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EXPANSION VALVE

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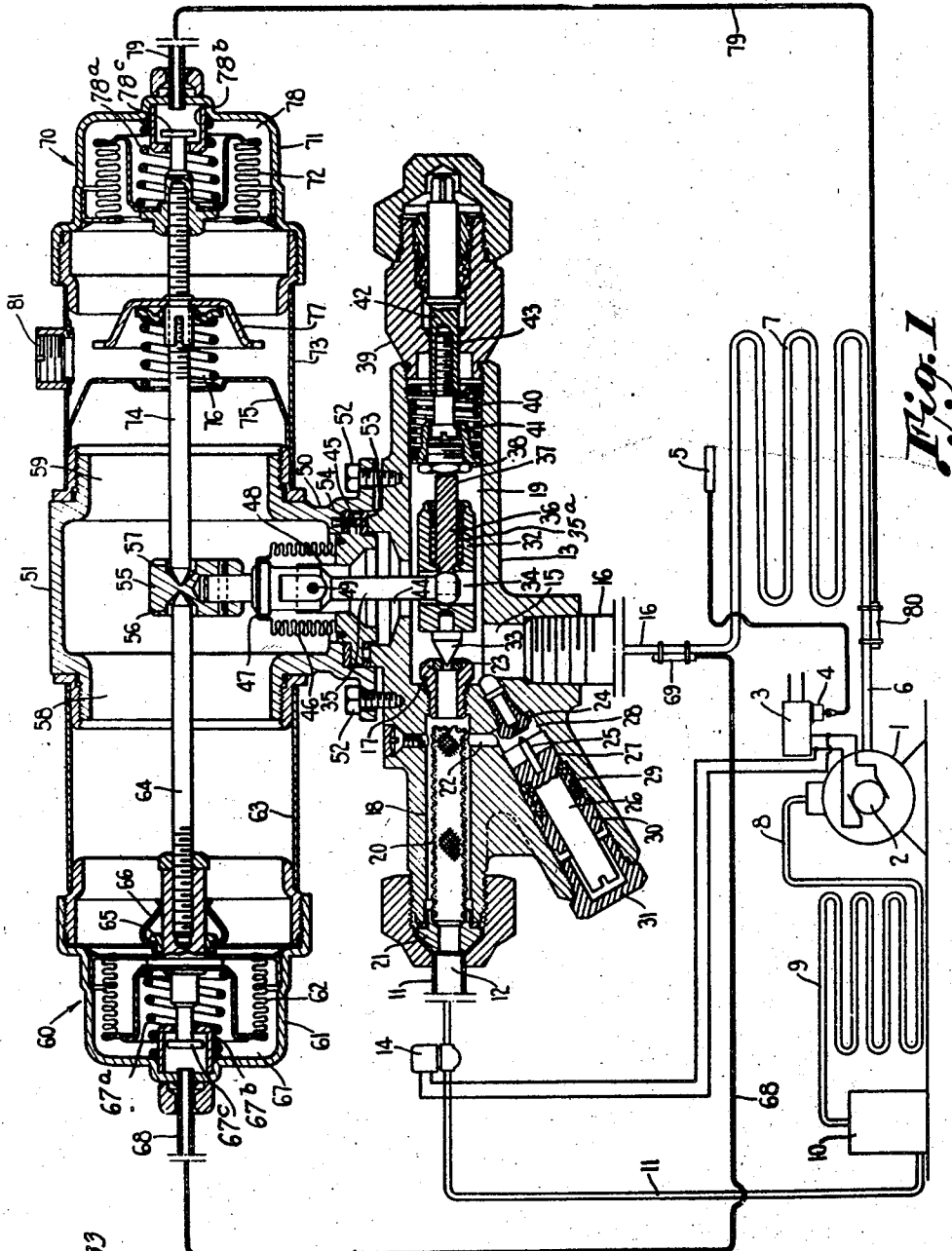


Fig. 1

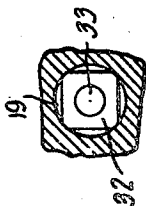


Fig. 2

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EXPANSION VALVE

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This invention relates to new and useful improvements in expansion valves for controlling the flow of refrigerant medium to evaporators to be operated in extremely low temperature ranges.

An object of the invention is to provide a thermostatic expansion valve which will be sensitive in operation irrespective of extremely low refrigerant medium pressures in the evaporator.

Another object is to provide thermostatic means to move the valve toward closed position in order to amplify the force available from refrigerant medium pressures.

Another object is to provide means for obtaining a dual or stepped superheat setting of the valve so that there can be a limit of maximum valve opening movement in the normal operating range of the valve and the evaporator supplied thereby.

The invention consists in the novel construction and combination of parts to be more fully described hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawing, there is fully and clearly illustrated a preferred embodiment of the invention, in which drawing:

Figure 1 is a view in longitudinal vertical section of a thermostatic expansion valve embodying the invention and operatively arranged in a refrigerating system, and

Fig. 2 is a detail view showing the guided support of the valve member by the walls of the valve chamber.

Referring to the drawing by characters of reference, 1 designates generally a refrigerant compressor driven by an electric motor 2 controlled by an automatic switch 3, controlled by a liquid or vapor charged power element 4 having a temperature responsive bulb element 5 positioned in the space of which the temperature is to be controlled, the power element 4 serving to stop and to start the motor 2 respectively upon the occurrence of the desired low and high temperature limits in said space. The compressor 1 has its inlet or suction side connected by a refrigerant return line or conduit 6 to the outlet end of a refrigerant medium evaporator 7 positioned in the space to be refrigerated. The outlet or pressure side of the compressor 1 is connected by a conduit 8 to a refrigerant condenser 9 which feeds into a tank or receiver 10. From the receiver 10 the refrigerant liquid line or conduit 11 connects to an inlet 12 of the valve or body member 13 of the thermostatic expansion valve. Intercalated in the liquid line 11 there is

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an electrically operated shut off valve 14 preferably of the solenoid type operable to stop the flow of refrigerant medium to the inlet 12 and controlled by the switch 3 such that the valve 14 is opened upon starting of the compressor 1 and is closed when the compressor motor 2 is deenergized. The outlet 15 from the valve casing 13 is connected by a refrigerant supply line or conduit 16 to the inlet of the evaporator 7.

The valve casing 13 is of elongated tubular form having a longitudinal bore extending from the inlet 12 and separated by a valve seat member 17 into a strainer inlet chamber 18 and a valve chamber 19. In the chamber 18 there is a tubular strainer member 20 of fine wire mesh which is attached to the inlet fitting member 21 and removable thereby from the chamber 18. The outlet 15 opens laterally from the chamber 19 adjacent the valve seat member 17 and is connected to the inlet 12 by a passageway 22 which connects into the strainer chamber 18 and bypasses the passageway and valve port 23 through the seat member 17. In the bypass passageway 22 there is a flow restricting member 24 having a calibrated bleed port or orifice for minimum effective flow direct from the valve inlet to the valve outlet, the calibrated port being of say twenty thousandths inches diameter. The port in member 24 can be still further reduced in size to further restrict flow through the bypass passageway 22 by means of a valve member 25 of needle type carried by a manually operable stem 26. The inner end portion of stem 26 is adjustably screw-threaded, as at 27, in a casing bore which provides a valve chamber 28 intercalated in the passageway 22. Leakage of refrigerant medium around the stem 26 is prevented by packing material 29 and a packing gland 30. A screw cap or cover 31 houses the external end of the stem 26 and is removable from the casing 13 for access to the stem 26 to adjust the valve member 25. In the valve chamber 19 there is a valve member 32 having a conical metering valve head 33 cooperable with the valve port 23 to regulate flow of refrigerant medium to the evaporator 7. The valve member 34 is of rectangular cross section, see Fig. 2, so that its side edges engage the cylindrical wall of the chamber 19 to guide the valve member in longitudinal movement toward and from the port 23. The member 32 has a transverse cylindrical aperture 34 therethrough which receives one end of a lever member 35, which end is preferably of substantially spherical form. Play or lost motion of the spherical end of lever 35 in the aperture 34 is

prevented by a spring 35^a on a spring-pressed abutment rod 36 guided in a longitudinal bore in the back or outer end portion of the valve member 32. The rod 36 projects from the valve member 32, as at 37, for engagement with an adjustable stop member 38 which is carried by an end closure member 39 for the chamber 19. The stop member 38 is backed by a helical coil spring 40 which is limited in its expansion and held under compression by lost motion stop members, as at 41. The stop member 38 is adjustable longitudinally of the chamber 19 by a stem 42 adjustably screw-threaded, as at 43, in the closure member 39. The stem 42 may be screwed inward to engage the stop member 38 with the projecting end portion of rod 37 to seat the valve head 33 and close the port 23 or may be positioned such as to position the stop member 38, as shown, in which it limits the maximum opening movement of the valve member for the desired operating range of the valve and evaporator. The resistance of the spring 40 is such that the valve member 32 may have opening movement beyond its limit established by the stop member 38 for temperature ranges of the valve and the evaporator above the desired operating range.

The lever member 35 extends through a side wall opening 44 in the casing 13 and laterally of the valve member 32. The opening 44 is closed by an annular supporting member 45 carrying a flexible metal bellows member 46 which is hermetically sealed at one end to the supporting member 45 and at its other end, as at 47, to the lever member 35. The member 45 has upstanding spaced ears or posts 48 positioned at opposite sides of the lever member 35 and which support a pivot pin 49 on which the lever member 35 is journaled or fulcrumed. The supporting member 45 is clamped to the casing 13 by a downward facing annular shoulder in the tubular stem 50 of a T-shaped hollow housing member 51, which is tightly clamped to the casing 13 by bolts 52. Packing or sealing rings 53, 54 are interposed respectively between the supporting member 45 and the casing 13 and the housing member 51 to seal the opening 44 and the stem 50.

The lever member 35, which serves as a reciprocal motion transmitting thrust member for operating the valve member 32, has its external end portion 55 terminating in the housing member 51 and provided with oppositely facing conical sockets 56, 57 which are concentrically aligned with the hollow cylindrical arms 58, 59 respectively of the housing member 51. Carried by the arm 58 there is a thermostatic actuator 60 comprising a cup-shaped casing 61 having an expansible contractible wall or closure member 62 facing the socket 56. The casing 60 is connected to and supported from the arm 58 by a thin walled tube 63 of heat flow resisting material, such as stainless steel. The movable wall member 62 is connected to the lever end portion 55 by a thrust member 64, preferably a two piece rod of adjustable length reciprocally supported in a guide ring 65 carried by the casing 60. The thrust member 64 has one end secured to the member 62 and has its other end seating in the socket 56. Resilient damping fingers 66 are carried by the guide ring 65 and frictionally engage the rod 64. The pressure chamber 67 formed within the casing 61 by the member 62 is connected by a tube 68 of capillary or small bore to a bulb element or feeler member 69 which is clamped in intimate heat exchange relation to the evaporator inlet line or conduit 16, preferably

adjacent the evaporator inlet. The bulb element 69 is charged with a minute quantity of volatile liquid having a steep pressure-temperature curve in the extremely low temperature operating range of the evaporator, such a liquid being for example ethane. The use of a minute quantity of liquid or so-called gas charging of the thermostatic actuator serves to limit the pressure exerted on the wall member 62 and by the actuator 60 at temperatures above the operating range of the evaporator which may be say between the limits of 110° F. below zero to 120° F. below zero. The chamber 67 contains the usual spring 67^a held under compression between the end wall of casing 61 and the movable wall 62 and tending to hold the rod 64 in engagement with the lever end 55. Cooperable stop members 67^b and 67^c rigid respectively with the casing 61 and the wall 62 serve by their engagement with each other to limit expansion of the chamber 67. The actuator 60 is opposed by a thermostatic actuator 70 having a cup-shaped casing 71 closed by an expansible contractible wall or movable member 72 which faces the lever member socket 57, the casing 71 being carried by a thin walled tube 73 of heat flow resisting material, such as stainless steel, which extends from the housing arm 59. The wall member 72 is operatively connected to the lever member 35 by a thrust member 74 which may be a two piece expandably adjustable rod having one end secured to the member 72 and having its other end seating in the socket 57. Surrounding the thrust member 74 and apertured for free movement of the same therethrough, there is a spring abutment member 75 which is rigid with the tube 73. Seating against the member 75 in surrounding relation to the thrust member 74 and extending toward the actuator 70, there is a helical coil spring 76 which is held under compression against an adjustable abutment member 77 screw-threaded on the thrust member 74. The spring 76 opposes expansion of the wall member 72 upon temperature increase of the actuator 70 and determines the superheat setting of the valve in the operating range of the evaporator. The casing 71 and member 72 provide a pressure chamber 78 which communicate through a tube 79 of small or capillary bore with a bulb element or feeler member 80 which is clamped in intimate heat exchange relation to the suction line 6 adjacent the outlet of the evaporator 7. The bulb element 80 is charged with a minute quantity of volatile liquid such that the actuator 70 is gas charged, the liquid preferably being ethane and being in such minute quantity that at temperatures above the operating range of the evaporator 7 the liquid will be in gas phase and thereby have its force limited which acts on the wall member 72 and which is exerted by the actuator 70 to move the valve member 32 toward open position. The chamber 78 contains the usual spring 78^a tending to hold the rod 74 in engagement with the lever end 55 and held under compression between the casing 71 and the movable wall 72. Expansion of the chamber 78 is limited by the cooperable stop members 78^b and 78^c which are rigid with the casing 71 and the wall 72, respectively. The forces exerted by the actuators 60 and 70 are equal at equal temperatures of the bulb elements 69 and 80 respectively. The force exerted by the spring 76 in opposition to expansion of the actuator 70 establishes the differential of the forces of the actuators 60 and 70 on and which operate the valve member. The valve member

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32 will be in closed position unless the temperature of the bulb element 80 is sufficiently higher than the temperature of the bulb element 69 such as to overcome the force of spring 76. A removable plug 81 closing an aperture in the wall of tube 73 permits access to the abutment member 77 for adjustment of the force of spring 76 and, therefore, the superheat setting of the valve.

The operation of the refrigerating system and of the expansion valve when embodied therein is as follows: Assuming that the evaporator 7 is at room temperature or a temperature well above its operating range and that the temperatures of the bulb elements 69 and 80 have equalized, the switch operating power element 4, due to the bulb element 5 being at a temperature above the desired temperature of the space containing the evaporator 7, will have closed the switch 3. Therefore, upon closure of the circuit at the switch 3 the motor 2 will be started in operation and the valve 14 will be energized and opened. The operation of the compressor 1 by the motor 2 will withdraw refrigerant medium which is at high back pressure from the evaporator 7 and discharge the same to the condenser 9 and receiver 10 for flow through the liquid line 11 and the open valve 14 to the strainer chamber 18. Since the valve head 33 is seated and closing its port 23 due to the force of spring 76, there will be a minimum restricted flow of refrigerant medium through the bypass passageway 22 and the calibrated orifice member 24 to the outlet 15 and thence via conduit 16 to the evaporator 7. The refrigerant medium evaporating in the conduit 16 will reduce the temperature of the bulb element 69 and when the gas pressure in chamber 67 decreases below the differential force of spring 76, the actuator 70 will overcome the lesser force of the actuator 60 and act through the lever thrust member 35 to move the valve member 32 toward open position. As refrigerant medium feeds through the port 23, the temperature of the bulb element 69 will be further decreased thereby still further reducing the force of the actuator 60 so that the actuator 70, which is unaffected by this first flow of refrigerant medium, will move the valve member 32 to its maximum open position limited by the stop member 38. As the pressure in the inlet to the evaporator 7 is further decreased by the compressor 1, the force exerted by the actuator 60 will be still further decreased so that the gas in chamber 78 will exert sufficient pressure due to the relatively high temperature of the superheated refrigerant affecting the bulb 80, to overcome the spring 40 so that the valve head 33 will be moved to wide open position beyond the limit of the stop 38 thereby permitting substantially unobstructed flow through the port 23. The compressor 1 will therefore be permitted to operate efficiently during the period when the evaporator 7 is being pulled down to its operating pressure range. As soon as the refrigerant medium in the evaporator 7 cools the bulb element 80 to a temperature such that the force exerted by its thermostatic actuator 70 becomes less than the sum of the forces exerted by the actuator 60, the superheat spring 76 and the spring 40, then the spring 40 will expand and move its limiting members toward engagement at 41. Expansion of the spring 40 will move the valve member 32 toward its seat, thereby reducing the rate of flow of the refrigerant medium to the evaporator 7. The spring 40 will continue to exert its force to close the valve member 32 until the temperature of the

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bulb element 80 has been reduced to the point where the stop members engage each other at 41 and thereby prevent further expansion of the spring 40. The pressure in the chamber 78 which is no longer opposed by the spring 40, will now hold the rod end 37 in engagement with the stop member 38 which determines the maximum open position of the valve member 32 in the operating range of the evaporator. This maximum limit determined by the stop 38 and spring 40 for the open position of the valve in the evaporator operating range serves to reduce surging of the system which would be caused by excessive flow of refrigerant medium through the valve port 23. When the evaporator 7 becomes completely refrigerated by the supply of refrigerant medium thereto, such that evaporation is occurring to a point adjacent but on the evaporator side of the bulb element 80, then the bulb elements 69 and 80 will cooperate to regulate the opposing pressures in the thermostatic actuators 60 and 70 so as to throttle the valve member 32 for the necessary flow of refrigerant medium through the port 23 to keep the evaporator 7 flooded throughout its length. The system will continue in operation with the compressor 1 running until the temperature of the space refrigerated by the evaporator 7 decreases to the desired temperature at which power element 4 will open the switch 3 and deenergize the motor 2 and the valve 14 to stop flow of refrigerant medium to the valve inlet 12. It may be noted that the minimum flow permitted through the orifice member 24 will aid in preventing surging due to complete closure of the valve head 33 during the operation of the compressor 1 and which may result from frictions at the extreme low temperatures of operation of the valve.

What is claimed and is desired to be secured by Letters Patent of the United States is:

1. The combination with a refrigerant evaporator of a refrigerant expansion valve for controlling flow of a refrigerant medium to the evaporator and comprising an elongated tubular open ended casing having one end open for admission of refrigerant medium, a valve seat member in the bore of said casing, a valve member cooperable with said seat member and guided for longitudinal movement in said bore, said casing having an outlet passageway through the side wall of said bore on the outlet side of said valve seat member, said casing having a passageway bypassing said seat member, an orifice member determining the minimum flow to said outlet and positioned in and restricting flow through said bypass passageway, a needle valve cooperable with said orifice member to throttle the flow through the orifice in said orifice member, said casing having a side wall opening positioned at the side of said valve member, a motion transmitting member connected to and for actuating said valve member and extending through said opening, means sealing said opening around said transmitting member, a housing mounted on said casing and surrounding the exterior end portion of said transmitting member, a fluid charged thermostatic actuator carried by said housing and having a bulb element responsive to temperature of the refrigerant medium adjacent the inlet to the evaporator, a rod connecting said actuator to said transmitting member to move said valve member toward closed position upon temperature increase of said bulb element, a fluid charged thermostatic actuator carried by said

housing in opposing relation to said first-named actuator and having a bulb element responsive to temperature of the refrigerant medium adjacent the outlet of the evaporator, a rod connecting said second-named actuator to said transmitting member to move said valve member toward open position upon temperature increase of said second-named bulb element, a superheat determining spring opposing opening of said valve member by said second-named actuator, and means closing the other open end of said casing and determining the maximum opening of said valve member in its operating range.

2. An expansion valve for controlling the flow of refrigerant medium to an evaporator to be operated at extremely low temperatures, said valve being controlled in accordance with the difference in the refrigerant medium temperatures adjacent the inlet and outlet of the evaporator and comprising a tubular valve casing having an inlet and an outlet, a valve seat member in said casing and having a valve port, a valve member reciprocal in said casing and cooperable with said seat member, said casing having a restricted passageway bypassing said port and leading from said inlet to said outlet, said casing having a side wall opening at the side of said valve member, an annular supporting member sealed to said casing concentric with said opening, a motion transmitting lever member extending through said supporting member and said opening and having one end engaging said valve member, means pivotally securing said lever member to said supporting member, a flexible closure member surrounding said lever member and sealed to said supporting member and to said lever member, a T-shaped housing member having its stem receiving the external end of said lever member, means clamping said stem to said casing around said opening, said external lever end having aligned sockets concentric with and facing the arms of said housing member, tubular supporting members aligned with each other and extending one from each of said arms, thermostatic actuators secured one to each of said arms and each having a pressure chamber with a movable wall facing one of said sockets, thrust rods extending between said movable walls and said sockets, bulb elements containing a minute quantity of volatile liquid and communicatively connected one to each of said pressure chambers, said liquid having a steep pressure-temperature curve relative to the pressure-temperature curve of the refrigerant medium in the low temperature operating range of the evaporator so as to exert a greater pressure per degree of temperature change than is exerted by the refrigerant medium, one of said bulb elements being adapted to respond to the refrigerant medium temperature adjacent the inlet to the evaporator and tending upon temperature increase to cause valve member closing movement and the other of said bulb elements being adapted to respond to the temperature of the refrigerant medium adjacent the outlet of the evaporator and tending upon temperature increase to cause valve member opening movement, and a spring resisting valve member opening movement by the actuator having said other bulb element thereby to determine the superheat setting of the valve.

3. An expansion valve for controlling the flow of refrigerant medium to an evaporator to be operated at extremely low temperatures, said valve being controlled in accordance with the difference in the refrigerant medium tempera-

tures adjacent the inlet and outlet of the evaporator and comprising a valve casing having an inlet and an outlet, a valve member in said casing and controlling flow therethrough, means for minimum flow through said casing when said valve member is closed, means responsive to temperature of the refrigerant medium adjacent the evaporator inlet for moving said valve member toward closed position upon temperature increase of the refrigerant medium, a gas-charged thermostatic actuator having a bulb element containing a minute volatile liquid charge having a steep pressure-temperature curve in the operating range of the evaporator, said thermostatic actuator being operatively connected to said valve member and acting upon temperature increase to move said valve member toward open position, a superheat determining spring opposing said thermostatic actuator, and a spring operable to stop in an open position the opening movement of said valve member in the operating range of the evaporator, said stop spring being overcome by said thermostatic actuator at temperatures above said operating range thereby to provide wider opening of said valve member.

4. A thermostatic expansion valve for controlling flow of refrigerant medium to an evaporator in accordance with the difference in the refrigerant medium temperatures adjacent the inlet and the outlet of the evaporator, comprising a valve casing having a passageway therethrough with a valve seat, a valve member having a lateral opening and being cooperable with said seat, said casing having a side wall aperture aligned with said lateral opening, a lever extending through said aperture and having one end positioned in said lateral opening, means holding said lever end against lateral play in said opening, a T-shaped housing having its stem end secured and sealed to said casing around said aperture, said lever extending into said housing and having oppositely directed sockets aligned with the arms of said housing, tubular supporting members in concentric relation and extending one from each arm of said housing, a fluid charged thermostatic actuator mounted on the free end of one of said supporting members and having a bulb element adapted to respond to refrigerant medium temperature adjacent the evaporator inlet, a rod seating in one of said sockets and connected to said actuator to urge said valve member positively toward closed position upon temperature increase of said bulb element, a fluid charged thermostatic actuator mounted on the free end of the other of said supporting members in opposition to said first-named actuator and having a bulb element adapted to respond to refrigerant medium temperature adjacent the evaporator outlet, a rod seating in the other of said sockets and connected to said second-named actuator to urge said valve member positively toward open position upon temperature increase of said second-named bulb element, and a spring surrounding and acting on said second-named rod in opposition to opening of said valve member by said second-named actuator thereby to establish the superheat setting of the valve.

5. The combination of a refrigerant evaporator and an expansion valve for controlling flow of refrigerant medium to the evaporator and the superheat of the refrigerant medium leaving the evaporator, said valve comprising a casing having a passageway therethrough with its outlet connected to the evaporator inlet, said passage-

way having a valve seat, a valve member cooperable with said seat, a lever operable to move said valve member toward and from said seat and extending out of said casing, a supporting structure surrounding the external end of said lever, a pair of fluid charged thermostatic actuators carried by said structure on opposite sides of said lever end and in opposing relation to each other, a first thrust rod connecting one of said actuators to said lever end, a second thrust rod aligned with said first rod and connecting the other actuator to said lever end, said one actuator having a bulb element responsive to the temperature of the refrigerant medium adjacent the inlet to the evaporator and acting on temperature decrease to permit said other actuator to move said valve member toward open position, said other actuator having a bulb element responsive to the temperature of the refrigerant medium adjacent the outlet of the evaporator, said actuators being so constructed and charged as to exert equal and opposite forces on said lever end for equal temperatures of said bulb elements, a superheat determining spring surrounding and acting through said second rod to oppose opening movement of said valve member by said other actuator, said casing having a bypass passageway around said seat for flow of refrigerant medium to cool said first-named bulb element so that said other actuator can open said valve member, and stop means including a spring and engageable by and limiting the opening movement of said valve member, said stop means spring having a resistance which is overcome by said other actuator during the starting period of evaporator operation so that said valve member can have opening movement beyond the limit of said stop means.

6. In a refrigerating system, the combination with a compressor, a condenser and an evaporator communicatively connected in circuit, of a thermostatic expansion valve comprising a valve casing having a passageway therethrough containing a valve seat, said passageway having its inlet connected to said condenser and having its outlet connected to the inlet of said evaporator, a valve member cooperable with said seat to throttle flow of refrigerant medium from said condenser to said evaporator, a lever operable to move said valve member, a fluid charged thermostatic actuator facing said lever and having a bulb element responsive to temperature of the refrigerant medium adjacent the inlet to the evaporator, a rod connecting said actuator to said lever such that temperature increase of said bulb element will tend to close said valve member, a

fluid charged thermostatic actuator facing said lever and said first-named actuator and having a bulb element responsive to temperature of the refrigerant medium adjacent the outlet of the evaporator, a rod aligned with said first-named rod and connecting said second-named actuator to said lever such that temperature increase of said second-named bulb element will tend to open said valve member, a superheat determining spring acting on and through said second-named rod in opposition to opening of said valve member by said second-named actuator, and means to bleed refrigerant medium from said passageway inlet to said passageway outlet to cool said first-named bulb element so that said second-named actuator can overcome said spring and open said valve member.

7. A thermostatic expansion valve for controlling flow of refrigerant medium to an evaporator, comprising a valve casing having a passageway therethrough with a valve seat, a valve member having a lateral opening and being cooperable with said seat, said casing having a side wall aperture aligned with said lateral opening, a lever extending through said aperture and having one end positioned in said lateral opening, means holding said lever end against lateral play in said opening, a T-shaped housing having its stem end secured and sealed to said casing around said aperture, said lever extending into said housing and having oppositely directed sockets aligned with the arms of said housing, tubular supporting members in concentric relation and extending one from each arm of said housing, a fluid pressure responsive actuator mounted on the free end of one of said supporting members, a rod seating in one of said sockets and connected to said actuator to urge said valve member positively toward closed position upon pressure increase, a fluid charged thermostatic actuator mounted on the free end of the other of said supporting members in opposition to said first-named actuator and having a bulb element adapted to respond to refrigerant medium temperature adjacent the evaporator outlet, a rod seating in the other of said sockets and connected to said second-named actuator to urge said valve member positively toward open position upon temperature increase of said bulb element, and a spring surrounding and acting on said second-named rod in opposition to opening of said valve member by said second-named actuator thereby to establish the superheat setting of the valve.

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