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REFRIGERANT EXPANSION VALVE MECHANISM

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FIG. 1.

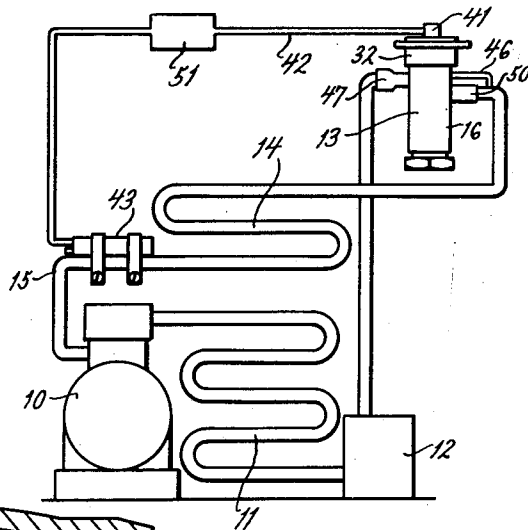
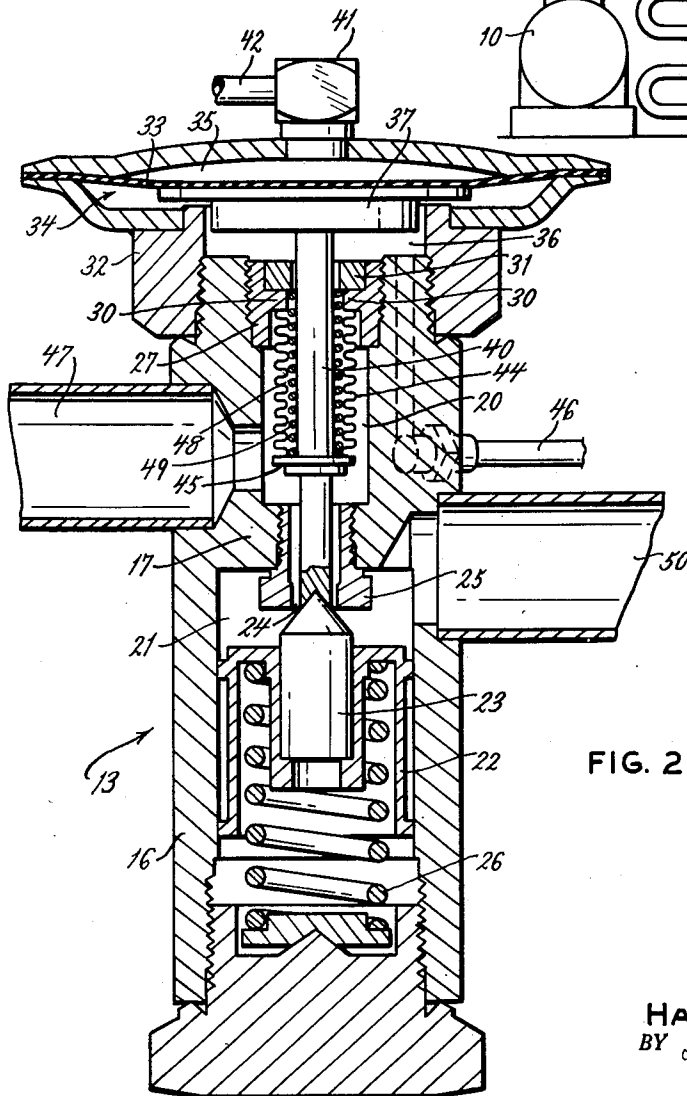


FIG. 2.

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REFRIGERANT EXPANSION VALVE MECHANISM 5

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9 Claims. (Cl. 62—3)

This invention relates to improvements in a valve mechanism, and more particularly to improvements in a valve mechanism adapted to control the flow of refrigerant to an evaporator of a refrigerating system.

In refrigerating systems, variations in head pressure are very slight where water-cooled condensers are equipped with pressure-type water regulators. However, the use of water conservation devices such as cooling towers, evaporative and particularly air-cooled condensers induce conditions of widely fluctuating head pressures on a given unit. Coupled with the increasing use of this equipment is the trend, for economic reasons, toward even closer motor to compressor sizing. The practical result is that the overload protection formerly afforded by valves, which maintain superheat control and also maintain a predetermined maximum suction pressure despite further increases in suction temperature, is no longer adequate and further refinement is necessary in order to compensate for excessive head pressure and air temperatures.

In the usual utilization of an expansion valve between the condenser and the evaporator of a refrigerating system, an increase in head pressure at or above the predetermined suction pressure limit, affects the expansion valve in a number of ways. It results in an increased pressure drop across the valve port and requires a reduced valve opening to maintain the same rate of flow, and it adds to the unbalanced pressure of the valve port. Reducing the valve opening displaces the diaphragm upwardly to produce a decrease in volume and a corresponding increase in vapor pressure in the thermostatic element. The increase in the pressure unbalance of the valve port acts against the superheat spring, diminishing its effectiveness in maintaining the initial vapor pressure vs. suction pressure and spring force equilibrium. The effect of both reduced valve opening and increased pressure unbalance of the port is to establish a new balance point at a higher suction pressure. In addition, as the valve throttles, the suction temperature at the evaporator outlet is increased, which causes a rise in vapor pressure of the thermostatic assembly. This increase in vapor pressure is normally balanced by an increase in suction pressure.

Accordingly, it is a major objective of this invention to provide means which will compensate for any increased pressure differential across the valve port, for any increased pressure unbalance of the valve port, and for any increase of suction temperature caused as the valve throttles, upon an increase of valve inlet or head pressure.

Another important object is realized in the improved construction and combination of parts which provides the advantageous results discussed previously, the particular improved structural arrangement of the valve mechanism being hereinafter described and distinctly claimed.

The foregoing and numerous other objects of the invention will more clearly appear from the following de-

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tailed description of a preferred embodiment, particularly when considered in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic view of a refrigeration system embodying the improved expansion valve, and

Fig. 2 is a longitudinal cross sectional view of the expansion valve shown in Fig. 1.

Referring now by characters of reference to the drawing, and first to Fig. 1, there is shown a diagrammatic view of a refrigeration system including a compressor-electric motor unit, generally referred to at 10, that delivers refrigerant to a condenser 11 that is usually air cooled. The condenser 11 in turn delivers the refrigerant to a receiver 12, and thence delivered to a thermostatic expansion valve 13 controlling the flow of refrigerant to an evaporator generally indicated at 14. As is usual in a system of this type, the evaporator 14 is connected through suction line 15 back to the inlet side of the compressor unit 10.

The thermostatic expansion valve 13 includes a body 16 forming an enclosure which is in the nature of a housing, casing or barrel. A partition 17 is provided internally of body 16 which forms a separate inlet chamber 20 and a separate outlet chamber 21. Located and reciprocally movable within outlet chamber 21 is a valve guide 22 that constitutes a carriage for carrying a valve 23 operable to open and close a valve seat port 24. The valve port 24 is formed in a replaceable threaded element 25 fastened and located in partition 17. The valve 23 and valve seat port cooperate to control the flow of refrigerant between chambers 20 and 21. A spring 26 is located in outlet chamber 21, and engages guide 22 so as to urge valve 23 toward a closed position.

Disposed at the upper end of inlet chamber 20 and secured to body 16 is a threaded member 27 having an internal flange 30 with a passage therethrough. A metallic guide 31 is seated in threaded member 27 and on flange 30. A casing structure 32 is attached to the upper end of body 16, and includes a diaphragm 33 constituting a flexible movable element located in a diaphragm chamber generally indicated at 34. The diaphragm 33 divides chamber 34 into separate compartments 35 and 36, one of which 36 is immediately adjacent to, but separate from inlet chamber 20. In contact with diaphragm 33 is a follower 37 in contact with a valve stem 40. The valve stem 40 extends from compartment 36, through guide 31 and threaded member 30, and through inlet chamber 20 to engagement with valve 23.

The upper compartment 35 of diaphragm chamber 34 is connected through fitting 41 and capillary tubing 42 to a bulb 43 (Fig. 1) located in thermal responsive relation to the outlet of evaporator 14. A limited fluid charge is introduced into bulb 43, and consists preferably of a fluid having characteristics approaching or identical with those of the refrigerant employed in the system, and will usually consist of Freon 12, Freon 22, methyl chloride or any other of the refrigerants selected for the system according to preference and field of usage. Below a predetermined temperature at the bulb, the charge is partly in liquid phase and partly in vapor phase. Above this temperature all of the charge is in vapor phase. The diaphragm 33 is capable of flexing action under the influence of fluid pressure changes occurring by reason of thermal effects imparted to bulb 43 in response to changes in superheat in the suction line 15. Motion of the diaphragm 33 and follower 37 is imparted to stem 40, and hence to valve 23. Thus downward or opening valve movement (Fig. 2) is opposed by the action of valve spring 26.

An extensible contractible motor element 44 in the nature of a bellows, and constituting a flexible movable element is located in inlet chamber 20. The motor ele-

ment 44 consists of a movable wall having its upper end attached to flanges 30 of threaded member 27, and having its lower end attached to collar 45 of movable valve stem 40. Being located in inlet chamber 20, the wall of motor element 44 is subjected externally to head pressure, while the wall and the chamber 48 of motor element 44 is subjected internally to suction pressure by its communication with compartment 36. An external equalizer connection 46 places the compartment 36 in communication with the evaporator pressure. A compression spring 49 is disposed in chamber 48 of motor element 44, the spring abutting guide 31 and collar 45.

Thus it is seen that inlet 47 and inlet chamber 20 are under head pressure, and that the outlet chamber 21, compartment 36 and motor chamber 48 are subjected to suction pressure.

The expansion valve mechanism 13 described and explained above will maintain a substantially constant suction pressure at predetermined maximum value despite further increases in head pressure or in evaporator outlet temperatures. The practical result of this pressure-limiting feature is to limit the refrigerative load on the compressor, and thereby permit fairly close sizing of the compressor motor without danger of electrical overloading.

An increase in head pressure, in the limited evaporator pressure region, increases the available pressure drop across the valve port 24 which calls for a reduced valve opening to maintain the same rate of flow, and also adds to the unbalanced pressure of the valve port 24. The reduced valve opening produces a decrease in the pressure of the superheat spring 26. The reduced valve opening also displaces the diaphragm upwardly producing a decrease in volume and an increase in vapor pressure of the thermostatic assembly. The increase in the pressure unbalance of the valve port 24 also acts against the superheat spring 26, and hence diminishes its effectiveness in maintaining the initial vapor pressure vs. suction pressure-spring force equilibrium. The effect of both reduced valve opening and increased port unbalance tends to establish a new balance point at a higher suction pressure.

Moreover, as the valve throttles, the suction temperature at the bulb 43 increases which results in a slight increase in vapor pressure in the bulb 43 and diaphragm chamber 35.

However, since the motor element 44 is subjected externally to head pressure, and subjected internally to evaporator pressure, a state of unbalance exists across the bellows acting in a direction opposite to that of the valve port. The magnitude of this pressure unbalance is a function of the effective area of the bellows. A bellows whose effective area is equal to that of the valve port 24 will completely offset the pressure unbalance of the port, and will leave the valve undercompensated only with respect to the decrease in spring pressure, and the change of volume and vapor pressure of the thermostatic assembly due to reduced valve opening. A larger bellows will provide this additional compensation, even to the point of overcompensating so that there will result a decrease in suction pressure upon an increase in head pressure.

The above pressure compensation is of primary interest only in regard to the pressure-limiting phase of expansion valve control, although it applies also in the superheat control phase. In the latter instance, it would result in progressively higher superheats as the head pressure increases. A properly sized expansion valve, however, has a natural gradient of only four or five degrees superheat from its closed position to rated capacity. Under normal conditions of fluctuating load, the operating superheat would not vary more than two or three degrees, an amount insufficient to effect adversely the evaporator capacity.

To facilitate in compensating for head pressure rise and consequent suction temperature increase, an element constituting an expansion chamber 51 may be utilized in

tube 42 of the thermostatic assembly. This expansion chamber 51 may be used in conjunction with motor element 44 for the stated purpose. Its effect is to increase the total volume of the thermostatic element so that a given displacement of the diaphragm 33 will produce a relatively smaller increase in total vapor pressure against which the suction pressure must balance. A similar effect is noted with increasing suction temperature. If the temperatures of the diaphragm casing 32 and the expansion bulb 43 are held fairly constant, the increase in suction temperature influences only that portion of the charge contained in the bulb 43. An increase in the superheat of this portion of the charge raises its specific volume. However, because of the larger total volume afforded by expansion chamber 51, a greater portion of this rise can be absorbed by chamber 51, and hence results in a relatively smaller rise in vapor pressure on one side of diaphragm 33.

Although the improvements have been described by making particularized reference to a preferred expansion valve mechanism, the detail of description is not to be understood as restrictive, numerous variants being possible within the principles disclosed and within the fair scope of the claims hereunto appended.

I claim as my invention:

1. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition dividing the valve body into separate inlet and outlet chambers, a valve seat port in said partition, a valve pin located in said outlet chamber, and adapted to coact with said valve seat port to regulate flow between said chambers, a valve stem in contact with said valve pin, and extending through said inlet chamber, a spring urging said pin toward a closed position, a diaphragm connected to said valve stem, means for subjecting one side of said diaphragm to a vapor pressure responsive to temperature at the evaporator outlet, means for subjecting the other side of said diaphragm to suction pressure, an extensible contractible chambered motor element connected to said stem, and located in said inlet chamber so as to be subjected on one side to head pressure, and means for subjecting the motor element on the other side to suction pressure.

2. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition dividing the valve body into separate inlet and outlet chambers, a valve seat port in said partition, a valve pin in said outlet chamber, and adapted to coact with said valve port to regulate flow between said chambers, a valve stem connected to said pin, the stem extending through said inlet chamber, a diaphragm operatively connected to said stem, means for subjecting one side of said diaphragm to a vapor pressure responsive to the temperature of the evaporator outlet, means for subjecting the other side of said diaphragm to suction pressure, a spring in said outlet chamber urging said pin toward a closed position, an extensible contractible, chambered motor element having a movable wall connected to said valve stem, said motor element being located so as to subject said wall on one side to head pressure, and means communicating the chamber of said motor element with the side of the diaphragm under suction pressure so as to subject the wall on the other side to said suction pressure, said wall being of sufficient effective area to compensate for any increased unbalance pressure across the valve port and for any increase of temperature at the evaporator outlet and for any decrease in valve opening upon an increase of head pressure.

3. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition in said body providing separate inlet and outlet chambers, a valve seat port in the partition, a valve pin coacting with said valve port to regulate flow between said chambers, a spring urging said pin toward a closed position, a valve stem operatively

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connected to said pin, and extending through said inlet chamber, diaphragm means operatively connected to said valve stem, and adapted to move said pin responsive to suction pressure and temperature, an extensible contractible, chambered motor element having a movable wall attached to said valve stem, said motor element being located in said inlet chamber so as to subject said wall externally to head pressure, means for subjecting said wall internally to suction pressure, said wall having sufficient effective area so as to compensate for the pressure unbalance of said valve port upon an increase in head pressure.

4. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition in said body providing separate inlet and outlet chambers, a valve seat port in said partition, a valve pin in said outlet chamber, and cooperating with said valve port to regulate flow between said chambers, a spring in said outlet chamber urging said pin toward a closed position, a valve stem operatively connected to said pin, and extending through said inlet chamber, a casing attached to said body, a diaphragm in said casing and providing separate compartments, the valve stem extending into said casing and connected to said diaphragm, means for subjecting one of the compartments to pressure responsive to temperature at the evaporator outlet, means for subjecting the opposite compartment to suction pressure, an extensible contractible, chambered motor element having a movable wall connected to said valve stem, and located in said inlet chamber so as to subject said wall on one side to head pressure, and means communicating one of said compartments with the chamber of said motor element so as to subject the wall on the other side to suction pressure, said motor element being of such size as to effect a reduction in evaporator pressure upon an increase in head pressure.

5. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition in said body providing separate inlet and outlet chambers, a valve seat port in said partition, a valve pin in said outlet chamber, and cooperating with said valve port to regulate flow between said chambers, a spring in said outlet chamber urging said pin toward closed position, a valve stem operatively connected to said pin and extending through said inlet chamber, a diaphragm connected to said stem, means for subjecting one side of said diaphragm to pressure responsive to temperature conditions at the evaporator outlet, means for subjecting the opposite side of said diaphragm to suction pressure of said outlet chamber, an extensible contractible, chambered motor element having a movable wall attached to said valve stem, and located in said inlet chamber between the valve port and said diaphragm, said wall being subjected on one side to head pressure, said wall, upon contraction, moving said stem in a direction to release the compressive force on said spring so as to permit the spring to urge said pin toward a closed position, said wall being of sufficient effective area to at least compensate for the increased unbalanced pressure of said valve port upon an increase of head pressure.

6. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising an elongate valve body, a partition in said body to provide separate inlet and outlet chambers, a valve seat port in said partition, a valve pin in said outlet chamber, and cooperable with said port to regulate flow between said chambers, a spring in said outlet chamber urging said pin toward a closed position, means providing a diaphragm chamber adjacent said inlet chamber, a diaphragm in said diaphragm chamber, means for subjecting one side of the diaphragm to pressure responsive to temperature conditions at the evaporator outlet, means for subjecting the other side of said diaphragm to suc-

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tion pressure, a valve stem operatively connected to said valve pin, said stem extending through said inlet chamber and into said diaphragm chamber for connection to said diaphragm, an extensible contractible, chambered motor element having a movable wall connected to said stem between the port and diaphragm, said motor element being located in said inlet chamber so as to subject the wall to head pressure, and means communicating the chamber of the motor element with one side of said diaphragm so as to subject the other side of said wall to suction pressure, said wall having an effective area so as to at least compensate for any increased unbalance of pressure of said valve port and for any increase of temperature at the evaporator outlet, and for any decrease in spring pressure, upon an increase of head pressure.

7. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition in said body providing separate inlet and outlet chambers, a valve seat port in said partition, a valve coacting with said valve port for regulating flow between said chambers, spring means urging said valve toward a closed position, a bulb having a fluid charge adapted to be located at the evaporator outlet, means providing a diaphragm chamber adjacent said inlet chamber, a diaphragm in said diaphragm chamber operatively connected to said valve, tubing connecting said bulb to said diaphragm chamber so as to subject the diaphragm to pressure of said fluid charge, means providing an expansion chamber in said tubing, means for subjecting the other side of said diaphragm to suction pressure, the expansion chamber being of sufficient size to minimize the increase of vapor pressure for temperature increase at the evaporator outlet, when all of the fluid charge is in vapor phase.

8. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body, a partition in said body providing separate inlet and outlet chambers, a valve seat port in said partition, a valve coacting with said valve port for regulating flow between said chambers, spring means urging said valve toward a closed position, a bulb having a fluid charge adapted to be located near the evaporator outlet, means providing a chamber adjacent said inlet chamber, both chambers being separated by a flexible, movable partition, the flexible movable partition being operatively connected to said valve, tubing connecting said bulb to said chamber so as to subject one side of said flexible movable partition to pressure of said charge, means providing an increased volume in said tubing, means for subjecting the other side of said flexible movable partition to evaporator pressure, an extensible contractible chambered motor element operatively connected to said valve, and located so as to be subjected on one side to head pressure, and means for subjecting the motor element on the other side to suction pressure, said motor element and expansion chamber serving to at least limit the suction pressure upon an increase in head pressure and suction outlet temperature when the fluid charge in the bulb is completely in vapor phase.

9. A valve mechanism for controlling the flow of refrigerant to an evaporator of a refrigerating system comprising a valve body having an inlet and an outlet and an interconnecting passageway therebetween, a partition in the passageway to provide an outlet chamber, a valve seat port in said partition, a valve pin located in said outlet chamber, and adapted to coact with said valve seat port to regulate flow through said passageway, a valve stem operatively connected to said valve pin and extending through said partition, means in said outlet chamber biasing said pin toward a closed position, a diaphragm connected to said valve stem, means for subjecting one side of said diaphragm to a fluid pressure responsive to temperature at the evaporator outlet, means

for subjecting the other side of said diaphragm to suction pressure, an extensible-contractible chambered motor element operatively connected to said stem and located on the opposite side of the partition from said outlet chamber and valve pin, means subjecting one side of the motor element to head pressure, the motor element being subjected on the other side to suction pressure.

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