United States Patent

Oshima et al.

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[54] **FLOW CONTROL VALVE**

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[52] **U.S. Cl.**.....**62/225,** 62/504, 236/92 B

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

[58] **Field of Search**.....62/210, 222, 224, 225, 504; 236/92

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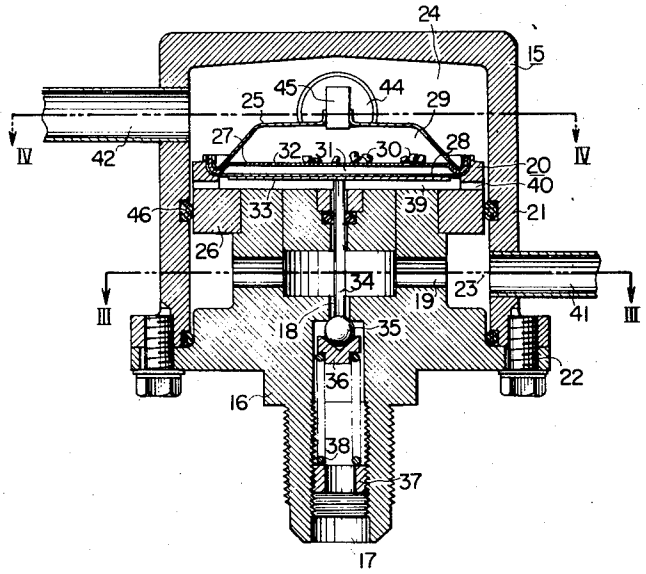
[57] **ABSTRACT**

A flow control valve in which a part of a low pressure refrigerant passage connected to an evaporator in a refrigeration cycle is placed in a very closely spaced apart relation with a part of a high pressure refrigerant passage to the evaporator; a heat sensitive device having means for detecting the environmental temperature and means which is displaced in response to the detected temperature is so placed as to contact the temperature detecting means with refrigerant the low pressure refrigerant passage; and a flow control valve for controlling the flow in the high pressure refrigerant passage is operatively coupled to the heat sensitive member.

9 Claims, 6 Drawing Figures



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4 Sheets-Sheet 1

FIG. 1

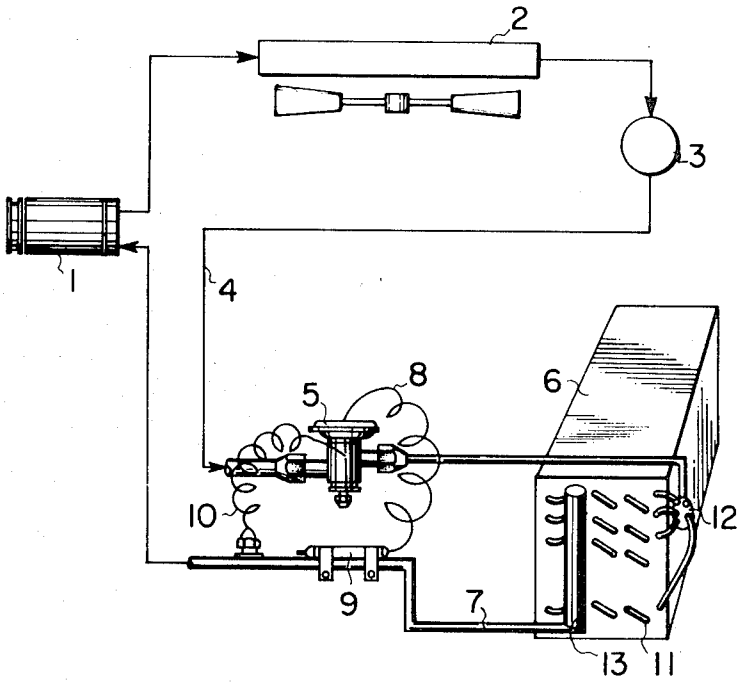

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FIG. 2

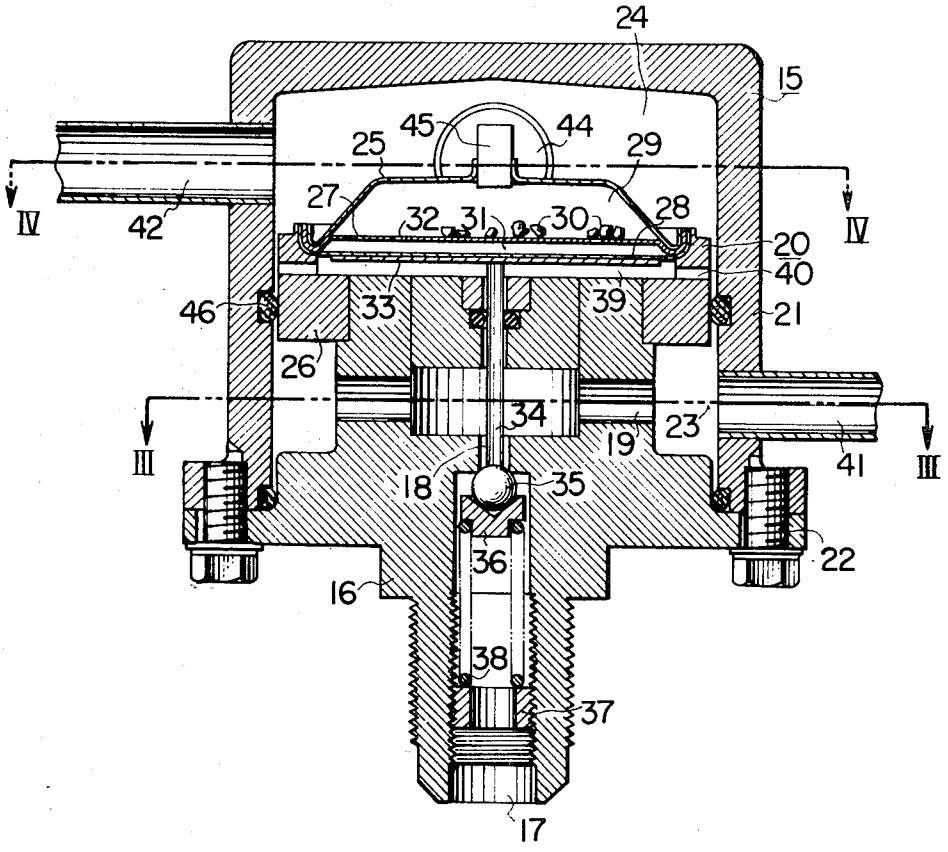

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FIG. 3

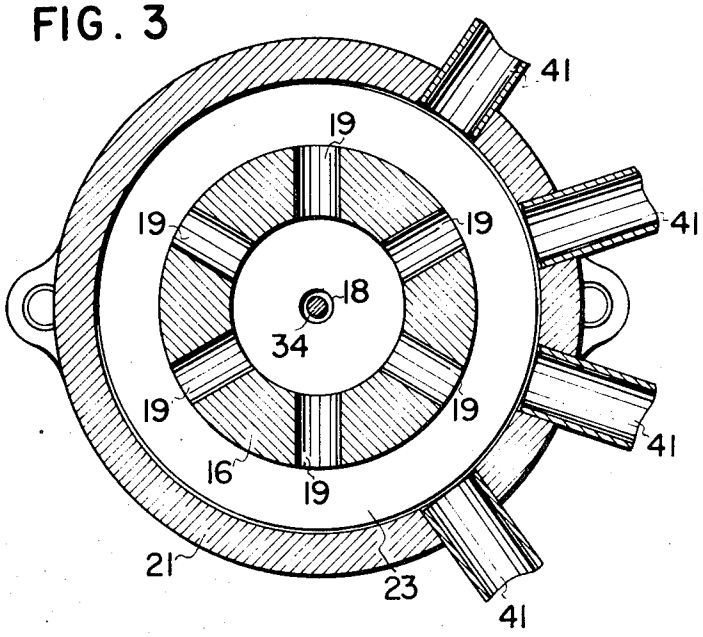

FIG. 4

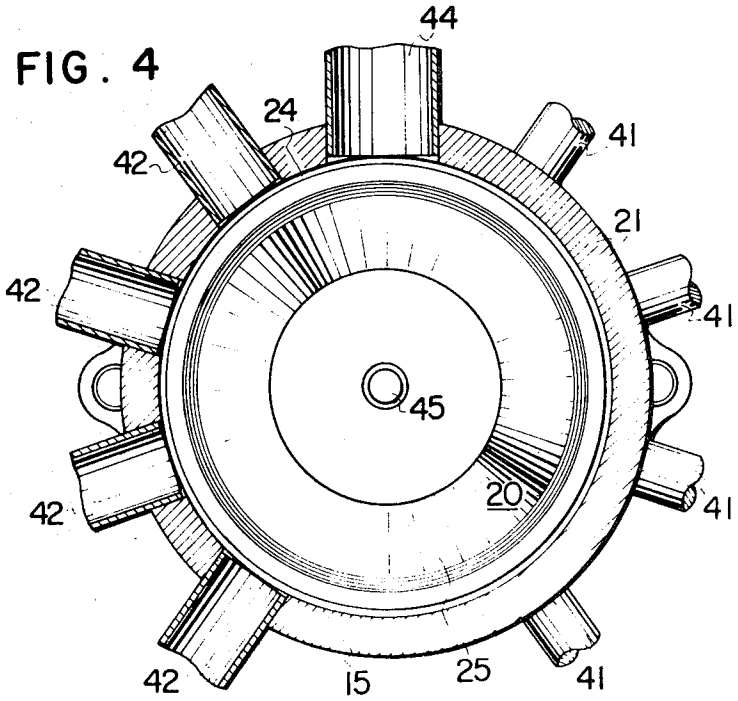

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FIG. 5

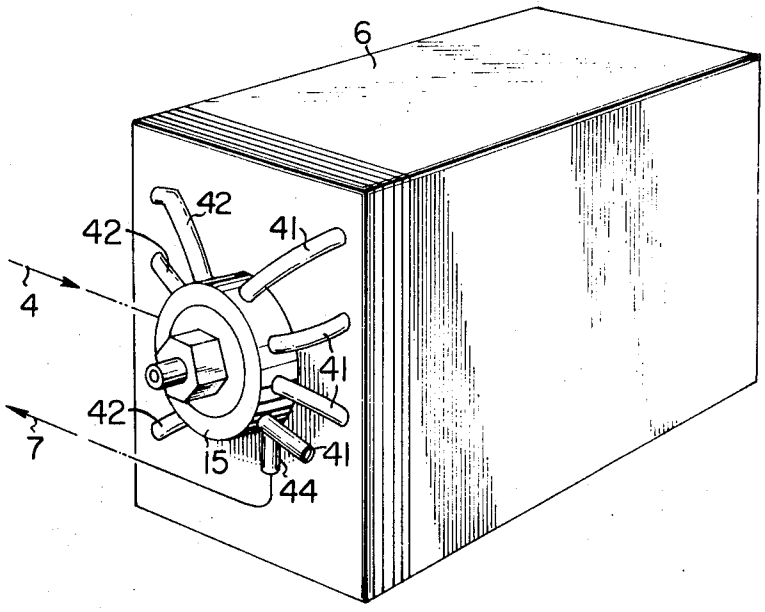
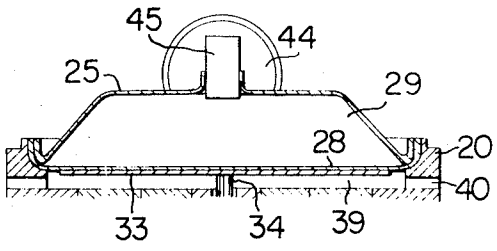


FIG. 6



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FLOW CONTROL VALVE

BACKGROUND OF THE INVENTION

The present invention relates to a flow control device in a refrigeration cycle.

In general, the expansion valves are used as the device described. In order to control the flow of the refrigerant to be supplied into an evaporator, the pressure as well as temperature of the refrigerant at the outlet of the evaporator are detected so that their deviations from the reference values may be exerted upon the surfaces of a diaphragm to thereby control the opening of the inlet of the evaporator by a valve which is actuated in response to the displacement of the diaphragm. More specifically, the pressure representative of the temperature of the refrigerant is applied to one surface of the diaphragm while the pressure of the refrigerant is applied to the other surface thereof so that the valve may be actuated in response to the pressure difference between the two pressures. The temperature of the refrigerant may be converted into the pressure by a remote bulb attached to the outer periphery of the pipe connected to the outlet of the evaporator and the thus converted pressure may be transmitted to a chamber on the side of one surface of the diaphragm through a capillary tube. The pressure acting upon one surface of the diaphragm is transmitted with a relatively long time delay and is influence by the ambient temperature so that the correct pressure is not transmitted to the diaphragm. Therefore, the expansion valve cannot function properly. Especially in case of an air conditioning unit mounted in an automobile, the air flowing in contact with and in vicinity of the remote bulb pulsates so that the pulsating signals are transmitted to the diaphragm.

On the other hand, the pressure acting upon the other side of the diaphragm is generally the static pressure of the refrigerant at the outlet of the evaporator so that the suitable control may be attained in the normal operation of the air conditioning unit.

However, in case of the air conditioning unit mounted in the automobile, the variation in refrigeration load occurs especially when the air conditioner is started and when the door is opened so that the large amount of the surrounding air flows into the compartment. In consequence, there occurs liquid-back phenomenon, that is the phenomenon that the liquid refrigerant cannot vaporize in the evaporator completely so that the liquid refrigerant is forced into the compressor. Consequently, the recovery to the optimum overheated temperature is delayed so that the cooling or refrigeration capacity is accordingly lowered. Furthermore, the compressor is adversely affected because of the sudden increase of the pressure within the compressor and noise is produced.

These problems may be overcome if the expansion valve may immediately reduce the flow of the refrigerant so that the suitable amount of flow may be introduced into the evaporator in response to the capacity thereof.

The expansion valve is interconnected with the evaporator through a member connecting the outlet of the expansion valve to the evaporator through the distributor and through capillary tubes for transmitting the pressures to the expansion valve, said capillary tubes being connected to a remote bulb attached to a low pressure pipe connected to the evaporator through a header and to the low pressure pipe itself. Thus, the interconnecting system is very complex and there arises a problem of leakage of gas from the capillary tubes.

SUMMARY OF THE INVENTION

The present invention was made to overcome the problems described above, and provides a novel flow control valve which not only functions as an expansion valve but also accomplishes other functions to be described in more detail hereinafter.

The first object of the present invention is to provide a flow control valve in which the pressure variation which is representative of the variation in temperature of the refrigerant at the outlet of an evaporator may be accurately and immediately transmitted to a diaphragm in the flow control valve.

The second object of the present invention is to provide a flow control valve in which the variation in pressure of the refrigerant in the evaporator may be immediately transmitted to the diaphragm so that optimum flow control of the refrigerant may be attained.

The third object of the present invention is to simplify the combination of the flow control valve of type described with the evaporator while the above described objects may be accomplished.

In brief, the novel feature of the present invention resides in the fact that an inlet passage of an evaporator is disposed in contact with or in the very closely spaced apart relation with the outlet passage from the evaporator; a heat sensitive bulb is placed in the outlet passage and is made in contact with a casing of one chamber on one side of a diaphragm of an expansion valve; the total pressure (static as well as dynamic pressures) of the refrigerant in the outlet passage of the evaporator may be transmitted to a chamber on the other side of the diaphragm; and a valve placed in the inlet passage of the evaporator may be controlled in response to the displacement of the diaphragm.

The present invention will become more apparent from the following desciption of the preferred embodiment thereof taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating the well known refrigeration cycle;

FIG. 2 is a vertical sectional view of a flow control valve in accordance with the present invention;

FIGS. 3 and 4 are sectional views taken along the lines 3 — 3 and 4 — 4 of FIG. 2 respectively; and

FIG. 5 is a perspective view illustrating an expansion valve in accordance with the present invention mounted upon an evaporator.

FIG. 6 is a vertical sectional view of a modified heat sensitive element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Prior Art

Referring to FIG. 1, the refrigeration cycle of the prior art air conditioner will be described in brief in order to aid the understanding of the present invention. A refrigerant is compressed by a compressor 1, cooled

by a condenser 2 and stored in liquid phase in a liquid tank or receiver 3. The main flow control of the refrigerant to an evaporator 6 is made by an expansion valve 5 in a high pressure pipe 4, and after the heat exchange for cooling the air in a room, the refrigerant is returned to the compressor 1 through a low pressure pipe 7. The expansion valve 5 is provided with a device consisting of a capillary tube 8 and a remote bulb 9 for detecting a temperature of the refrigerant in the low pressure pipe 7 and converting it into a pressure and a capillary tube 10 for directly detecting a pressure of the refrigerant. The high pressure pipe 4 is communicated with each tube 11 of the evaporator through a distributor 12 while the low pressure pipe 7 is communicated with the tubes 11 through a header 13.

The Invention

In brief, the present invention contemplates to arrange the high and low pressure pipes 4 and 7 in closely spaced apart relation with each other and locate the remote bulb 9 in the low pressure pipe 4 so as to eliminate the capillary tubes 8 and 10. Furthermore, the distributor 12, header 13, expansion valve and remote bulb are made into a unitary construction so that the device may be designed compact in size.

Referring to FIGS. 2 to 5, the present invention will be described. A flow control valve generally designated by 15 comprises a valve body 16 provided with an inlet passage 17, a reduced diameter passage 18 and a plurality of distributor passages 19. A heat sensitive element 20 is placed upon the valve body 16 and enclosed by a cover 21, which is securely fixed to the valve body 16 by means of bolts 22. Within the cover 21 are defined a distribution chamber 23 and header chamber 24. The heat sensitive element 20 comprises a partition plate 27 and a diaphragm 28 both of which are secured in position between a lower casing 26 and an upper casing 25. The lower casing 26 is retained on the valve body 16. CO_2 gas as well as activated carbon 30 are enclosed in a chamber 29 defined between the upper casing 25 and the partition plate 27. In a chamber 31 defined between the partition plate 27 and the diaphragm 28 is filled with CO_2 gas. The upper and lower chambers 29 and 31 are intercommunicated with each other through passages 32. A valve rod 34 has one end fixed to a ball valve 35, with the other end being in contact with a spacer 33. The spacer 33 consists of a thin plate disposed between the diaphragm 28 and the valve rod 34 to protect said diaphragm 28. The ball valve 35 is received by a valve seat 36 and a spring 38 is interposed between the valve seat 37 and an adjustment screw 37. A chamber 39 defined between the diaphragm 28 and a lower casing 26 is intercommunicated with the header chamber 24 through passages 40. The distribution chamber 23 has a plurality of distribution pipes 41 connected thereto and the pipes 41 are the inlets of the tubes in the evaporator 6. The outlets of the tubes of the evaporator 6 which are the header pipes 42 are communicated with the header chamber 24. The inlet passage 17 is communicated with the liquid tank through the high pressure pipe. A low pressure pipe 44 from the header chamber 24 is connected to the suction port of the compressor. Reference numeral 45 designates a tube for sealing the gas. Reference numeral 46 designates sealing members and the distribution and header chambers 23 and 24 are sealed from each other by a sealing member 46.

The flow control of the refrigerant entering into the inlet passage 17 is made by the ball valve 35 and the refrigerant is forced into the distribution chamber 23 through the reduced diameter passage 18 and then to the evaporator 6 through the distribution pipes 41. The refrigerant from the evaporator 6 flows into the header chamber 24 through the header pipes 42 and then into the compressor through the low pressure pipe 44.

In this case, the degree of opening of the ball valve 35 is determined by the downwardly acting force of the diaphragm 28 of the heat sensitive element 20 and the reaction force of the spring 38. The downwardly acting force is produced by the difference in pressure acting upon the upper surface and undersurface of the diaphragm. The pressure exerting upon the upper surface of the diaphragm 28 is a function of a temperature of the refrigerant in the header chamber 24 while the pressure exerting upon the undersurface of the diaphragm 28 is the sum of the static and dynamic pressures of the refrigerant in the header chamber 24 transmitted through the passages 40.

In the present invention, CO_2 gas 29 can be replaced by other gas, such as Freon or the like which is sensitive to the variation of the temperature. In this case, activated carbon 30 and the partition plate 27 are eliminated as shown in FIG. 6.

In the prior art system, the expansion valve is communicated with the remote bulb through the capillary tubes as described above. However, in accordance with the present invention, the diaphragm chamber in the expansion chamber is directly made in contact with the heat sensitive cylinder, that is the heat sensitive element 20, so that there is an advantage that the variation in output pressure in response to the variation in detected temperature may be accurately and immediately transmitted to the diaphragm.

Since the header pipes 42 are angularly displaced from the low pressure pipe 44 so that the refrigerant is forced to change its flow in the header chamber 24. In consequence, the whole pressure of the refrigerant may be directly transmitted to the chamber 39.

The diaphragm in the flow control valve of the present invention may be displaced precisely in response to the variation in pressure and temperature of the refrigerant in the low pressure passage.

In the prior art expansion valve, there is a long time interval from the time the variation in pressure and temperature of the refrigerant in the low pressure passage occurs to the time the diaphragm is displaced accordingly. That is, a response time is very long. However, the response of the flow control valve in accordance with the present invention is very fast. This means, the flow of the refrigerant may be quickly controlled in response to the operating conditions of the air conditioner or the variation in load. Therefore, the pulsations of various physical quantities which tend to occur in response to the actuation of a suction throttle valve of the conventional type may be eliminated.

Furthermore, the cool-down capacity of quickly cooling the room temperature to a desired level after the air conditioner is started is much improved. The flow into the evaporator of the refrigerant may be so controlled that the liquid back may be minimized.

What is claimed is:

1. A flow control valve comprising; a valve body, an inlet passage formed in one end of said valve body, a

plurality of distribution passages formed in the side of the valve body so as to communicate with said inlet passage, valve means disposed between the inlet passage and the distribution passages, a heat sensitive device retained on the valve body on the side opposite the portion where said inlet passage is formed, said heat sensitive device having an output member operative upon sensing the temperature and pressure of surrounding refrigerant, means for operatively connecting the output member of said heat sensitive device to said valve means, a cup-shaped cover fixed to said valve body with the sides of heat sensitive device and said valve body located inside thereof, a distribution chamber formed between the valve body and the cover, a header chamber formed between the heat sensitive device and the cover, sealing means for sealingly separating said distribution and header chambers from one another, distribution means for communicating each of the inlet ends of a plurality of tubes of an evaporator directly with the distribution chamber, header means for communicating each of the outlet ends of a plurality of the tubes of the evaporator directly with the header chamber, said cover being supported at said distribution chamber and header chamber such that the portion of said cover forming the outer surface of said header chamber is closely spaced from the evaporator, means for connecting a low pressure refrigerant passage of a refrigeration cycle with the header chamber, and means for connecting a high pressure refrigerant passage of a refrigeration cycle to the inlet passage of the valve body.

2. A flow control valve as defined in claim 1, wherein said heat sensitive device is composed of a partition wall and a diaphragm interposed between upper and lower casings, integrally secured to each other at their outer edges, said lower casing being retained directly on the valve body, said upper casing and said partition wall defining a first chamber therebetween, said partition wall and said diaphragm defining a second chamber therebetween, said diaphragm and said lower casing and said valve body defining a third chamber therebetween, said first and second chambers being communicated with each other through passage means, said first chamber being charged with gas and an adsorbent, said second chamber being charged with the same gas as in said first chamber, and said third chamber being communicated with the header chamber through a passage.

3. A flow control valve as defined in claim 1, wherein said heat sensitive device is composed of a diaphragm interposed between an upper casing and a lower casing integrally secured to each other at their outer edges, said lower casing being retained directly on the valve body, said upper casing and said diaphragm defining a first chamber therebetween, said diaphragm and said lower casing defining a second chamber therebetween, said first chamber having gas sealed therein and said second chamber being communicated with the header chamber through a passage.

4. A flow control valve as defined in claim 1, wherein said valve means includes a ball valve provided in the inlet passage and a spring urging said ball valve into a closed position, a valve rod being axially slidably disposed within the valve body with one end thereof connected to said valve ball, and a spacer being interposed between one end of the valve rod and undersurface of the output member of the heat sensitive device.

5. A flow control valve arrangement for a refrigerating cycle of the type having a plurality of evaporator tubes running parallely through an evaporator; said arrangement comprising: housing means, inlet means in said housing means for introducing refrigerant from a high pressure refrigerant source, a distributing chamber in communication with said inlet means by way of inlet valve means, a plurality of distributor chamber outlet means for communicating between said distributor chamber and respective inlets to a plurality of evaporator tubes, a header chamber in direct communication with all of the respective outlets of said plurality of evaporator tubes for collecting all the low pressure refrigerant after it passes through the evaporator, a sensing device arranged in said header chamber for sensing pressure and temperature characteristics of the low pressure refrigerant in said header chamber, and control means operatively connecting said sensing device to the inlet valve means for controlling the flow of refrigerant into the distrubition chamber as a function of the temperature and pressure characteristics of the refrigerant in said header chamber, said header chamber and said distribution chamber being arranged in said housing means and being separated from one another by common partition means.

6. An arrangement according to claim 5, characterized in that said control means includes a rigid control rod extending through said common partition means.

7. An arrangement according to claim 5, characterized in that said housing means is constructed as a cylindrically shaped rigid housing, said inlet means including an inlet passage at one end of the housing, said distribution chamber outlet means comprising a first set of passages extending radially outward through the side walls of the housing, and the communication between the header chamber and the outlets of said evaporator tubes being by way of a second set of passages extending radially outward through the side walls of the housing.

8. An arrangement according to claim 7, characterized in that said housing is supported with respect to the remaining refrigerating cycle by the connection between the evaporation tubes and the first and second set of passages.

9. An arrangement according to claim 7, characterized in that said housing includes a one-piece cylindrical cup shaped cover detachably attached to a valve body at the edges of the open end of the cover, said first and second sets of passages extending through the side walls of said cover.

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