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2,260,682

AUTOMATIC EXPANSION VALVE

Filed Nov. 24, 1939

2 Sheets-Sheet 1

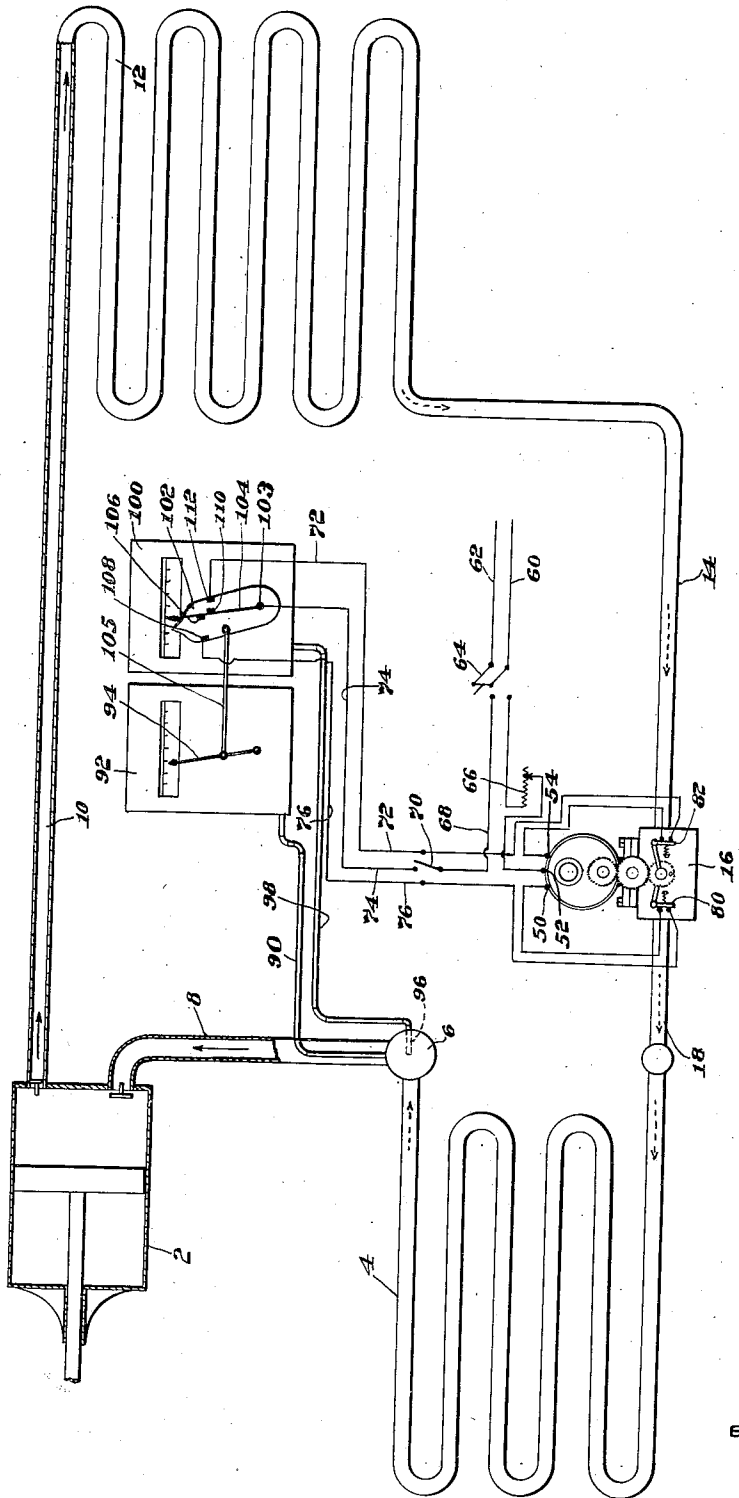


Fig. 1

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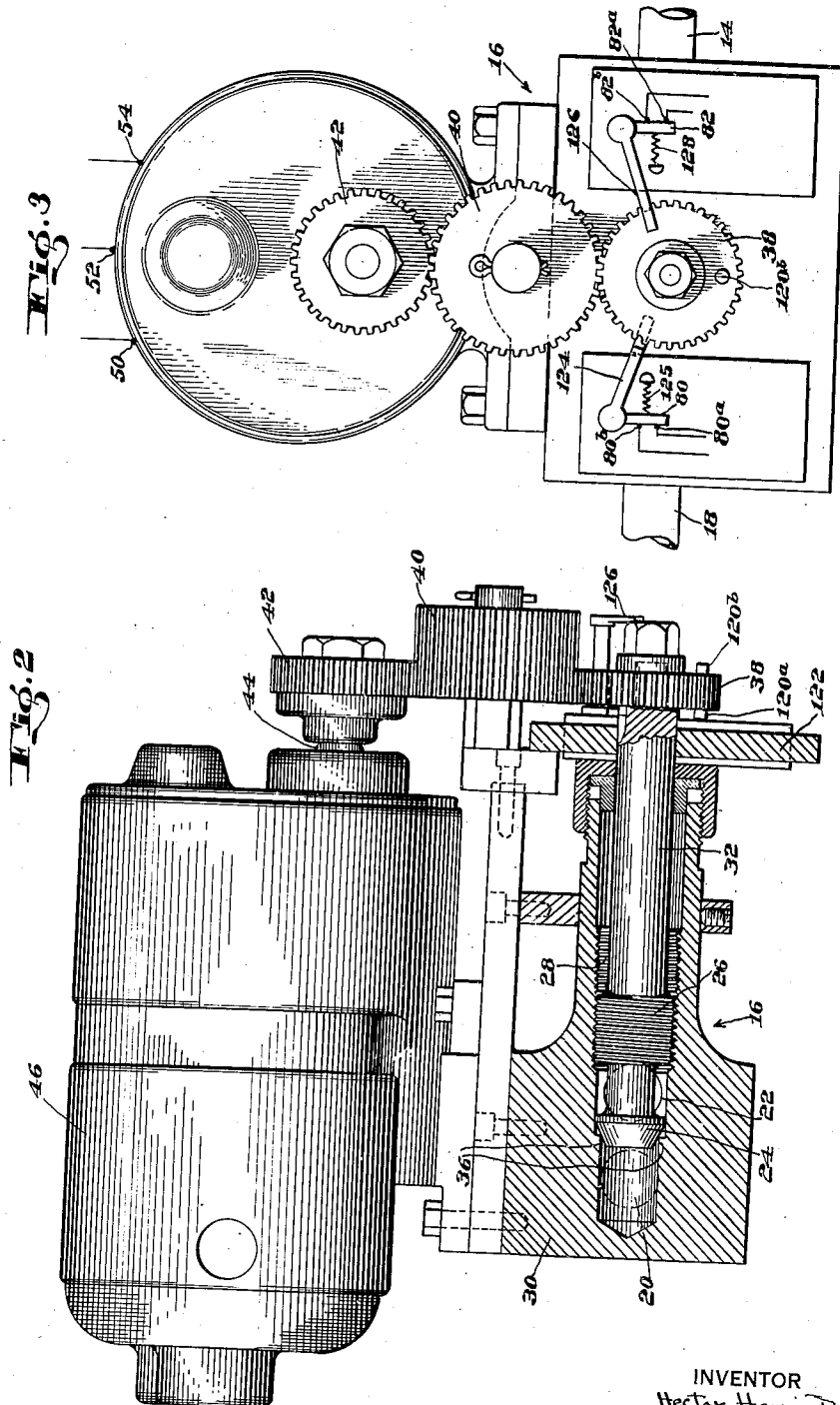
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

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AUTOMATIC EXPANSION VALVE

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10 Claims. (Cl. 62—8)

This invention relates to expansion valves for use in refrigerating systems and its object is to provide an improved automatic control for the valve which insures admission to the evaporator of precisely the right amount of refrigerant for optimum refrigeration under varying conditions of temperature and pressure within the evaporator. Thus, it is well known that in most systems maximum efficiency is attained by maintaining a slight amount of superheat at or adjacent the evaporator outlet or the compressor inlet and by my invention I am able so to regulate automatically the size of the valve opening as to admit that amount of refrigerant which will maintain such superheat to within a fraction of a degree F., for any normal range of pressure and temperature fluctuations within the evaporator or for any change in the capacity of the system. My system furthermore achieves that precision of regulation even with refrigerants such as carbon dioxide which have comparatively low critical temperatures and therefore which may be presented to the expansion valve in the form of a gas or a liquid or a mixture of both depending upon varying working conditions within the condenser.

In the drawings:

Fig. 1 is a diagrammatic view of apparatus embodying my invention;

Fig. 2 is a side elevation view, partly in section, and Fig. 3 is an end elevation view, of a motorized valve which I preferably employ.

In Fig. 1 the numeral 2 represents a compressor of usual construction for withdrawing refrigerant from the evaporator coil 4, through suction header 6 and pipe 8 and for forcing compressed refrigerant through pipe 10 to a condenser coil 12, whose turns are suitably cooled by an external medium. From the condenser 12 the condensed refrigerant passes through pipe 14 to an expansion valve 16 where the fluid is expanded as it passes through outlet 18 and thence to the evaporator coil 4. Except as hereinafter indicated, all of the above described apparatus is of conventional construction and operation.

The expansion valve 16 is shown enlarged in Figs. 2 and 3. It includes an inlet port 20 and an outlet port 22 to which the pipes 14 and 18 respectively are connected. Communication between the two ports is regulated by valve 24 having a stem 32 screw threaded at 26 to mate with a corresponding screw thread 28 in the frame 30, so that rotation of the valve stem 32 in one or the other direction moves valve 24 toward or away from its seat 36. I have shown the seat

sharp edged as is preferred for precision in regulation of the amount of refrigerant passed from the condenser into the evaporator. To open and close the valve, its stem carries fixed to it a pinion 38 meshing with gear 40 which, in turn, meshes with pinion 42 on a countershaft 44 of motor 46. Speed reduction gears, not shown, within the motor casing connect the armature shaft of the motor with the shaft 44 so that when the motor is connected to a suitable source of power, shaft 44 rotates very slowly, such as at two revolutions per hour. With shaft 44 rotating that slowly there need be no substantial reduction in gears 42, 40 and 38. The pitch of threads 26 and 28 is low and as a result of the slow rotation of the stem, the valve moves very slowly toward its open or closed positions when motor 46 is operated.

The motor 46 is reversible and in the embodiment shown I employ a direct current circuit leading to the three binding posts 50, 52 and 54. With one direct current lead closed to the post 52, the motor will rotate in a direction to close the valve if the other direct current lead is closed to post 50 and will be rotated in a direction to open the valve if that other lead is closed to post 54.

The direct current power source is indicated by leads 60 and 62 (Fig. 1). When switch 64 is closed lead 60 is connected through variable resistance 66 (adapted to regulate the speed of the motor in an obvious manner) to the central binding post 52. Lead 62 is connected through line 68 to contact lever 70 adapted to close circuit selectively to lines 72, 74 and 76. The switches 80 and 82 are limit switches to be described that are normally closed and, accordingly, when switch 70 completes circuit to line 72 the valve will open very slowly. When switch 70 is closed to line 76 the valve will rotate very slowly toward its closed position. When switch 70 contacts neither line 72 nor 76, but closes circuit to line 74, the opening and closing of the valve is automatically effected in the following manner, responsive to fluctuations in relative conditions of pressure and temperature within the suction header 6.

90 indicates a small tube communicating at one end with the suction header 6 and its other end with a pressure responsive instrument 92 having an element 94 which moves to the right as viewed in Fig. 1 when the pressure in the header 6 increases and to the left when it decreases. Within the suction header 6 is a temperature responsive instrument such as a ther-

meter 96, connected by tube 98 with a temperature responsive instrument 100 having an element 104 pivoted at 103 and moved to the right when the temperature in the header 6 rises and to the left when it falls. Also mounted on pivot 103 of the temperature responsive instrument 100 is a lever 102 connected by link 105 to element 94. Lever 102 is freely mounted on the pivot 103 and by the link connection 105 is moved to the right or left upon a corresponding movement of the pressure indicating element 94 when the pressure in the header increases or decreases respectively.

Element 104 carries contact 106 adapted to close an electric circuit with contact 108 carried by the lever 102 when the relative positions of elements 94 and 104 are such that the contacts abut each other. Element 104 also carries contact 110 adapted to close circuit with contact 112 fixed to lever 102 when the relative positions of the elements make those contacts abut each other. Element 104 is connected to the line 74.

Element 104 and lever 102 are electrically insulated from each other. The line 76 is connected to terminal 108 and line 72 is connected to terminal 112.

With the device constructed as above described, it will be apparent that if switch 70 is closed to line 74, thereby energizing temperature indicating element 104, a relative movement either of pressure indicating element 94 or temperature indicating element 104 such that contact is made from 110 to contact 112, circuit will be completed through line 72 to terminal 54 of motor 46, thus rotating the valve stem in a direction to open the valve. On the other hand, if the relative positions of pressure indicating element 94 and temperature indicating element 104 are such that contact is made from 106 to 108, circuit will be completed to terminal 50 of motor 46 moving the valve toward closed position. The limit switches 80 and 82 are provided to insure automatically against such continued actuation of motor 46 as would force the valve 24 beyond its extreme open or closed positions. As will be seen from Fig. 2, the pinion 38 not only rotates in either direction but moves to the right or to the left as the valve is opened or closed and the gear 40 is elongated to accommodate such movement. The pinion 38 carries a pin having a portion 120a projecting rearwardly and a portion 120b projecting in front of the pinion. The gear rotates clockwise to close the valve during which the pinion advances toward the frame member 122. Projecting into the path of pin portion 120a as the valve nears its closed position is the rotatably mounted lever 124, to which is secured switch arm 80 spring pressed at 125 against the terminals 80a and 80b. Thus, the circuit is automatically opened in the lead to binding post 50 before the valve is injured. Similarly, the pin portion 120b engages the lever 126 spring pressed at 128 against terminals 82a and 82b to open circuit to the binding post 54 as the valve arrives at its extreme open position. Limit switches of this character are well known and need not be further described.

By suitably constructing lever 102 and spacing its contacts from the corresponding contacts on temperature indicating element 104 I can effect automatic movement of the valve toward its open or closed position upon substantially any desired predetermined relative conditions of temperature and pressure at whatever point the pressure and temperature are taken, in this in-

stance at the outlet header 6. In practice, I have found that maximum efficiency of the system is attained by maintaining the refrigerant which reaches the suction header 6 at between 1° F. and 2° F. superheat since thereby I insure maximum refrigerating effect within the evaporator, optimum conditions of heat interchange between evaporator 4 and the medium to be cooled which surrounds it and maximum efficiency of the compressor. To obtain this 1° F. limit variation of control I so space the contacts 108 and 112 from their corresponding contacts 106 and 110 that a relative movement equivalent to 1° F. between element 104 and lever 102 commencing with either circuit being made will cause that circuit to be broken and the other to be made. I then adjust the position of lever 102 with reference to temperature indicating element 104 so that that 1° F. variation conforms to the range between 1° F. and 2° F. superheat for whatever pressure is registered by the element 94. Specifically, if carbon dioxide is employed as the refrigerant and a temperature of 33° F. is assumed to be the saturation temperature for a pressure of 500 lbs. per square inch, I so position the parts in an obvious manner that relative to a pressure reading of that value on meter 92 contact is made across terminals 106 and 108 to operate the valve toward its closed position when a temperature of 34° F. is reached, and contact is made between points 110 and 112 to operate the valve toward its open position when a temperature of 35° F. is reached. Obviously, this same relationship will be maintained for the corresponding superheat temperatures when the pressure varies from 500 lbs. per square inch.

It will be observed that after a change has been made in the position of valve 16, the effect of that change on the refrigerant in the coil is not felt by the temperature and pressure responsive apparatus until the refrigerant reaches the suction header 6. It is partly to guard against the possibility of over regulation under those conditions that I provide for extremely slow movement of the valve by the motor 46 and in practice I have found that over regulation is entirely obviated thereby.

It will thus be apparent that the apparatus above described so automatically effects opening and closing of the valve 16 that the size of valve opening is varied to meet precisely the load demand on the evaporator for all changes in pressure and temperature within it. My system insures maintenance of that size valve opening which will produce a predetermined superheat under any changes in capacity of the system, whether resulting from differences in refrigerating load imposed by the medium to be cooled which surrounds the evaporator or from changes in the speed of the compressor. Unlike prior automatic expansion valves which are operated by the pressure difference between a thermostatic pressure on one side of a movable diaphragm and an actual pressure on the other side, my apparatus insures the necessary variations in size of the valve opening for the same amount of superheat at different pressures and temperatures within the evaporator and thus is particularly effective to maintain maximum efficiency when the capacity of the system is in any way varied. Furthermore, my system effects this sensitivity of control even with gases, which like carbon dioxide have low critical temperatures and thereby may in commercial operation

be presented to the expansion valve either as a liquid or as a gas, or as a mixture of both.

My invention is not to be limited to any of the details above described except as required by the appended claims, since various modifications to suit the needs of individual users can be made in an apparent manner without departing from the principle of my invention. Thus, although my invention fills a need which has not heretofore been supplied for automatic expansion valve regulation for use with carbon dioxide refrigerant, its use is, of course, not limited thereto. Nor are the specific temperatures above recited in any way essential as others may be required under different conditions of operation. Although the temperature and pressure connections are preferably located within the suction header, this is not essential as they can be located elsewhere. I prefer, however, to dispose both connections in the same part of the system. The direct current motor described as my preferred source of power for moving the valve may, of course, be replaced by any motivator whether electric, pneumatic, hydraulic or mechanical, as is desired. It is contemplated that the contacts 108 and 112 be adjustably mounted on the lever 102 so that the spacing between them, representing the latitude of relative positions of lever 102 and member 104 throughout which neither circuit is closed to the valve motor, may be varied at will and that the length of connecting link 105 may be made adjustable. All such adjustable constructions are within the scope of my invention, although it is obviously unnecessary to illustrate them in detail in the drawings.

I claim:

1. A refrigerating system adapted to operate at a substantially constant superheat throughout a range of temperatures in the system, comprising a compressor, condenser and evaporator connected in circuit, an expansion valve admitting refrigerant to the evaporator, and means for operating the valve to maintain said superheat, said means comprising an element moved by changes in pressure in the system, a second element moved by changes in temperature in the system and independently of the movement of the first element, and means responsive to a predetermined relative positioning of said elements to move the valve toward its open position and responsive to a second predetermined relative positioning of said elements to move the valve toward its closed position.

2. A refrigerating system adapted to operate at a substantially constant superheat throughout a range of temperatures in the system, comprising a compressor, condenser and evaporator connected in circuit, an expansion valve admitting refrigerant to the evaporator, and means for operating the valve to maintain said superheat, said means comprising an element moved by changes in pressure in the system, a second element moved by changes in temperature in the system and independently of the movement of the first element, means responsive to a predetermined relative positioning of said elements to move the valve toward its open position and means responsive to a second predetermined relative positioning of said elements to move the valve toward its closed position, the said elements having a third predetermined relative positioning intermediate said first and second relative positionings, corresponding to the desired superheat, at which the valve remains stationary.

3. A refrigerating system comprising a compressor, condenser and evaporator connected in circuit, an expansion valve admitting refrigerant to the evaporator, and means for operating the valve to maintain in the system a predetermined range of superheat, said means comprising an element moved by changes in pressure in the system, a second element moved by changes in temperature in the system and independently of the movement of the first element, means responsive to a predetermined relative positioning of said elements to move the valve toward its open position and means responsive to a second predetermined relative positioning of said elements to move the valve toward its closed position, the said elements having a predetermined range of relative positionings intermediate said first and second relative positionings, corresponding to a range of superheat, at which the size of the aperture remains unchanged, and means for changing said range of relative positionings to vary the range of superheat.

4. A refrigerating system adapted to operate at a substantially constant superheat throughout a range of temperatures in the system, comprising a compressor, condenser and evaporator connected in circuit, an expansion valve admitting refrigerant to the evaporator, and means for operating the valve to maintain said superheat, said means comprising an element moved by changes in pressure in the system, a second element moved by changes in temperature in the system and independently of the movement of the first element, one of said elements having two members movable with the rest of the element as a unit and disposed in spaced relation relative to each other, the other of said elements constituting a single member movable through the space separating said spaced members and adapted to engage said members at opposite limits of its said movement, means for moving the valve toward its open position when said single member engages one of said spaced members and means for moving the valve toward its closed position when said single member engages the other of said spaced members, said valve remaining stationary when said single member is not in engagement with either of said spaced members.

5. A refrigerating system adapted to operate at a substantially constant superheat throughout a range of temperatures in the system, comprising a compressor, condenser and evaporator connected in circuit, an expansion valve having an aperture through which refrigerant is admitted to the evaporator, and means for operating the valve to maintain said superheat, said means comprising an element moved by changes in pressure at a predetermined point in the system, a second element moved by changes in temperature at substantially the same predetermined point in the system and independently of the movement of the first element, power operated means for varying the size of said aperture by moving the valve selectively toward its open or closed positions, means responsive to one predetermined relative positioning of said elements to actuate the power operated means for moving the valve toward its open position and means responsive to a second predetermined relative positioning of said elements to actuate the power operated means for moving the valve toward its closed position, the said power operated means being adapted, when actuated, to move the valve so slowly that the effect of a slight change in

aperture size is felt at said predetermined point before any substantial change in aperture size is made.

6. A refrigerating system adapted to operate at a substantially constant superheat throughout a range of temperatures in the system, comprising a compressor, condenser and evaporator connected in circuit, an expansion valve admitting refrigerant to the evaporator, and means for operating the valve to maintain said superheat, said means comprising an element moved through predetermined distance increments in response to predetermined changes in temperature at a given location within the system, a second element moved through the same increments in response to the same predetermined changes in saturation temperature corresponding to changes in pressure at said location and independently of the movement of said first element, means responsive to a predetermined relative positioning of said elements to move the valve toward closed position to prevent decrease below said superheat, and means responsive to a second predetermined relative positioning of said elements to move the valve toward open position to prevent increase above said superheat.

7. In a superheat control for an expansion valve, the combination of means for power operating said valve, independently movable pressure and temperature responsive elements controlling said valve operating means, means for subjecting the said elements respectively to pressure and temperature conditions prevailing at substantially the same point in a system to cause said operating means to move the valve toward open position at the upper limit of a predetermined range of superheat and toward closed position at the lower limit of said range.

8. In a superheat control for an expansion valve, the combination of an electric motor driving the valve and having one circuit for moving the valve toward open position and a second circuit for moving the valve toward closed position, a switch in said valve opening circuit, a switch in said valve closing circuit, independent-

ly movable pressure and temperature responsive elements controlling said switches, means for subjecting the said elements respectively to pressure and temperature conditions prevailing at substantially the same point in a system to close said switch in said valve opening circuit at the upper limit of a predetermined range of superheat and to close said switch in said valve closing circuit at the lower limit of said range.

9. In a superheat control for an expansion valve, the combination of an element adapted to be moved through predetermined space increments in accordance with predetermined changes in temperature within a system, a second element adapted to be moved through the same predetermined space increments by the same predetermined changes in saturation temperature corresponding to changes in pressure within the system, means for moving the valve toward open position when said elements are disposed in a predetermined relative position, and means for moving the valve toward closed position when said elements are disposed in a second predetermined relative position.

10. In a superheat control for an expansion valve, the combination which includes a pair of members engageable to move the valve toward open position at the upper limit of a superheat range, a pair of members engageable to move the valve toward closed position at the lower limit of said range and apparatus for maintaining said range fixed for different pressures and temperatures at a predetermined location within a system comprising means for moving one member of each pair through predetermined distance increments in response to predetermined changes in temperature at said location and means for moving the other member of each pair through the same increments in response to the same changes in saturation temperature corresponding to changes in pressure at said location and independently of the movement of the first mentioned member in each pair.

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