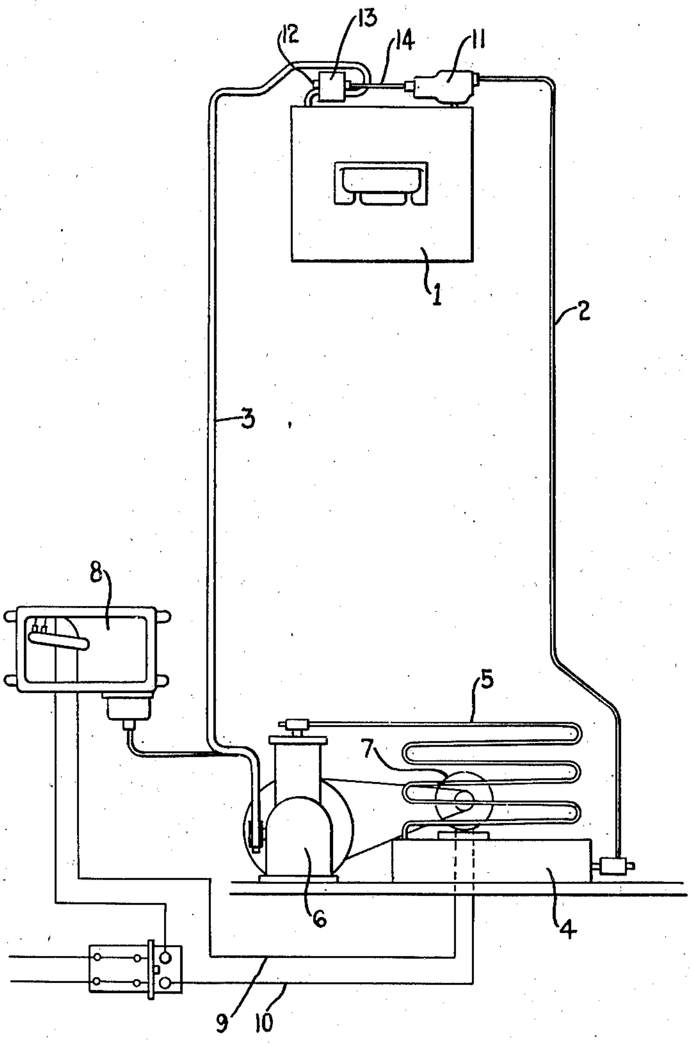

Fig 1

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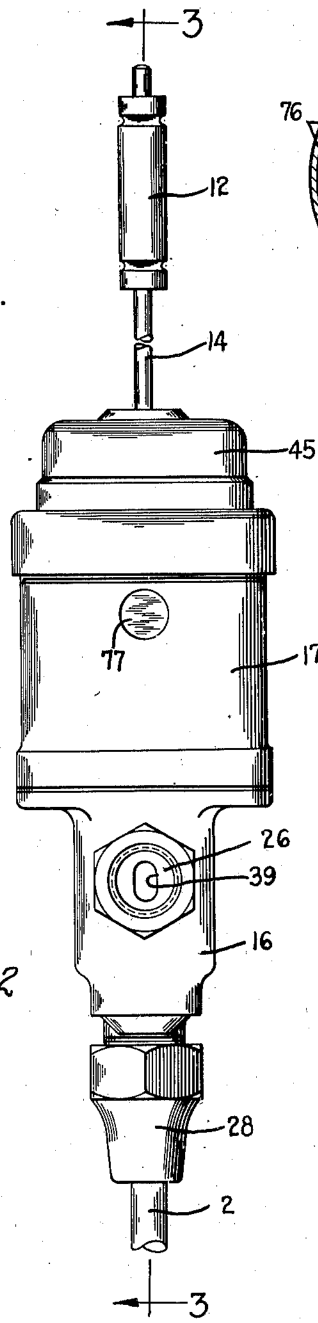

Fig. 2

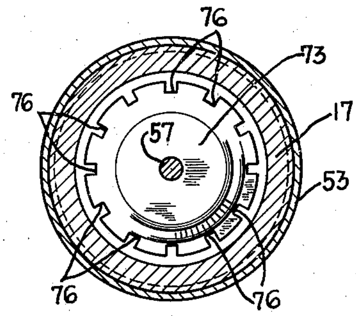

Fig. 4

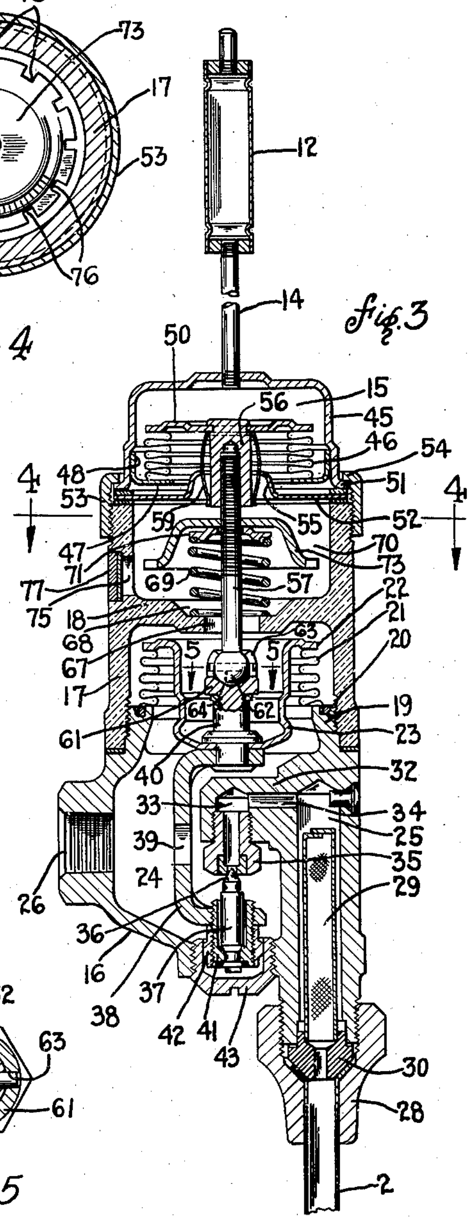

Fig. 3

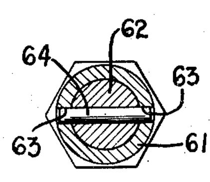

Fig. 5

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2,168,564

CONTROL DEVICE

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Application April 24, 1935, Serial No. 17,926

4 Claims. (Cl. 236—92)

Our invention relates to new and useful improvements in control devices, and more particularly to control devices of the thermostatic expansion valve type.

One of the objects of our invention is to provide a control device of the thermostatic expansion valve type having a new and improved arrangement of the operating parts thereof.

Another object of our invention is to provide a new and improved thermostatic expansion valve control device having adjustable operating parts, the operating parts being so arranged in a casing as to be adjustable without necessity of disassembling the device and in a manner so as to eliminate the necessity of having externally projecting adjusting mechanism.

Another object of our invention is to provide an expansion valve control device having a new and novel means for eliminating noise resulting from operation of the moving parts thereof.

Another object of our invention is to provide a thermostatic expansion valve control device of the type having metallic bellows for transmitting reciprocal movement to a valve and to provide a device of this character having a new and improved connecting member for the valve and bellows and of a character such that it compensates for inaccuracies in alignment of the valve and bellows to eliminate undue forces opposing free reciprocation of the operating parts.

In the accompanying drawings, to be taken as a part of this specification, we have fully and clearly illustrated a preferred embodiment of our invention, in which drawings:

Figure 1 is a diagrammatic view of a refrigerating system employing our improved control device;

Fig. 2 is a view shown in side elevation of our thermostatic expansion valve control device embodying features of our invention;

Fig. 3 is a view shown in cross section taken along the line 3—3 of Fig. 2;

Fig. 4 is a view shown in cross section taken along the line 4—4 of Fig. 3, and

Fig. 5 is a view shown in cross section taken along the line 5—5 of Fig. 3.

Referring to the drawings by characters of reference, the numeral 1 designates an evaporator or cooling element which may be of the coil type, having a refrigerant medium supply or feed line 2 and a return or suction line 3. The supply line 2 leads from a receiver 4 fed by a condenser 5 connected to the outlet or discharge side of a compressor 6 to the inlet of which the return line 3 leads and is connected. The compressor may be driven by an electric motor 7 having the usual condenser cooling fan (not shown). The motor is controlled by a pressure switch 8 responsive to variations in pressure in the return line 3 and connected in series circuit in the electric leads 9, 10 of the motor thereby to start and stop the motor and therefore the compressor at predetermined desired refrigerant medium pressure limits. In the supply conduit 2 is a valve 11 of the thermostatic expansion type which controls the admission of refrigerant medium to the evaporator 1. Referring now to the control device which is shown in detail in Fig. 2, the thermostatic expansion valve control device includes a temperature responsive bulb 12 containing or charged with a volatile fluid, such as methyl chloride, and when the control device is in operative position with the refrigerating system, the bulb 12 is preferably arranged in good heat conductive relation with the outlet or return conduit 3 of the evaporator such as by clamping means 13, Fig. 1, and preferably as close to the evaporator as practicable. The bulb 12 is in communication, by means of a tube or conduit 14, with a closed chamber 15 of a casing, which casing contains the expansion valve operating mechanism to be hereinafter described. As shown, the thermostatic expansion valve casing is preferably constructed in sections, including a valve housing section 16 and an extension section 17 fixed to the valve housing. Preferably the extension section 17, of the sectional casing, is constructed of an insulating material, such as Bakelite, and is tubular in shape, having a transverse wall 18 intermediate its ends. The tubular extension 17 is preferably internally threaded at one end for threading over an externally threaded tubular portion 19, of the valve housing 16, to fix the extension 17 to the housing and also so that the circular transverse end wall 20 of the portion 19 provides an offset portion or shoulder relative to the inner wall of the tubular extension 17.

Secured and sealed to the transverse circular end wall 20 of the valve housing is a pressure responsive means including an expansible-collapsible member 21, such as a circumferentially corrugated, substantially cylindrical, resilient, metallic bellows, which extends into the tubular section 17 towards the transverse wall 18 thereof. Secured and hermetically sealed to the free end of the bellows 21, which end is disposed toward the wall 18 of the tubular extension 17, is a cup-shaped head or end wall 22, the cup-shaped portion 23 of which extends centrally through the bellows 21 and into the valve housing 16. The bellows 21 and the cup-shaped end wall 22, closing the free end of the bellows, thus cooperate to close and seal the valve housing from the interior of the tubular extension, providing a closed chamber 24 within the valve housing 16.

The valve housing 16 is provided with an inlet passage 25 and an outlet passage 26 in communication with chamber 24. The inlet passage 25, which may be termed the high side of the control device, may be connected to the refrigerant supply conduit 2, such as by means of a fitting or nut 28. A strainer member 29 is disposed in inlet passageway 25 and is supported therein by a nipple 30 which in turn is clamped to the valve housing 16 by means of the nut 28. The outlet 26 may be connected to the inlet side of the evaporator 1, such as by a fitting or nut (not shown), or by any other suitable attaching means. From the chamber 24, refrigerant is drawn through outlet 26 into the evaporator 1 by the compressor, and the chamber 24 may be termed the low side of the control device.

Disposed within the valve casing 16 between the high side and low side of the control device is a valve structure for controlling the admission of refrigerant from the high side to the low side of chamber 24. The valve structure includes a protuberance or boss 32 which may be an integral portion of the side wall of the casing 16, preferably adjacent the inlet passage 25 as shown, and the boss 32 extends into the casing transversely to the axis or direction of movement of the bellows 21. In the end portion of the boss 32 is provided a bore 33 in central alignment with the longitudinal axis of bellows 21 and in communication with inlet passageway 25 through a communicating bore 34. One end of a tubular member 35 is screw-threaded into bore 33, the other end having a seat for cooperating with the conical face 36 of a needle valve 37. The valve 37 and the end of the cup-shaped portion 23 are connected by a yoke or U-shaped bracket 38, the yoke being part of an articulated push rod structure for operating the valve. Preferably the yoke 38 is provided with an aperture 39 substantially in alignment with the outlet 26 and through which refrigerant leaving the valve port may readily pass unobstructed to the outlet port 26. The oppositely disposed sides or arms of the yoke 38 are provided with apertures, the side adjacent the end of the cup-shaped member 23 being rigidly fixed thereto by a post 40 which extends through the aperture in the side and through an aligned aperture in the end wall of the cup-shaped member 23. The other side of the yoke 38 receives a threaded retainer member 41 in which the valve 37 is fixed. A tubular member 42 is threaded over the valve retainer 41 and is arranged for reciprocal movement in a guide 43 which is threaded in the wall of the casing 16.

On the other end of the tubular section 17 is mounted a temperature responsive power element or actuating member which comprises in general, a cap or housing member 45 and an expansible-collapsible member 46, such as a circumferentially corrugated substantially cylindrical, resilient, metallic bellows. A wall member or plate 47 is fixed within the cap 45 preferably adjacent the open end thereof and is formed with a circular flange 48 by means of which it may be fixed to the inner wall of the cap, such as by welding. The plate 47 extends transversely to the side wall of the cap 45 and one end of the bellows 46 is hermetically secured and sealed thereto. The other end of the bellows, or free end, is closed and sealed by a plate 50. Thus, the bellows are carried by and within the cap member 45 as an integral part thereof and seal and close the interior of the cap providing the chamber 15 with which the bulb 12 is in communication through the tube 14, as previously described.

Preferably the cap 45 is formed with an outturned circular flange 51 for bearing against the circular end wall of the tubular extension 17 and for clamping the cap 45 thereto. Interposed between the circular end wall of the tubular extension 17 and the flange 51 of the cap is a detachable wall means or plate 52. The end of the tubular extension 17 adjacent the cap 45 is externally threaded for threaded engagement with an internally threaded ring member or sleeve 53 which surrounds the tubular section and is formed with a circular and in-turned flange 54 on one end for engaging the out-turned flange 51 of the cap 45 to clamp the same to the tubular section 17. Between the cap 45 and the plate 52 and between the plate 52 and the circular end wall of the tubular section 17, packing material may be employed and clamped therebetween to insure a fluid-tight connection.

The detachable plate or wall 52 is preferably formed centrally thereof with a cup-shaped portion 55 which extends towards the bellows 46 and in the end wall of which is provided an aperture centrally thereof. The valve 37 and the free ends of the bellows 21 and 46 are connected by an articulated push rod structure which includes a connecting member or nut 56 having one end connected to the closure member or movable end wall 50 of the bellows 46, the other end having a threaded central aperture for receiving the threaded end of a push rod 57, which rod constitutes a section of the articulated push rod structure. The connecting member 56 may be rigidly secured to the plate 50 by providing an aperture in the plate for receiving a reduced end portion of the member 56, the end of which may be peened over to rivet the plate tightly against the shoulder of the connecting member, or the plate and connecting member may be secured together in any other suitable manner.

The connecting member or nut 56 extends centrally through the bellows 46 and through the aperture in the detachable plate 52, and preferably the aperture in the plate is sufficiently larger than the connecting member 56 to receive and hold a pair of oppositely disposed frictional bearing members 59 under compression against the connecting member 56, to prevent vibratory movement of the valve, bellows and articulated push rod structure. The bearing members 59 may be fixed for movement with the articulated push rod structure by clamping one end of each member between the shoulder of the connecting member 56 and the plate 50 or in any other suitable manner. Preferably the frictional bearing members 59 are constructed of spring sheet metal and formed having a curved or convex surface. The bearing members 59 are preferably arranged so that the convex surface of each is in frictional engagement with the wall defining the aperture in plate 52. The other ends of the bearing members frictionally engage the sides of the connecting member 56 and are free to move along the connecting member so that the spring bearing members 59 can elongate and contract upon reciprocating engagement with the wall defining the aperture in plate 52.

Preferably the size of the aperture in plate 52 and the curvature of the convex surface of the bearing members 59 are made such that when the valve 37 is in closed position, as shown in Fig. 2, the bearing members 59 are under compression although the highest points on their convex surfaces are not in bearing engagement with the wall defining the aperture in plate 52 so that when the valve is opened, the bearing members will be placed under a slightly greater pressure. The free ends of the bearing members 59 are preferably curved to present a small convex surface at their ends, in engagement with the connecting member 56 so as to reduce friction between the relatively moving parts. It will thus be seen that the friction bearing members 59 will serve to prevent vibrating movement and resultant noise of the moving valve structure and without appreciably opposing or resisting the free reciprocal movement of the structure.

The end of the post 40 that extends into the cup-shaped portion 23 of the end wall 22 is provided with a central axial bore threaded to receive an externally threaded shank of a socket member 61. The socket 61 which receives and retains the ball formed end 62 of the rod 57 may be spun around the ball 62 in the well known manner so that the socket wall retains the ball end of the rod. Preferably the socket 61 is provided with oppositely disposed slots 63 in its side wall to receive a pin 64 which extends through an aperture in the ball to prevent rotation of the rod 57. It will thus be seen that by providing an articulated push rod structure, having a ball and socket connection, for operatively connecting the bellows and valve that inaccuracies in alignment of the bellows and valve, or inaccuracies in the bellows which would cause them to move in a line not concentric with each other or with the guided reciprocating valve 37 will be compensated for, to eliminate opposing forces to the free movement of the parts which would otherwise be present.

The transverse wall 18 of the extension member 17 is provided with a central bore 67 and a counterbore 68 through which extends the rod 57 of the articulated push rod structure. A coil spring 69 is disposed in the chamber 70 between the transverse wall 18 and the plate 52 and surrounds the rod 57 with one end seated in the counterbore 68 and bearing against wall 18. The other end of spring 69 is positioned in a guide or retainer member 71 having an aperture for receiving the rod 57, the aperture being sufficiently large to permit free movement of the rod 57 therethrough without interference. The guide member 71 and the adjacent end portion of the spring 69 extends into a cup-shaped adjusting member 73 having an open side disposed toward the wall 18 of the extension member 17. The spring 69 is thus held under compression by the adjusting member 73 and acts in a direction tending to close the valve 37. The adjusting member 73 has a central aperture for receiving the rod 57, the aperture being threaded for threaded engagement with the threaded portion of the rod 57. By rotating the adjusting member 73 on the rod 57, the tension of spring 69 may be varied as desired and in the present construction this may be accomplished after the device is assembled by providing an opening 75 leading into chamber 70 giving access to the adjusting member 73. As shown in Fig. 4, the edge defining the open side of the cup-shaped adjusting member 73 may be provided with a series of spaced notches 76 for receiving a tool insertable through opening 75 to rotate the adjusting member 73. Preferably a removable closure member or plug 77 is provided for closing the opening 75.

When assembling the control device, the power element which is a unitary structure may be positioned on the open end of the extension and rotated in a direction such that the connecting member 56 advances on the threaded rod 57 thus collapsing the bellows. After the bellows are completely collapsed, the power element is rotated in the opposite direction until the bellows are opened to the proper working position. This position may be determined by the type of thread employed on rod 57 which may be selected such that, say, two turns of the power element will open the bellows to the desired working position. By reason of the arrangement of the parts of the power element as a unitary structure so that the bellows may be expanded or collapsed through rotation of the cap, it will be appreciated that adjustment may be made after the bellows are enclosed and without the necessity of externally projecting adjusting mechanism. After the bellows have been properly positioned, the clamping ring is threaded to the tubular extension 17 and the cap 45 tightly clamped thereby to the casing.

The operation of a refrigerating system employing a thermostatic control device of the character described is as follows: With a temperature differential of eleven and one-half degrees Fahrenheit between the temperature of the return or suction line 3 at the evaporator 1, the evaporator will be operating at maximum capacity. By maintaining this temperature differential for all evaporator temperatures, the evaporator will be maintained at maximum capacity and the system at maximum efficiency. This temperature differential may be maintained by controlling the admission of refrigerant medium to the evaporator in accordance with the maintenance of the predetermined differential. If, for example, the refrigerant medium employed is methyl chloride, then with evaporation of the refrigerant medium in the evaporator occurring at say, 13.5° F., the evaporator will be at maximum capacity when the temperature of the return line at a point near the evaporator is 25° F. At these temperatures the valve 37 of the thermostatic expansion valve should be seated or closed with the force tending to open the valve balancing the force tending to close the valve, so that if there is any increase in the temperature of the return line 3, and therefore of the bulb 13, at the evaporator, or if there is any decrease in the temperature of evaporation within the evaporator, the valve 37 will be opened to admit refrigerant medium to the evaporator and maintain the desired temperature differential. In order to maintain this differential for all operating temperatures of the evaporator, the change in force exerted by the power element for each degree change of temperature must be less than the change in force exerted by the bellows 21 and if, for example, the ratio in square inches of the effective areas of the power element and the bellows 21 is as 1.00 to 1.16, then the desired temperature differential will be maintained for methyl chloride refrigerant. The pressure or force exerted by the power element at a bulb temperature of 25° F., will be for methyl chloride 17.5 pounds, as the effective area of the power element is unity, and the force exerted by the bellows 21 will be in accordance with the temperature of evaporation of the refrigerant in the evaporator, which at 13.5° F., is 10.5 pounds per square inch for methyl chloride, so that the force exerted by bellows 21 tending to close the valve 37 will be 12.18 pounds. Therefore in order to have the valve in balanced closed position, the spring 69 is adjusted by the adjusting member 73 to exert a resultant force equal to the difference between the opposing forces, namely, a force of 5.32 pounds acting to seat the valve.

When the system is started in operation from a warm condition by closing of the circuit of motor 7, with the temperature of the bulb 12 at say 80° F., the force exerted by the power element will be 71.75 pounds acting through the articulated push rod structure and tending to open the valve 37. In order that the evaporator may be operating at maximum capacity at this starting temperature, there should be a differential of 11.5° F., or the temperature in the evaporator should be 68.5° F., which corresponds to a refrigerant medium pressure with methyl chloride of 57.2 pounds per square inch. This force acting through the bellows 21 to close valve 37 will, due to the effective areas of bellows 21, be exerting a force on the push rod structure of 66.43 pounds, which added to the force exerted by the spring 69 of 5.32 pounds equals 71.75 pounds, so that the valve is held in balanced closed position. When the compressor reduces the pressure in the evaporator below 57.2 pounds per square inch, the power element being subject to a temperature of 80° F., will act to open valve 37 to admit refrigerant medium to the evaporator, the medium expanding therein to increase the pressure and close the valve. This will, however, decrease the temperature of the return line and therefore of the bulb 13, so that the pressure in the evaporator may be further reduced by the compressor before the valve 37 will be opened. This gradual step by step reduction of pressure while maintaining a substantially constant temperature differential will continue until the low pressure limit is reached, corresponding to a temperature of, say, 25° F., at the bulb 13, when the switch 8 will stop the motor and compressor. As the bulb 13 warms, tending to open valve 37, the refrigerant medium in the evaporator will also expand to increase the evaporator pressure which acting through bellows 21 will prevent the valve from opening. The temperature of the evaporator increases until the predetermined desired maximum pressure in the return line is reached, when switch 8 will again turn on the motor 7 to complete a cycle of operation and start a decrease of evaporator temperature.

From the foregoing description, it will be seen that we have provided a thermostatic expansion valve having a new and improved arrangement of the operating parts thereof. It will be understood that by providing a separate attaching means for the power element cap 45 that the cap may be rotated to vary the position of the free end of the bellows relative to its fixed end without necessity of removing the cap or otherwise disassembling the device. It will also be seen that we have provided for eliminating noise or rattle of the operating parts of the device. In addition, we have provided a new and improved articulated push rod structure for connecting a bellows to a valve to prevent side strain between the rod and bellows.

What we claim and desire to secure by Letters Patent of the United States is:

1. In a device of the character described, a casing having an inlet and an outlet and a valve port within the casing, a reciprocal valve within the casing for controlling flow therethrough, a removable cap member mounted on the casing, a bellows carried by said cap member having one end connected thereto and closing and sealing the cap providing a chamber for a volatile fluid within the cap, a detachable plate disposed between the cap member and the casing and having an opening therethrough, means for clamping the cap and plate to the casing, an articulated push rod structure within the casing connecting the free end of the bellows and said valve, one end of said rod extending through said opening in said plate, a resilient bearing member cooperable with said plate and said rod and frictionally opposing movement of said rod through said plate opening, a spring in said casing surrounding said rod and acting to close said valve, and means carried by said rod and within the casing for adjusting the tension of said spring.

2. In a device of the character described, a casing having an inlet and an outlet and having a valve port therewithin, a reciprocal valve within said casing for controlling flow through said valve port, a removable cap member mounted on said casing, movable wall means carried by said cap member, said movable wall means sealing said cap member and cooperating therewith to provide a chamber for an expansible-contractible fluid operable for moving said movable wall means, a detachable wall means disposed between said cap member and said casing and having an opening therethrough, a clamping ring for securing said cap member and said detachable wall means together and to said casing, a connecting member in said casing having one end connected to said valve and the other end extending through the opening in said detachable wall means and connected to said movable wall means, and a resilient bearing member carried by said connecting member and positioned to engage with the wall defining the opening in said detachable wall means to dampen vibratory movement of said valve.

3. In an expansion valve, a casing including a valve body having an inlet and an outlet and containing a valve port, a reciprocal valve member cooperable with said valve port to control flow therethrough, said body having an opening in a wall thereof, a bellows member closing and sealing said opening and cooperating with the inner walls of said body to provide a pressure chamber in which the pressure of a fluid acts on the bellows member, an open ended tubular extension having one end secured to said body and surrounding said bellows member, temperature responsive means mounted on the other end of said extension and including a bellows member opposed to said first-named bellows member, said extension having an internal transverse wall intermediate its ends between said bellows members and cooperating therewith to provide a chamber on each side of the transverse wall, said transverse wall having an aperture therethrough, a thrust member operatively connecting said bellows members and said valve member and extending through said aperture, an abutment member adjustably supported on said thrust member in the chamber between said transverse wall and said second-named bellows, and a coil spring in said last-named chamber bearing against said abutment member and said internal wall, said spring acting with one of said bellows members and opposing the other of said bellows members.

4. In a device of the character described, a cas-

ing having a passage therethrough including a valve port and having an opening, a reciprocal valve to control said port and disposed within said casing, a removable wall member overlying said opening and having an opening therethrough, a removable cap member mounted on said casing and having a shoulder overlying said removable wall member, a bellows member within said cap member, said bellows member having one end secured and sealed to said cap member and cooperating therewith to provide a chamber within said cap member for a volatile fluid, ring means engaging said cap member shoulder and securing said removable cap member and said removable wall member to said casing, a thrust member within said casing operatively connecting the free end of said bellows member and said valve and extending through the said opening in said removable wall member, spring means operable to actuate said valve, and a spring bearing member carried by said thrust member and engaging the wall defining the opening in said removable wall member to dampen vibrating movement of said valve.

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