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[54] **VALVE ARRANGEMENT FOR A COOLING SYSTEM**

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[30] **Foreign Application Priority Data**

Oct. 6, 1970 Germany .... P 20 48 963.8

[52] **U.S. Cl.** **62/223,** 62/224, 62/514, 137/596

[51] **Int. Cl.** **F25b 19/00**

[58] **Field of Search** 62/64, 216, 222, 62/223, 217; 137/596.18, 596.1, 596, 627.5, 636; 251/285

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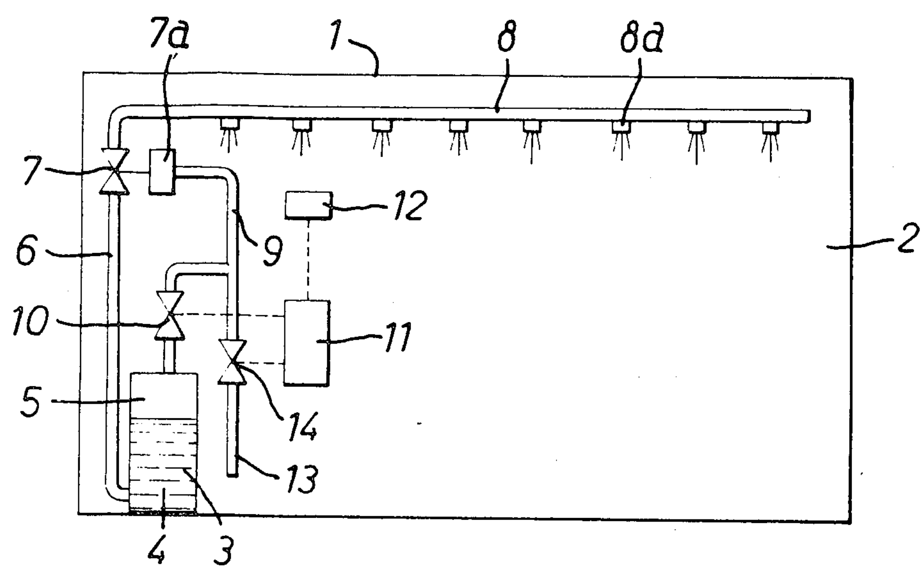
[57] **ABSTRACT**

The invention relates to a valve assembly for a cooling system. The cooling system has a container containing liquid nitrogen under pressure which is to be distributed in vapor form to an enclosed space to be cooled. The valve assembly includes a main valve and pressure operated means for operating the main valve which means utilizes the vapor pressure of the nitrogen in the container referred to above. Two auxiliary valves are provided which are actuated in unison in response to temperature changes in the space to be cooled. The auxiliary valves control the application of pressurized nitrogen vapor to the main valve operating means.

1 Claim, 3 Drawing Figures



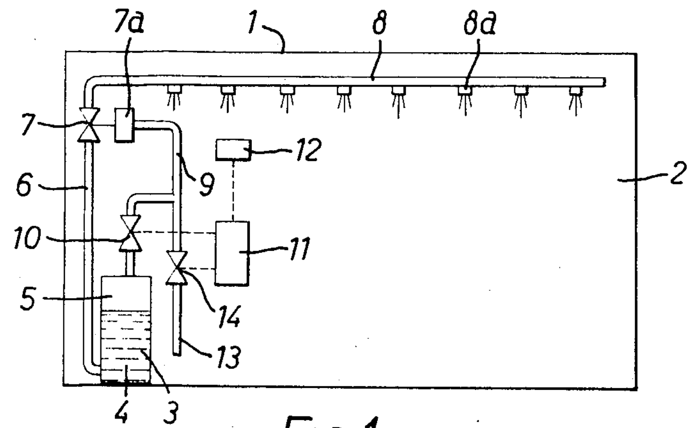

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FIG. 1

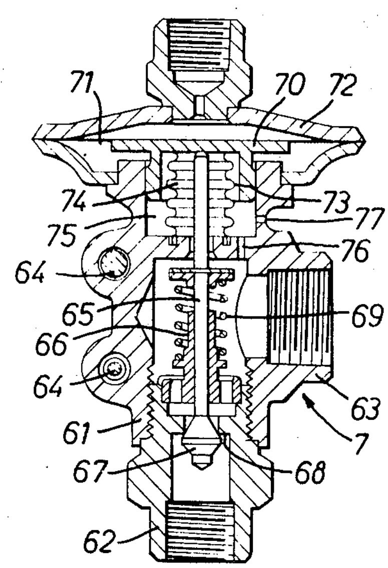
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FIG. 3

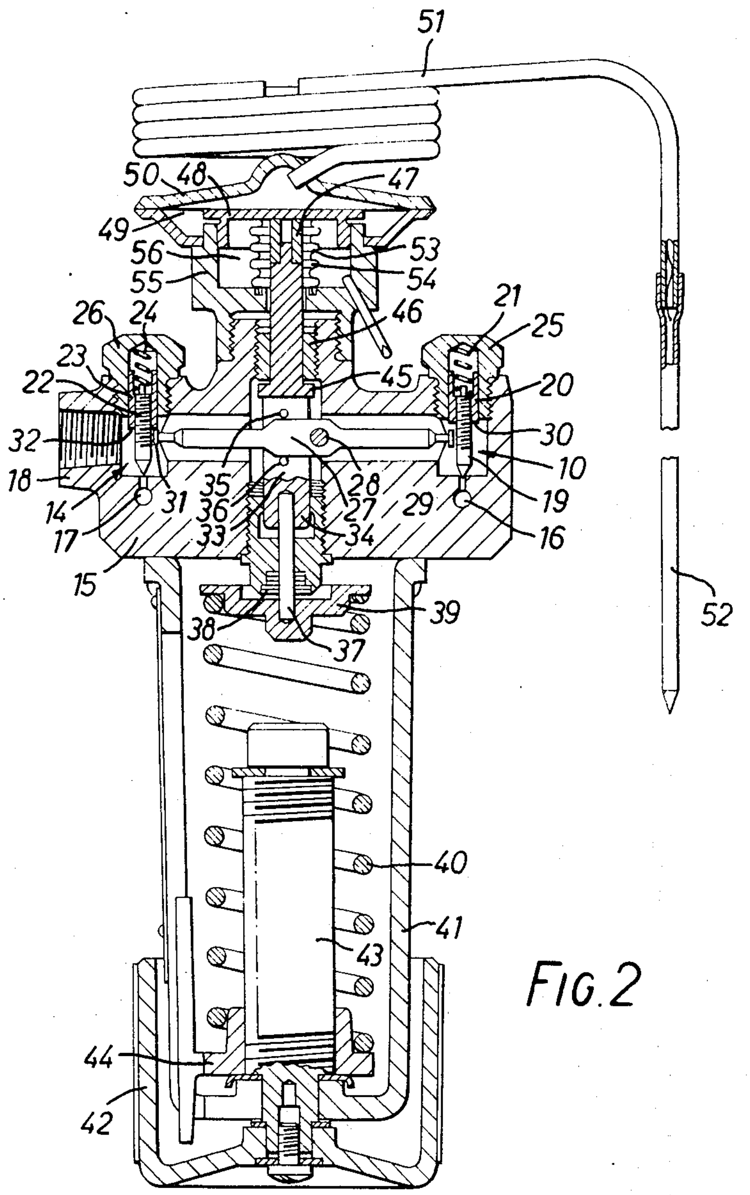
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FIG. 2

VALVE ARRANGEMENT FOR A COOLING SYSTEM

The invention relates to a valve arrangement for a cooling system and comprising a pressure-actuated main valve for supplying refrigerant, particularly liquid nitrogen, and an auxiliary valve which is operated in dependence upon temperature and is supplied with a pressurized medium, in particular the refrigerant itself, the outlet of the auxiliary valve being connected to the pressure pick-off of the main valve and to an air-exhaust passage.

For cooling container vehicles, trailers and the like it is often required to provide a cooling system that is independent of an outside source of energy. Thus, it is known practice for the compartment to be cooled to be provided with a container of liquid nitrogen which is sprayed directly into the cold compartment through nozzle pipes in dependence upon the position of the main valve, when the temperature in the cold compartment rises. For the purpose of actuating the main valve use is made of gaseous nitrogen from the same container, the gas being passed through the auxiliary valve into the pressure pick-off of the main valve. The position of the auxiliary valve is controlled by a temperature sensor in the cold compartment, and this valve forms a first flow-restricting point in the control system. Nitrogen may pass into the cold compartment by way of an "air-exhaust passage," i.e., a second flow-restricting point. Thus, in dependence upon the auxiliary valve an intermediate pressure dependent upon the temperature of the cold compartment is set up between the two flow-restricting points, this intermediate pressure causing a corresponding opening of the main valve to a greater or less extent.

It has been found that this valve arrangement does not enable the refrigerant to be uniformly distributed in the cold compartment. If the main valve is not fully opened, the liquid nitrogen only reaches some of the outlet nozzles, the other nozzles receiving no supply of the gas. The uneven distribution of refrigerant also affects the accuracy of operation of the temperature sensor in the cold compartment. Furthermore, relatively long periods are required for adjustment to take place; thus, after a door has been opened, quite a long time elapses before the required temperature is reached again. Also, a considerable part of the refrigerant is often consumed as the operating pressurized medium, and this part is therefore not available for the normal work of cooling.

The object of the invention is to provide a valve arrangement of the initially described kind in which the refrigerant is always uniformly distributed over the outlet nozzles, the periods required for adjustment are shorter, and smaller quantities of pressurized medium suffice for actuating the main valve.

According to the invention, this object is achieved by blocking the air-exhaust passage by means of a valve which operates in a sense contrary to that of the auxiliary valve and opens when the auxiliary valve is closed.

When in this arrangement the auxiliary valve opens, because of the closed air-exhaust passage, the entire pressure of the pressurized medium, i.e., the entire nitrogen-vapour pressure, for instance, obtains in the container. The main valve is therefore fully opened with the result that all the nozzles are uniformly supplied with refrigerant. The required temperature in the compartment is reached after only a short period. If the auxiliary valve then closes, the air-exhaust valve opens and the pressure in the control system equates with the pressure in the cold compartment. The main valve therefore moves into the closed position without delay. Continuous loss of pressurized medium is avoided. Only that part of the pressurized medium located between the auxiliary valve and the main valve is lost during each adjusting operation.

It is advantageous if, during operation in opposite directions, the closing ranges of the two valves, that is of the auxiliary valve and the air-exhaust valve, overlap. This ensures that the air-exhaust valve is actually closed before the auxiliary valve opens.

Expediently, the auxiliary valve and the air-exhaust valve are adjusted in opposite directions by a common actuating element. The actuating element may for example act on a double-armed lever, of which one arm moves the auxiliary valve and the other the air-exhaust valve. In this arrangement, the actuating element may engage near the pivotal point of the lever so that even slight movements of the actuating element lead to adjustment of the valve.

It is particularly advantageous if there is lost motion between the ends of the lever and a drive face on each of the two valves. Overlapping of the closing ranges of the two valves can be achieved in a simple manner with the help of this lost-motion arrangement.

The spring-biased closure member of at least one valve may be displaceable in a sleeve on which the drive face is formed. The required lost motion can be readily set if this step is taken.

A further possible way of carrying out adjustment is provided if the actuating element is a spindle with a stop surface which in one of its end positions bears against an adjustable stop in the common valve casing. The adjustable stop enables the double-armed lever to be set in the correct initial position.

In a preferred construction the lever is fitted in a passage connecting the auxiliary valve and the air-exhaust valve, the actuating element is loaded in known manner on one side by a diaphragm pressure element connected to a temperature sensor and on the other by a rated-value spring, and that end of the actuating element presented to the diaphragm is surrounded by a bellows which tightly seals off the space accommodating the actuating element and communicating with the passage and which has a small area in comparison with the area of the diaphragm. The area of the bellows may be 10 to 12 times smaller than the area of the diaphragm for example. Thus, whenever the full control pressure obtains in the connecting passage, this pressure can act only on a small area and cannot therefore interfere wih the regulating action.

The space surrounding the bellows is preferably sealed off tightly against the surrounding atmosphere and is filled with gas at a pressure lower than that of the pressurized medium. The gas pressure may also be less than one atmosphere. This arrangement is of advantage in the case of containers that are exposed to different atmospheric pressures, for example those containers transported in aircraft. The thermostatic system is not adversely affected by these differences in atmospheric pressure.

In a further form of the invention, a flow-restricting passage can lead from the outlet side of the main valve to the surrounding atmosphere by way of cavities in the valve which do not form part of the actuating pressurized medium system or of the controlled refrigerant system. In this way, all the cavities of the valve are acted upon by the refrigerant, even though this is not necessary for functional purposes, so that any accumulation of moisture in the valve that could lead to the formation of ice is prevented. Important in this connetion is that the refrigerant used for flushing purposes is taken from the main system and not from the control system.

In particular, the spindle of the main valve may in known manner be loaded on the one side by a diaphragm pressure unit connected to the auxiliary valve and on the other by a spring, that end of the valve spindle presented to the diaphragm can be surrounded by a bellows which tightly seals off the space accommodating the spindle and has an area that is small in comparison with the area of the diaphragm, and the bellows can surround a space which is substantially sealed off from the surrounding atmosphere and through which the flow-restricting passage extends. If the flow-restricting passage has a flow-restricting point upstream and downstream of the sealed-off space, the first of which points provides greater restriction than the second, then the pressure in the sealed-off space is only slightly above atmospheric pressure. With the help of the bellows the counter-action, on the diaphragm pressure unit, of the refrigerant to be controlled is reduced to a minimum. The flushing action of the refrigerant prevents the accumulation of moisture in the space surrounding the bellows.

The invention will now be described in more detail by reference to an embodiment illustrated in the drawing, in which:

FIG. 1 illustrates schematically a transport container fitted with the arrangement of the invention,

FIG. 2 is a longitudinal section through a valve casing which accommodates the auxiliary valve and the air-exhaust valve, and

FIG. 3 shows a longitudinal section through a main valve.

FIG. 1 illustrates a transport container 1 the interior 2 of which is to be cooled. For this purpose, there is provided a container 3 with liquid nitrogen 4 therein which is under the pressure of the nitrogen vapour 5. A pipe 6 runs from the nitrogen container through a main valve 7 to a distributing pipe 8. This is fitted with nozzles 8a from which liquid nitrogen is sprayed into the compartment 2 when the valve 7 is opened and vaporizes in said compartment to produce cold.

The main valve 7 is actuated by a pressure pick-off 7a which may be acted upon by nitrogen vapour 5 by way of a control pipe 9 when an auxiliary valve 10 is opened. This auxiliary valve is opened by an actuating device 11 in dependence upon a compartment-temperature sensor 12. Connected to the control pipe 9 is an air-exhaust pipe 13 with an air-exhaust valve 14. This valve is closed when the auxiliary valve 10 is open, and is opened when the auxiliary valve 10 is closed.

Consequently, either the full nitrogen pressure or the pressure of the compartment 2 obtains in the control pipe 9. The main valve is therefore either closed or fully opened. It merely has an on-off function. When the main valve 7 is opened, the flow-restricting effect is so slight that liquid nitrogen reaches the last nozzle *8a* along the distributing pipe 8.

FIG. 2 shows a casing 15 which accommodates the auxiliary valve 10 and the air-exhaust valve 14. A bore 16 leads to a connecting port which is connected to the vapour compartment of the container 3. A bore 17 leads to a port which is connected to the air-exhaust pipe 13. A port 18 is for connecting the control pipe 9.

The auxiliary valve 10 has a closure member 19 which is adapted to be screwed into a sleeve 20 and is biased by a spring 21. The air-exhaust valve is similarly constructed; it has a closure member 22 which is adapted to be screwed into a sleeve 23 and may be biased by a spring 24. The valves are guided in inserts 25 and 26. The two valves are actuated by a double-armed lever 27 which is adapted to swing about a pivotal point 28 solid with the casing. One end 29 of the lever, after passing through a lost-motion phase, is enabled to engage a drive face 30 on the sleeve 20, while the end 31 of the lever engages a drive face 32 on the sleeve 23. By altering the position of the sleeves 20 or 23 the lost motion and the valve setting can be adjusted.

The lever 27 extends through a slot 33 in an actuating element 34 and is driven by two pins 35 and 36 extending through the slot. The lower end of the actuating element is provided with a pin 37 which extends through a gland 38 and is provided at its outer end with a dished element 39. Against the dished element there presses a rated-value spring 40 which is accommodated in a casing attachment 41 and can be set to a predetermined value with the help of a hand wheel 42, a screw 43 and a screw-on backing element 44. The spring 40 is enabled to press a collar 45 on the actuating element 34 against a sleeve 46 which is adapted to be screwed into the casing 15. The inoperative position of the valve combination can be set with the help of this sleeve. In this inoperative position the double-armed lever 27 should hold the air-exhaust valve 14 open.

At the upper end of the actuating element 34 there engages a diaphragm 49 of a pressure unit 50, a distance sleeve 47 and a pressure cap 48 being interposed between the actuating element and the diaphragm. The pressure unit is connected to a temperature sensor 52 by way of a capillary tube 51. The sensing system contains CO_2 for example and, in the sensor, an absorption medium in the form of activated carbon. The upper end of the actuating element 34 and the distance sleeve 47 are surrounded by a bellows 53 which tightly seals off the space 54 accommodating the actuating element. The bellows is surrounded by an attachment 55 which together with the bellows and the diaphragm defines a chamber 56 sealed off against the exterior. This chamber is filled with a dry gas which has a lower pressure than atmospheric pressure. If only a very slight quantity of gas is present, the chamber can be regarded as being evacuated.

When the temperature in the cold compartment rises the pressure in the pressure unit 50 increases. The actuating element 34 is moved downwards. The air-exhaust valve 14 closes and then the auxiliary valve 10 opens. Nitrogen vapour 5 then flows into the control pipe 9. The high pressure also affects the space 54. Hoever since this space has only a small cross-sectional area in comparison with the diaphragm 49, interference is slight. In the chamber 56 there obtains a constant pressure which can be easily taken into acount during adjustment. If the temperature drops at a later stage, first the auxiliary valve 10 closes whereupon the air-exhaust valve 14 opens.

The main valve 7 illustrated in FIG. 3 has a casing 61 with an inlet port 62 and an outlet port 63. It is secured by means of screws **64.** A valve spindle **65** is held in a guide **66** solid with the casing. The closure member **67** cooperates with the valve seat **68.** The spindle **65** is acted upon at one end by a spring **69** and by a diaphragm **71** at the other end, a pressure cap **70** being fitted between the spindle and the diaphragm which is part of a pressure unit **72.** The control pipe **9** is connected to the port of this pressure unit.

The upper part of the spindle **65** is surrounded by a bellows **73** so that a space **74** is formed which communicates with the outlet side of the working chamber of the valve. The casing together with the diaphragm **71** and the bellows **73** forms a chamber **75.** This chamber **75** is substantially sealed off against the surrounding atmosphere. It is located along a flow-resisting passage which consists of the sections **76** and **77.** In section **76** the flow-restricting action is greater than in section **77.** The valve **7** is normally closed. The pressure in the compartment **2** then obtains in the workin chamber of the valve, in the passage sections **76** and **77** and in the chamber **75.** It is also possible for atmospheric air to pass through section **77** of the passage and into the chamber **75.** If nitrogen vapour is passed to the pressure unit **72** by way of the control valve **9,** the valve **7** opens fully and supplies liquid nitrogen to all the nozzles 8a. A very small quantity of nitrogen flows out through the passage sections **76** and **77.** During the flow-restricting action the nitrogen vaporizes and carries any moisture out of the chamber **75.** The pressure-drop at the flow-restricting point **76** results in so low a pressure in the chamber **75** that the control is not noticeably influenced by the pressure in the pressure unit **72.** The same purpose is served by the bellows **74** having a cross-sectional area which is only about one-twelfth of the area of the diaphragm.

It is not necessary for the valves **10** and **14** to be combined in a single unit and to be operated by a single actuating element. Instead, individual valves can be used and operated in opposite directions through stepping lines.

I claim:

1. A valve assembly for a cooling system comprising a container for storing a refrigerant under pressure, main valve means and first auxiliary valve means connected to said container, pressure operated valve operating means connected to said main valve means, main conduit means between said pressure operated valve operating means and said first auxiliary valve means, branch conduit means extending from said main conduit means for venting said main conduit means, second auxiliary valve means in said branch conduit means for controlling said venting, temperature responsive means for actuating said first and second auxiliary valve means, said auxiliary valve means including a common double armed lever for displacing said first and second auxiliary valve means in opposite directions, said first and second auxiliary valve means having overlapping ranges and being oppositely actuatable so that one is fully opened when the other is fully closed and vice versa.

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