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Takahashi et al.

[11] 3,855,836
[45] Dec. 24, 1974

[54] DEVICE FOR CONTROLLING COOLANT PRESSURE IN EVAPORATOR

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[21] Appl. No.: **435,971**

[30] **Foreign Application Priority Data**

Jan. 24, 1973 Japan 48-9542

[52] **U.S. Cl.** **62/217,** 62/225
[51] **Int. Cl.** **F25b 41/04**
[58] **Field of Search** 62/204, 210, 209, 222–225, 62/217; 236/92

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Primary Examiner—Meyer Perlin
Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

A mechanism for regulating pressure in an evaporator is provided integrally with a collecting chamber for collecting a coolant from an evaporator, which chamber is provided in a valve for controlling an expansion rate of a coolant, said valve being disposed in a heat cycle system for use in a car cooler or the like, thereby presenting ease in installation, ease in maintenance and ease in manufacture.

8 Claims, 6 Drawing Figures

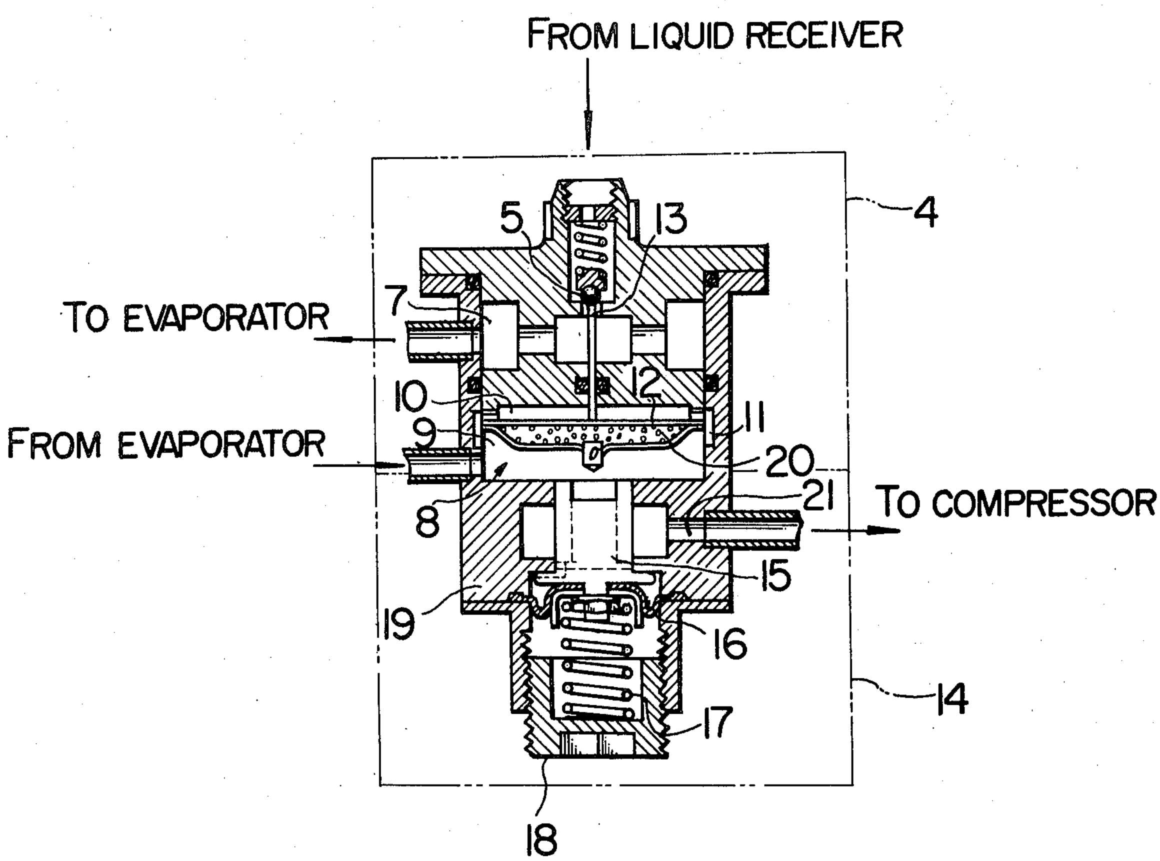


FIG. 1

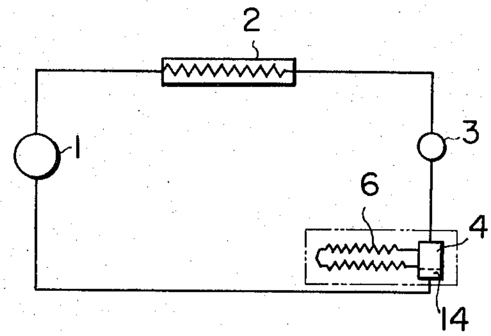

2
1
3
6
4
14

FIG. 2

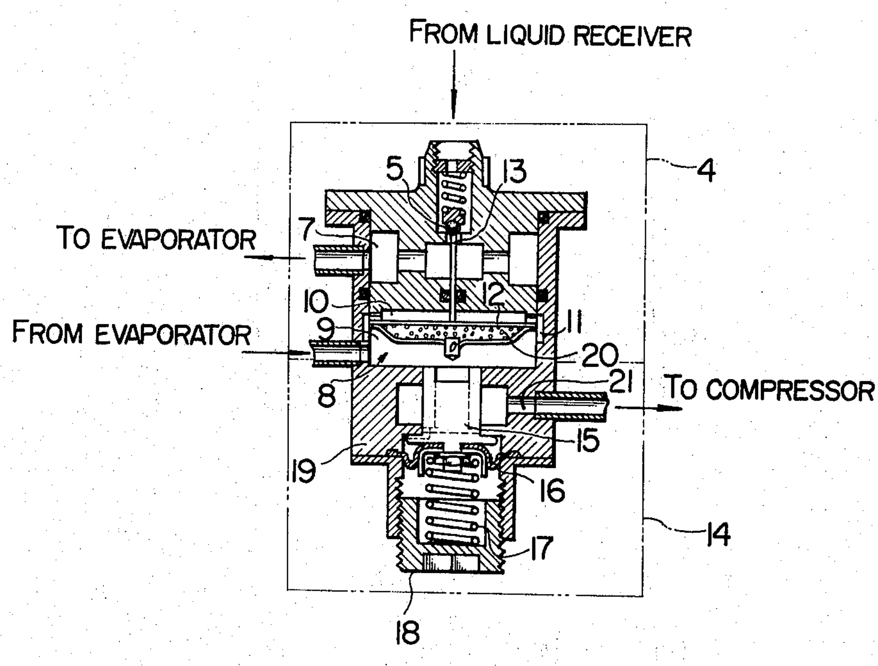
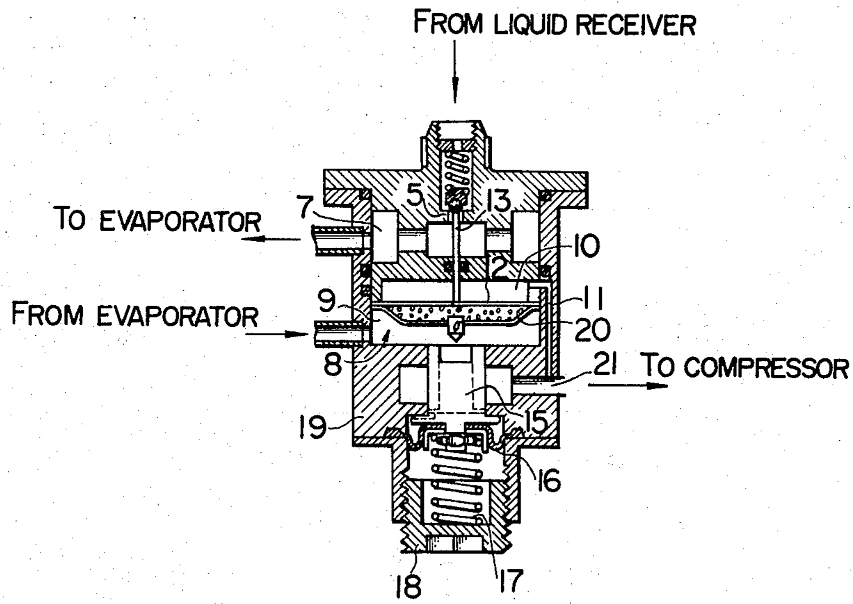

FROM LIQUID RECEIVER
TO EVAPORATOR
FROM EVAPORATOR
TO COMPRESSOR
4
5
13
7
10
12
9
11
20
21
8
15
19
16
14
17
18

FIG. 3


FROM LIQUID RECEIVER
TO EVAPORATOR
FROM EVAPORATOR
TO COMPRESSOR
5
13
7
10
2
9
11
20
8
21
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18
17

FIG. 5

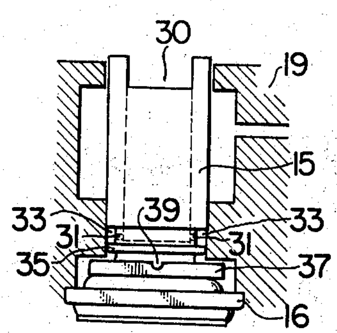

30
19
15
33
39
33
31
31
35
37
16

FIG. 4

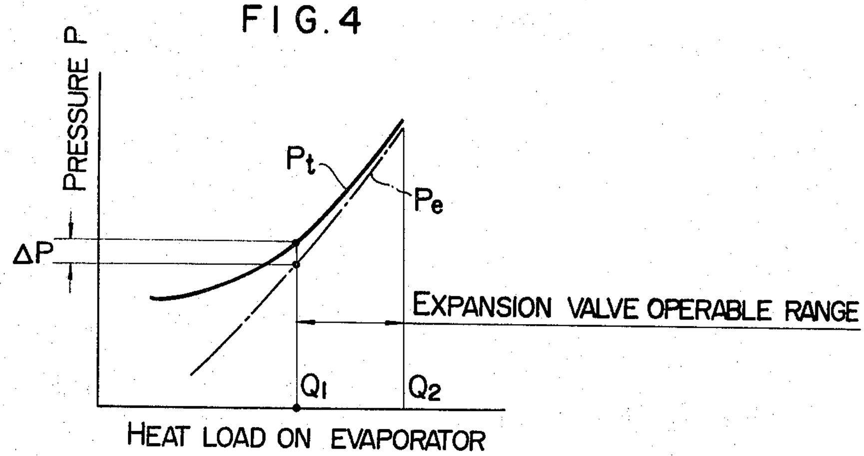
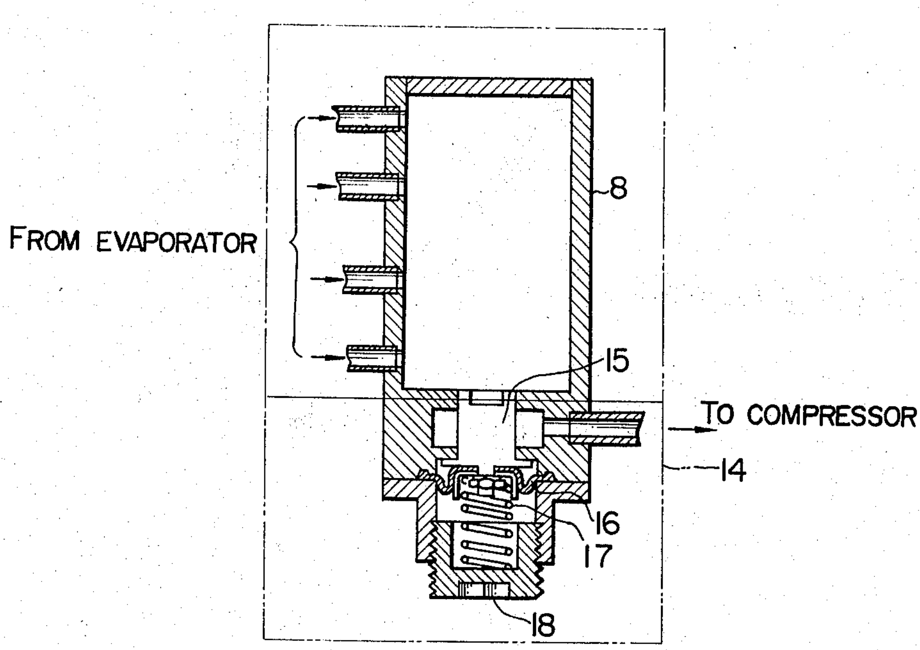

PRESSURE P
Pt
Pe
ΔP
EXPANSION VALVE OPERABLE RANGE
Q1
Q2
HEAT LOAD ON EVAPORATOR

FIG. 6


FROM EVAPORATOR
8
15
TO COMPRESSOR
14
16
17
18

DEVICE FOR CONTROLLING COOLANT PRESSURE IN EVAPORATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a coolant controlling device for use in an air conditioning apparatus, and more particularly to a mechanism for controlling a coolant pressure in an evaporator.

2. Description of the Prior Arts

It is a recent trend to use an air-conditioning unit through all seasons. In case a cooling cycle is used in a wide range of ambient temperatures, especially in a low temperature zone, there is experienced growth of frost or the freezing of moisture on an evaporator. Usually, the evaporator is so designed as to fulfil the satisfactory cooling performance, even when a high level of heat load is applied thereto. Accordingly, in case the heat load becomes lower, for example, in case the ambient temperature becomes lower and only the dehumidification is desired, the coolant evaporating pressure in the evaporator becomes lowered beyond the coolant controlling capability of the expansion valve. This brings about a phenomenon of the frozen outer surface of the evaporator, i.e., the growth of frost or a phenomenon that the coolant remains in the liquid state, thus incurring a risk of breaking various units of system, for example, a compressor of being broken. To avoid such a problem, it is required that the minimum evaporating pressure in the evaporator be set to a level at which no growth of frost arises, so as to cause evaporation of the coolant usually at a pressure over the predetermined level. Hitherto, to prevent the freezing of an evaporator or the like, the coolant evaporating pressure controlling device has been used. Such a coolant evaporating pressure controlling device, because it is independent of the other units of cooling system, presents various problems and difficulties in that there have to be provided various pipings for connecting the units, such as heat sensitive pipes, pressure-equalizing pipes or the like, resulting in the complicate construction, the leakage of gas, lowering of the efficiency in installation, and increase in the manufacturing cost as well as in a space required for the unit.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a device for controlling a coolant pressure in an evaporator which is superior in ready maintainance and good accessibility.

Another object of the present invention is to provide a device for controlling a coolant pressure in the evaporator which is simple and easy in the maintenance and check.

A further object of the present invention is to provide a device for controlling a coolant pressure in an evaporator which is small in size and superior in the controlling capability.

The present invention is directed to providing a pressure controlling valve mechanically integral with a collecting chamber leading to an outlet port of an evaporator, said collector serving to collect the coolant from the evaporator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a cooling system relating to the present invention;

FIG. 2 is a longitudinal cross-sectional view illustrating an expansion valve and a pressure control valve of FIG. 1.

FIG. 3 is a modification of FIG. 2.

FIG. 4 is a plot representing heat load exerted on an evaporator and a characteristic of a diaphragm responsive to temperature and pressure of a coolant within the evaporator.

FIG. 5 is an enlarged view of a spindle of FIGS. 2 and 3, and

FIG. 6 is a further embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The description will be given to preferred embodiments of the present invention in conjunction with the accompanying drawings.

Referring to FIG. 1 which shows an embodiment of a cooling system according to the present invention, shown at **1** is a compressor for compressing a coolant into a gaseous coolant of high temperature and high pressure, at **2** is a condenser for cooling the gaseous coolant for liquidification, at **3** is a liquid receiver, in which the coolant is separated into gas and liquid, and at **4** is an expansion valve control portion in which the liquid coolant from the liquid receiver **3** is subjected to expansion to be fed to an evaporator **6.** The coolant gas from the evaporator **6** returns via a pressure control valve portion **14** to the compressor **1** to control the pressure in the evaporator **6.**

The expansion valve control portion **4** and the pressure control valve portion **14** are illustrated in detail in FIG. 2. Referring to the drawing, the expansion valve control portion **4** includes a distributor **7** for introducing the coolant from the expansion valve **5** into the evaporator **6,** and a collector **8** for recovering same, said distributor **7** and collector **8** being constructed integrally with each other. The collector **8** is partitioned by an expansion-valve actuating diaphragm **12** into a primary chamber **9** (a heat sensitive chamber) and a secondary chamber **10,** both of which are communicated with each other by way of a connecting pipe **11** provided in a body proper of the device. The aforesaid expansion-valve actuating diaphragm is provided therein with a heat sensitive member **20** which is sealingly filled therein, with its secondary chamber side being communicated by way of a connecting rod **13** with a valve body, such as a ball valve of the expansion valve **5.** The expansion valve **5** is so adapted as to control a flow rate of coolant from the liquid receiver **3** and to be closed by means of a spring or the like when the pressure in the primary chamber **9** becomes low.

The pressure control valve portion **14** includes a valve body **19** and a spindle **15,** a bellows **16,** a spring **17** and an adjusting screw **18.**

Referring to the relationship of the pressure set by the adjusting means, which includes the aforesaid spring **17** and adjusting screw **18,** to the pressure in the primary chamber **9,** if the pressure in the primary chamber **9** relatively increases, the spindle **15** is forced downwardly, thereby bringing an outlet port **21** of pressure control valve portion **14** into communication with the primary chamber **9**. Accordingly, the pressure in the evaporator **6** may be maintained at a level above the pressure which has been set by said adjusting means.

With the provisions described, the coolant gas of high pressure and high temperature from the compressor **1** is cooled in the condenser **2** to a liquid state then introduced into the liquid receiver **3**, followed by the abrupt pressure-reduction in the expansion valve **5**, then heat-exchanged in the evaporator **6**, and then returned by way of the pressure control valve portion **14** into the compressor **1**. However, with the drop in the ambient temperature, the coolant evaporating pressure in the evaporator **6** will be decreased to a large extent resulting in the breakage of the cooling system due to freezing or the like. To avoid this drawback, the coolant, in the embodiment described, is introduced from the liquid receiver **3** into the expansion valve control portion **4** as well as the pressure control valve portion **14** which are provided integrally with each other. In detail, the expansion valve **5** in the expansion valve control portion **4** is so designed as to open or close its valve body, such as a ball, by means of the connecting rod **13**, depending upon the pressure difference between the internal pressure which varies according to the change in temperature of heat sensitive member **20** sealingly filled in the diaphragm **12**, which change is caused due to the coolant introduced in the collector **8** from the evaporator **6**, and the pressure in the secondary chamber **10** of the collector **8** which is communicated by way of the communicating passage **11** with the primary chamber **9** thereof. Thus, the coolant may be introduced in a proper amount accordingly, so that the breakage in the cooling system or reduction in the performance thereof due to freezing may be avoided, with the result of the stable performance. Furthermore, the coolant collector **8** and the pressure control valve portion **14** are provided integrally with each other, with the pressure of the coolant in the collector **8** being exerted on the side of spindle **15** of the bellows **16**, so that the movement of the spindle **15** may be controlled by ballancing the pressure in the collector **8** and the spring force of spring **17**, thereby controlling the flow rate of coolant, thus controlling the internal pressure in the evaporator **6**. It is natural that the critical pressure may be set up by exerting the spring pressure on the bellows **16** by turning the adjusting screw **18**. Now, suppose that a letter A represents the effective area of bellows **16**, K the spring constant of spring **17**, P the gas pressure sealingly filled in the heat sensitive chamber **20** of the expansion valve portion **4**, F the spring pressure at the time of set up, and ΔL the torsion of the spring during its operation (the movement of the spindle), then an equation $P \times A = F + K \times \Delta L$ will be obtained, in which the critical pressure is obtained as $\Delta L = 0$, and then $P = F/A$. This pressure can be utilized as the value for avoiding the frosting. Thus, the heater portion of the evaporator **6** is used as a part of the expansion valve portion **4** and pressure control valve portion **14**, so that the construction of the control system may be rendered simple and compact. In this case, if the pressure control valve portion **14** may be integrally formed under the collector **8**, considering the fluidity of the internal liquid within the expansion valve control portion **4** and pressure control valve portion **14**, then the circulation of the coolant to the compressor will be facilitated, without causing a trouble in the compressor due to oil shortage. In addition, this brings about another advantage that no oil return passage is required, although such a passage is essential where the expansion valve control portion **4** and the constant pressure control valve portion **14** are separately provided, and that no oil sump is required in the piping.

FIG. **3** shows a modification of the device of FIG. **2**. This is discriminative from FIG. **2** in that a communicating passage **11** is provided in the body proper **19** of the device, which comprises the expansion valve control mechanism and pressure control valve mechanism, in a manner to communicate the secondary chamber **10** of collector **8** with the outlet port **21** of pressure control valve, and the actuation of the expansion valve **5** is effected by a pressure difference caused between the aforesaid output port **21** of pressure control valve (the pressure in the secondary chamber **10**) and the diaphragm portion. This is most advantageous where the characteristics in the heat sensitive members of diaphragm and that of the secondary pressure portion do not present the equlibrium in temperature and pressure such as shown in FIG. **4**. In FIG. **4**, Pe is representative of the secondary pressure in the diaphragm, Pt a heat sensitive pressure in the diaphragm, Q a heat load in the evaporator **6**, and ΔP a critical pressure difference, and if the pressure difference becomes larger than the critical pressure difference, then the expansion valve **5** is brought into its fully open position. In the device of FIG. **2**, it is required that the valve rod of expansion valve **5** be forced downwardly so as to keep opening the orifice by overcoming the evaporating pressure, i.e., the critical pressure, or the pressure control valve pressure. On the other hand, in the device of FIG. **3**, since the pressure lower than the pressure of the low pressure control valve acts on the diaphragm, the relationship as plotted in FIG. **4** is not required in a strict sense. Accordingly, if the controlling valve actuating range is set to a point just above the critical freezing point, no accurate control means is required, and thus the ready manufacture of the control valve will result.

In FIG. **4**, represented by Pe is the secondary pressure of the coolant, which is the pressure in the secondary chamber **10** of FIGS. **2** and **3**. Represented by Pt is the pressure corresponding to the change in the coolant temperature in the primary chamber **9** or the collector **8**. As the pressure in the evaporator decreases, the pressure in the secondary chamber **10** decreases, thereby opening the expansion valve. With the temperature drop, the expansion valve will be closed. The aforesaid pressure Pe and Pt act on the expansion valve in a manner that the pressure Pt acts to open the valve and the pressure Pe acts to close the valve. Accordingly, the pressure difference ΔP between Pt and Pe may be referred to as an open angle of the expansion valve. When the heat load is decreased to less than Q1, in other words, when ambient temperature is dropped, the pressure control valve will be brought into actuation. By the action of the pressure control valve, the pressure Pe remains at a given pressure level. Depending upon the operational conditions, the pressures Pt and Pe will have a close access to each other. At this time, hunting may occure, with the accompanying vibration of the constant pressure controlling valve. To avoid such a phenomenon, the difference between Pt and Pe should be large. It is preferable from this viewpoint that the outlet port **21** of pressure control valve be communicated with the secondary chamber **10** as shown in FIG. **3.**

FIG. **5** is an enlarged view of the spindle **15** of FIGS. **2** and **3.** The spindle **15** has a cylindrical bore **30** provided centrally thereof and communicating by way of orifices **31** with space **33.** The pressure of coolant is transmitted through said orifices, via the outside of a flange **35** serving as a resistor, and via the outside of a stopper **37** or through a cut-away portion **39,** and eventually to the bellows **16.** The reason why the pressure of the coolant introduced in the collector **8** from the evaporator is applied via the resistor means to the bellows **16** is that the bellows **16** may be controlled for its responsiveness, and the vibration of the spindle **15** may be prevented.

FIG. **6** illustrates a further embodiment of the present invention. In this embodiment, the expansion valve control portion is provided independently, likewise in the conventional device, while the collector **8** for collecting the coolant from the evaporator and the pressure control valve portion **14** are formed integrally with each other. Such a construction is also advantageous from the viewpoint of performance. The efficacy of the device will be greatly increased by providing the expansion valve integrally with the pressure control valve portion, as shown in FIGS. **2** or **3.** In FIG. **6,** the distributors for supplying the coolant to the expansion valve and the evaporator are separately provided one from another. The spindle **15** is the same in construction as that of FIG. **5.**

Although the expansion valve and the pressure control valve in FIGS. **2** and **3** are formed integrally, it is recommendable that the manufacture and the testing be individually carried out, after which those members be assembled together, with mechanical sealing rings being interposed therebetween for preventing the leakage of the coolant therefrom.

What is claimed is:

1. A pressure control valve for:

a cooling system having,

a compressor for compressing a coolant,

a condenser for condensing the coolant compressed in said compressor into a liquid,

a liquid receiver for separating the coolant from the condenser into liquid and gas,

an expansion valve for subjecting the liquid coolant from the liquid receiver to expansion,

an evaporator for causing heat-exchange between coolant gas from the expansion valve and air,

a pressure control valve for maintaining the pressure in the evaporator at a level higher than a predetermined level, and

means for returning the coolant gas from said pressure control valve to the compressor; characterized by that

said evaporator includes a plurality of coolant gas passages arranged in parallel and a collector for collecting the coolant flowing through said plurality of the coolant gas passages;

a housing mechanically connected with said collector;

a biasing means provided in said housing, said biasing means having one side, to which is exerted the gas pressure in the collector;

a spring for exerting a force on the other side of said biasing means;

an adjusting screw for adjusting the pressure of the spring; and

a valve means provided between the collector and the means for returning the coolant to the compressor and having an opening capable for varying its size.

2. A pressure control valve as defined in claim **1,** wherein said valve means has a substantially cylindrical bore communicating with said collector, and a substantially cylindrical movable means retained within said cylindrical bore and adapted to be moved by said biasing means;

said substantially cylindrical bore communicating with said collector and having a diametrically enlarged space at a predetermined distance apart from said collector;

an exit port provided through said housing so as to communicate to said diametrically enlarged portion for discharging the coolant gas;

said movable means actuated by said biasing means being provided with a notched portion near to the collector;

whereby said ports is brought into communication by way of said notched portions when said movable means is urged under the pressure in the collector towards said spring.

3. A pressure control valve as defined in claim **2,** wherein said biasing means being adapted to air-tightly seal a portion between said substantially cylindrical movable means and said spring so as not to cause a leakage of gas, and said movable means is provided with a cylindrical inner bore, through which the gas pressure in said collector is exerted on the side of movable means of said biasing means.

4. A pressure control valve as defined in claim **3,** wherein said spring urging at its one end thereof said biasing means to the side of collector and being retained at the other end by the adjusting screw provided in the housing, said spring being changable in length due to rotation of said adjusting screw.

5. A pressure controlling valve as defined in claim **4,** wherein a diaphragm is provided in said collector chamber, said diaphragm having one surface, to which is applied the pressure in the collector chamber and the other surface, to which is applied the pressure in the collector by way of a passage having a large resistance, said diaphragm holding the gas or liquid expansible with the temperature rise, and controlling the expansion valve by biasing the other surface of the diaphragm.

6. A pressure control valve as defined in claim **5,** wherein said biasing means indudes a bellows, and a passage communicating said bellows with said collector having a cylindrical central bore provided in the center of said movable means and, a resistive passage crossing said movable means and formed between said movable means and an inner wall of said cylindrical bore of said housing which is adjacent to the bellows.

7. A pressure control valve as defined in claim **4,** wherein one side of said diaphragm constituting a wall of the collecting chamber and the other side thereof constituting a wall of other space, and other space being communicated by way of passages with an outlet port of said pressure control valve.

8. A pressure control valve as defined in claim **6,** wherein said biasing means consists of a bellows, and a passage communicating the bellows with the collecting chamber having a cylindrical central bore provided in the movable means, and a resistive passage crossing said movable means and formed between said movable means and an inner wall of said cylindrical bore of said housing which is adjacent to the bellows.

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