

[54] **THERMAL EXPANSION VALVE
REFRIGERATION SYSTEMS**

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[51] **Int. Cl.**..... **F25b 41/04**

[58] **Field of Search** 62/202, 222, 223, 224,
62/225, 211, 236

[56] **References Cited**
UNITED STATES PATENTS

3,205,675	9/1965	Matthies	62/225
3,405,535	10/1968	Matthies	62/225
3,464,227	9/1969	Matthies	62/225

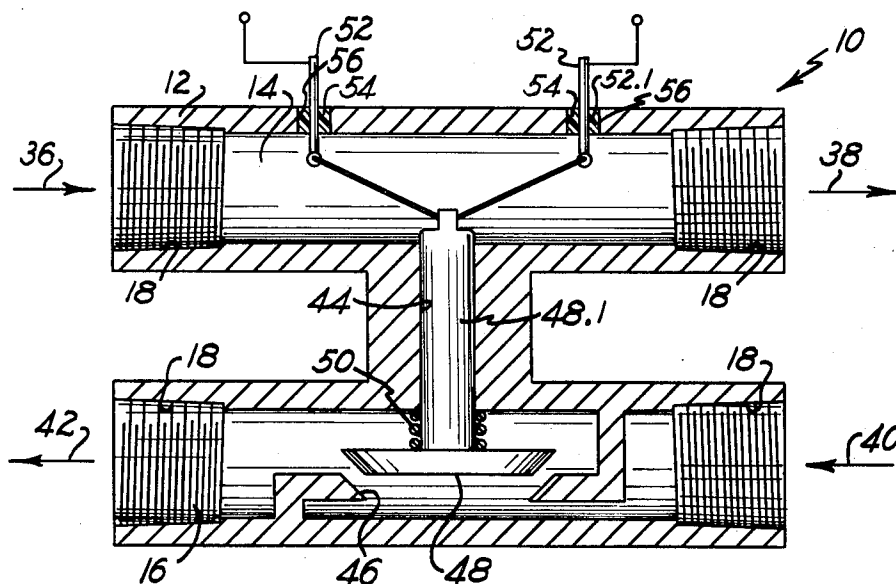
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[57] **ABSTRACT**

This disclosure relates to a compact, reliable and inexpensive expansion valve for use in a refrigeration sys-

tem. The valve has one passage to be arranged between the evaporator and the compressor of the refrigeration system and has a second passage to be arranged between the condenser and evaporator in the system. A valve member disposed in the second passage is spring biased to normally close that passage and a wire of a selected nickel-titanium alloy or the like is connected to the valve member and disposed in the first valve passage, this wire being adapted to abruptly contract in length for moving the valve member to open the second valve passage when the wire is heated above a selected transition temperature. A small electrical current is directed through the wire so that, when sufficient refrigerant has been released into the evaporator through the second valve passage, droplets of liquid refrigerant in the atmosphere moving from the evaporator to the compressor of the refrigeration system through the first valve passage cool the alloy wire and permit the noted spring bias to move the valve member to close the second valve passage. However, when no liquid droplets of refrigerant are present in the noted atmosphere, the alloy wire is heated to the noted temperature by the electrical current flowing through the wire, the wire then contracting in length for opening the second valve passage to allow more liquid refrigerant to enter the evaporator.

7 Claims, 4 Drawing Figures



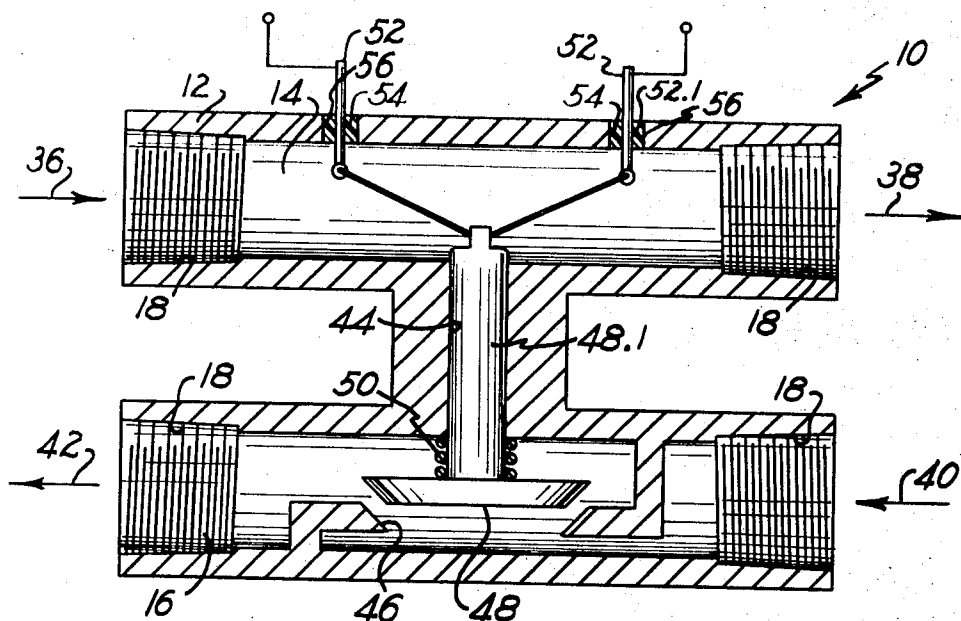


Fig. 1.

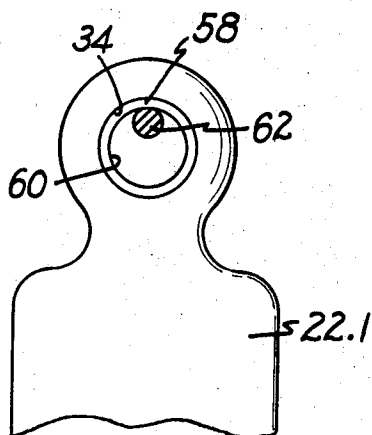


Fig. 2.

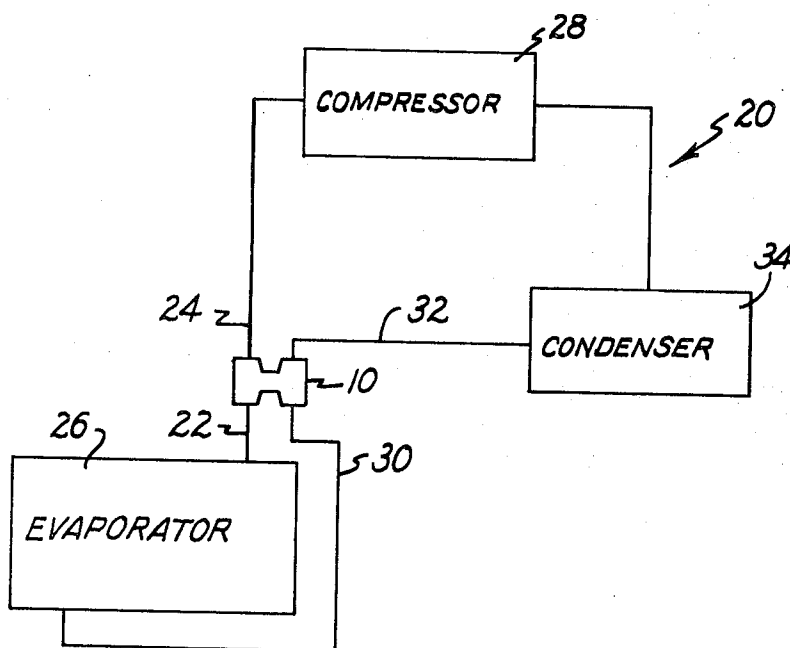


Fig. 3.

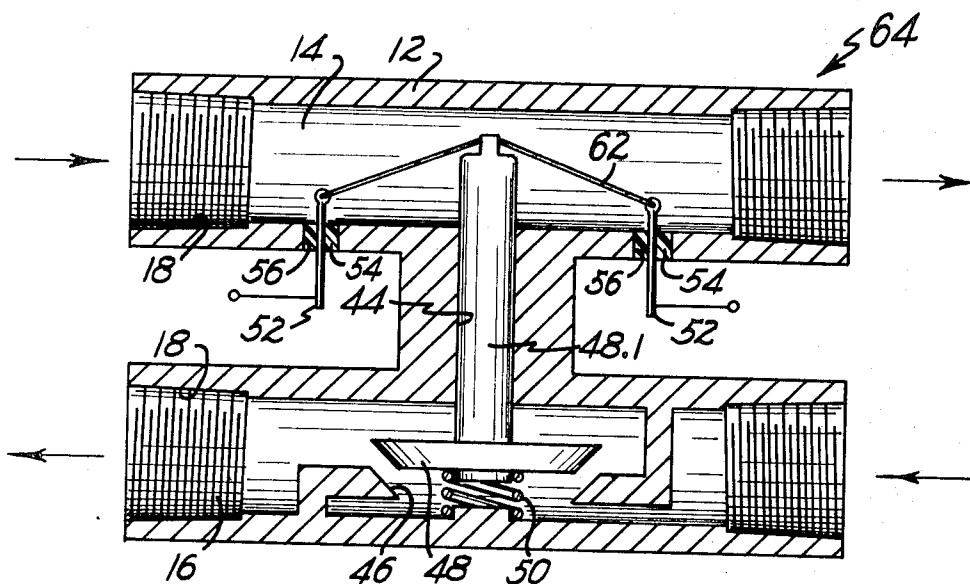


Fig. 4.

THERMAL EXPANSION VALVE REFRIGERATION SYSTEMS

Expansion valves for refrigeration systems previously known in the art have tended to be relatively expensive to fabricate and install. Frequently, such expansion valves have required the use of elaborate arrangements of capillary tubes or the like between the expansion valve and sensors regulating operation of the valve.

In accordance with the present invention, the above-noted problems of prior art expansion valves are substantially reduced and the expansion valve provided by the invention is relatively inexpensive to fabricate and install and does not require a separate set of wires or the like extending between the expansion valve and a sensor regulating the valve. Briefly, these desirable results are accomplished by providing an expansion valve having a first passage which is connected in a refrigeration system between the evaporator and the compressor of the system. The valve also has a second passage which is connected in the system between the condenser and evaporator of the system. The valve member is normally biased to close the second valve passage and a wire of a selected nickel-titanium alloy is disposed in the first valve passage and is connected to the valve member. The wire is arranged to be electrically heated by directing electrical current through the wire, the wire being adapted to abruptly contract in length when the wire is heated above a selected transition temperature. In this arrangement, the atmosphere passing from the evaporator to the compressor of the refrigeration system passes through the first valve passage around the noted alloy wire. Accordingly, if there is sufficient refrigerant in the evaporator so that liquid droplets of the refrigerant impinge upon the wire in the first valve passage, these droplets cool the wire and permit the spring bias on the movable valve member to close the second valve passage, thereby to cut-off the supply of liquid refrigerant to the evaporator through the second valve passage. However, when liquid droplets no longer impinge on the alloy wire as the atmosphere moves through the first valve passage, thereby indicating that additional liquid refrigerant should be supplied to the evaporator, the wire becomes heated to its transition temperature and abruptly contracts in length to open the second valve passage and to supply additional liquid refrigerant to the evaporator through the second valve passage.

It is therefore an object of this invention to provide a thermal expansion valve for refrigeration systems which is less expensive to fabricate and install than similar expansion valves previously used in refrigeration systems.

It is a further object of this invention to provide a thermal expansion valve for refrigeration systems using a nickel-titanium alloy wire as sensor and as an actuator.

It is a yet further object of this invention to provide a thermal expansion valve for refrigeration systems which requires no wiring or capillary tubing between valve and valve sensing means.

The above objects and still further objects of the invention will immediately become apparent to those skilled in the art after consideration of the following preferred embodiment thereof, which is provided by way of example and not by way of limitation wherein:

FIG. 1 is a sectional view along a principal axis of a thermal expansion valve in accordance with the present invention;

FIG. 2 is a partial side elevation view to enlarged scale of the valve stem;

FIG. 3 is a schematic diagram of a refrigeration system utilizing the thermal expansion valve in accordance with the present invention; and

FIG. 4 is a sectional view similar to FIG. 1 illustrating an alternate embodiment of this invention.

Referring now to FIG. 1 of the drawings, the novel and improved refrigeration expansion valve 10 of this invention is shown to include a valve housing 12 having a first passage 14 and a second passage 16, each end of each of these passages preferably having a pipe thread 18 or other suitable means for use in connecting these passages to appropriate tubing in a refrigeration system. That is, as is illustrated in FIG. 3, the valve 10 is adapted to be positioned in a refrigeration system indicated at 20 with the valve passage 14 connected by appropriate tubing 22 and 24 between a conventional evaporator 26 and compressor 28 in the system and with the valve passage 16 connected by appropriate tubing 30 and 32 between a conventional condenser 34 and the evaporator 26 in the system. In this arrangement, as indicated in FIG. 1, the passage 14 is adapted to receive refrigerant gas from the evaporator in the direction indicated by arrow 36 and to transmit such gas to the compressor as indicated by arrow 38. The valve passage 16 is adapted to receive liquid refrigerant from the condenser as indicated by arrow 40 in FIG. 1 and to release such refrigerant to the evaporator when the valve 10 is in open position as indicated by the arrow 42.

In accordance with this invention, the valve passages 14 and 16 are connected by a bore 44 and a valve seat 46 is disposed in a plane normal to the axis of the bore. A valve member 48 is then disposed with its stem 48.1 slidable in the bore 44 and biased by a conventional coil spring 50 to a normally closed position engaging the valve seat as will be understood.

In the valve 10 of this invention, a pair of input terminals 52 are secured in insulating bushings 54 of a phenolic resin or the like which are then mounted in apertures 56 in the valve housing 12 so that the apertures 56 are sealed by the bushings and so that the terminals 52 are in electrically insulated relation to each other and to the valve housing. If desired, the terminals 52 are threadedly secured in the bushings 54 as indicated at 52.1 for permitting adjustment of the terminal position in the bushings by rotation of the terminals. A bushing 58 of similar electrical insulating material is then disposed in an aperture 60 in the valve stem 48.1 as best shown in FIG. 2.

In accordance with this invention, a thermally-responsive metal actuator wire is arranged with its opposite ends secured to respective terminals 52 and with the wire extending through the bushing 58 in the valve stem 48.1 in electrically insulated relation to the valve stem. In the valve of this invention, the thermally-responsive wire 62 is formed of a nickel-titanium alloy, commonly called Nitinol, the alloy preferably having a composition by weight of from about 54 to 56 percent nickel and the balance titanium. As is known, this material is characterized in that, as the material is heated through a short transition temperature range, the material undergoes a crystalline transformation and displays

a very sharp or abrupt change in physical properties including a very substantial increase in modulus of elasticity, these changes being reversible as the material is again cooled below its transition temperature range. When properly conditioned in well known manner, the material is also adapted to display remarkable shape memory properties as the material is heated through its transition temperature range. For example, when the alloy material of the wire 62 is deformed while below its transition temperature by drawing the wire to increase the wire length up to about 8 percent, the wire is adapted to subsequently display remarkable shape memory and to sharply or abruptly shorten in length when the wire is thereafter heated above its transition temperature. After subsequent cooling of the wire below its transition temperature, the wire is again easily deformed by drawing or stretching to again prepare the wire for displaying its shape memory. Typically, for example, the wire 62 is formed of a nickel-titanium alloy comprising about 55 percent nickel, by weight, and the balance titanium, this alloy having a transition temperature at about 60°C. and having other physical properties as follows:

Ultimate tensile strength	125,000 psi
Density	6.5 g./cc.
Heat capacity	0.077 cal./degree C./g.
Resistivity	80×10^{-6} ohm-centimeters
Young's Modulus (below transition temperature)	3×10^{-4} psi
Young's Modulus (above transition temperature)	12×10^{-4} psi

In this arrangement of the valve 16, the coil spring 50 is selected so that, when the material of the wire 62 is below its transition temperature, the spring applies sufficient force to the wire to deform the wire to increase the wire length, preferably by at least about 4 percent, and to normally bias the valve member 48 to engage the valve seat 46 to close the second valve passage 16. However, electrical current is adapted to be directed through the wire 62 between the input terminals 52 for electrically self-heating the material of the wire 62 above its transition temperature so that the wire is sharply shortened in length and sharply increased in modulus of elasticity for moving the valve member 48 against the bias of the compression spring 50 to the open valve position as shown in FIG. 1. As will be understood, when the material of the wire 62 is thereafter permitted to cool below its transition temperature, whereby the modulus of elasticity of the wire material is returned to its initial relatively low level, the compression spring 50 again deforms the wire 62 to increase the wire length and to return the valve member 48 to closed valve position.

In accordance with this invention, the input terminals 52 of the valve are connected to a power source indicated in FIG. 1 by the terminals 64 so that current is directed through the wire 62 to generate heat at a selected rate in the wire for regulating the valve 10 to control the release of liquid refrigerant from the condenser 34 into the evaporator 26. That is, where substantially all of the refrigerant leaving the evaporator is in vapor form indicating that, as refrigerant is passed from the evaporator to the compressor 28 through the valve passage 14, additional refrigerant could be supplied to the evaporator from the condenser 34, the vapor passing over the wire 62 in the valve passage 14 has little cooling effect on the wire. Accordingly, the

wire is heated above its transition temperature so that the wire is shortened in length to hold the valve 10 open and so that additional liquid refrigerant is passed through the valve passage 16 and is permitted to vaporize in the evaporator 26 to replace the refrigerant gas being passed from the evaporator to the cooling section 25 and toward the compressor. However, if the liquid refrigerant being released through the valve 10 into the evaporator results in an excess of refrigerant in the evaporator, the evaporator atmosphere becomes super-saturated and all of the refrigerant being released into the evaporator is not converted to a vapor. As a result, liquid droplets from the super-saturated refrigerant impinge on the wire 62, which droplets tend to cool the wire 62 as the droplets are vaporized by heat transfer from the wire. Accordingly, the wire 62 is cooled below its transition temperature allowing the wire to be lengthened by the bias of the spring 50 and to allow this bias to move the valve member 48 to close the valve passage 16. This closing of the valve, of course, cuts off supply of further liquid refrigerant to the evaporator.

In this way, the wire 62 serves as an economical sensor and actuator for regulating the valve 10 so that only the terminals 52 need be connected to a power source outside the valve. Further, the bore 44 in the valve extends between portions of the valve passages 14 and 16 which are both subjected to the pressure in the evaporator so that no sealing of the bore around the valve stem 48.1 is required.

Another alternate embodiment of this invention is illustrated at 64 in FIG. 4 wherein components corresponding to those incorporated in the valve 10 are identified with similar numerals. As illustrated in FIG. 4, in this embodiment 64 of this invention, the wire 62 is adapted to move the valve member 48 to its closed circuit position when the wire is contracted in length and the spring 50 is adapted to move the valve to open position when the wire 62 is lengthened. As will be understood, this embodiment of the valve of this invention can be utilized for opening and closing the valve 64 in response to flow of other fluids through the valve passage 14 in other applications.

It should be understood that although particular embodiments of this invention have been described by way of illustrating the invention, this invention includes all modifications and equivalents of the disclosed embodiments falling within the scope of the appended claims.

I claim:

1. A refrigeration expansion valve system comprising valve body means defining a first passage to be arranged between an evaporator and a compressor in a refrigeration system, defining a second passage to be arranged between a condenser and said evaporator in said refrigeration system, and having a bore extending between said passages, valve seat means in said second passage, a valve member slidable in said bore between a position engaging said valve seat means for closing said second passage and a position spaced from said valve seat means for opening said second passage, spring means biasing said valve member to one of said positions, a pair of terminals extending in electrically insulated relation to each other into said first passage through said valve body means, and a wire electrically connected between said terminals within said first passage and secured to said valve member to be exposed to the cooling effect of the flow of gaseous and liquid

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refrigerant in said first passage, said wire being of a selected metal alloy to be deformed from an original length to a second length by said spring bias as said valve member is moved to said one position by said spring bias while said alloy displays a relatively low modulus of elasticity below a transition temperature and to abruptly return to said original length and to display a relatively higher modulus of elasticity to move said valve member to the other of said positions against said spring bias when said wire is heated to said transition temperature and means directing electrical current through said wire between said terminals for heating said wire to said transition temperature while substantially gaseous refrigerant flows in said first passage and for permitting said wire to cool below said transition temperature in response to the flow of selected liquid refrigerant in said first passage.

2. A valve as set forth in claim 1 wherein said wire is formed of a selected nickel-titanium alloy.

3. A valve as set forth in claim 1 wherein said valve body means define said passages in parallel relation to each other having said bore extending between said

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passages in a direction normal to the axis of said passages and having said valve seat means disposed in a plane normal to the axis of said bore.

4. A valve as set forth in claim 1 wherein said spring means bias said valve member to said position closing said second valve passage.

5. A valve as set forth in claim 1 wherein said spring means bias said valve member to said position opening said second valve passage.

6. A valve as set forth in claim 1 wherein said valve body means is formed of metal and has a pair of apertures extending into said first passage, wherein said terminals extend into said first passage through said respective apertures, and wherein insulating bushing means secure said terminals within said apertures in sealing relation thereto and in electrically insulated relation to each other.

7. A valve as set forth in claim 6 wherein said terminals threadedly engage said respective insulating bushings for permitting adjustment of the extension of said terminals into said first passage.

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