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VALVE UNIT

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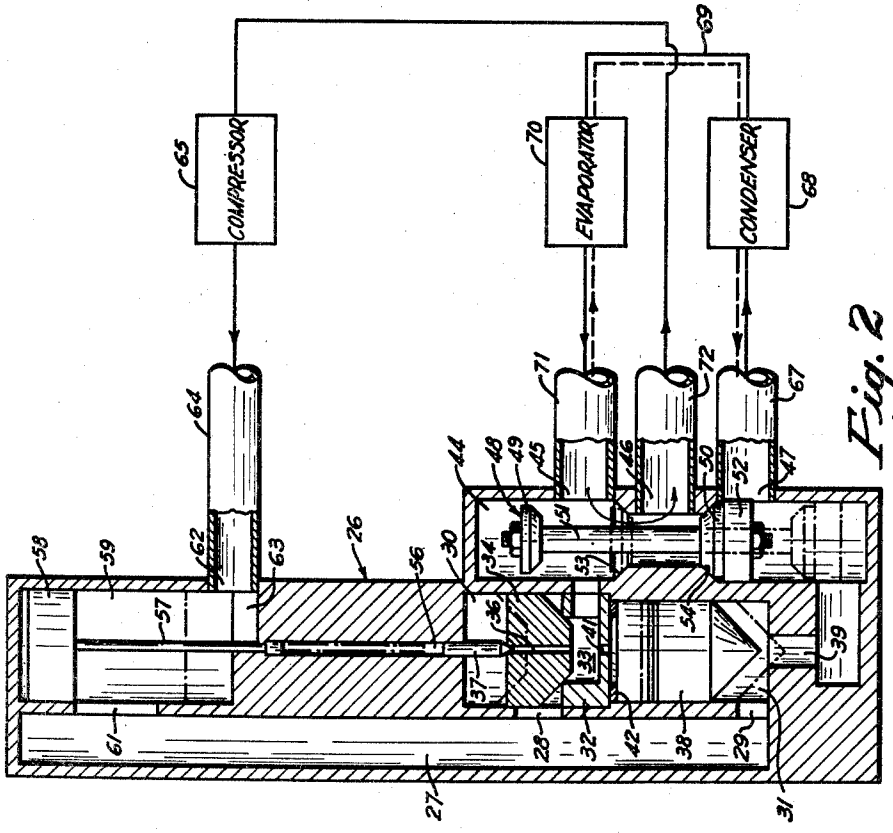


Fig. 2

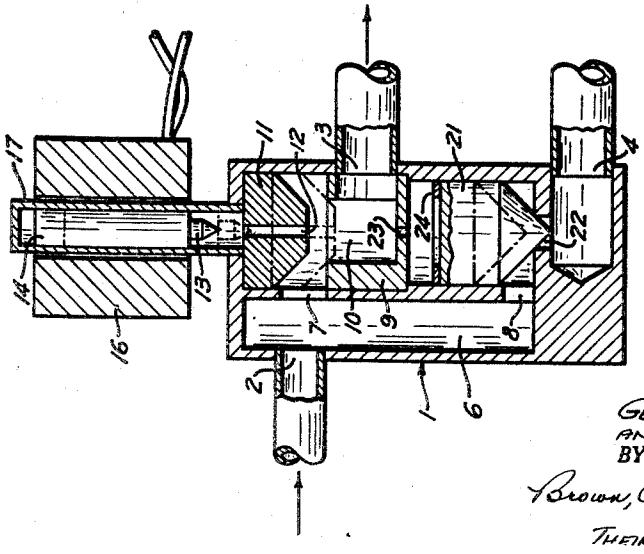


Fig. 1

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VALVE UNIT

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This invention relates to valves, and more particularly to those suitable for use when a reversing valve is needed, such as in reverse cycle refrigeration systems.

In a reverse cycle refrigeration system, defrosting of the evaporator or freezing unit is accomplished by delivering hot compressed refrigerant gas directly to the evaporator. This is done by reversing part of the flow in the system by means of a valve unit, which heretofore has allowed the sudden surge of compressed gas from the condenser at the moment of reversal to impact against the compressor. Also such valve units have been rather complicated and expensive, because the different movable elements therein have been linked together mechanically, thereby requiring a considerable degree of accuracy in making the valves. Also, in the past, the alternate reversing and return of the system to normal flow has had to be done either manually or by timing devices.

It is among the objects of this invention to provide a multiple outlet valve unit which may be operated automatically without the use of external timing devices, which can readily be controlled with a small amount of energy, in which the movable elements follow the path of least resistance to fluid flow, in which the different movable elements are not physically connected with one another in any way, in which the movable elements seat fully and gently in all positions, and which when used as a reversing valve in a pressurized system will permit surge pressure to be dissipated at points of lowest pressure in the system without first passing through the compressor or pump.

The invention is illustrated in the accompanying drawings, in which

Fig. 1 is a central longitudinal section through a three-way valve unit; and

Fig. 2 is a similar section through a four-way valve unit forming part of a reverse cycle refrigeration system.

Referring to Fig. 1 of the drawings, a valve housing 1 is provided with an inlet 2 and two outlets 3 and 4. The inlet opens into the upper part of a vertical passage 6, the opposite side of which has upper and lower outlet ports. The upper port 7 opens into the side of an upper chamber and the lower port 8 opens into the side of the lower part of a lower chamber. The two chambers are separated by a partition block 9, which has a passage 10 through it connecting the upper chamber with the upper outlet 3 of the valve housing. Around the upper end of this passage, the block forms a seat for the tapered lower part of a control valve 11 that can slide up and down in the upper chamber. The control valve preferably is provided with a central vertical passage 12 through it. When the valve is on the seat, the upper end of this passage is closed by a closure pin 13 on the lower end of the core 14 of a solenoid coil 16. The coil encircles a vertical tube 17 mounted on top of the valve housing and having a closed upper end. The solenoid core is raised in this tube when the coil is energized, as shown.

Slidable vertically in the lower chamber of the housing is a floating valve 21, by which is meant a valve that is actuated only by fluid pressure, gravity or spring pressure. Its lower part is tapered downward and normally closes the upper end of a passage 22 that connects the lower chamber with the lower outlet 4 of the valve. The bottom of the block 9 above this valve has a small opening 23 through it connecting the upper and lower chambers. The top of the floating valve preferably carries a gasket 24, which engages the bottom of the block when the valve is raised.

When this valve unit is not in use, both the control valve 11 and the floating valve 21 will be in their lower positions, where they are held by gravity, and closure pin 13 will be resting on top of the control valve. As soon as fluid under pressure is delivered to the inlet 2 of the valve housing, it will raise the floating valve to its dotted line position because the space above it is connected by the small opening 23 with the lower pressure at the upper outlet 3. With the floating valve raised, flow is through the main passage 22 connecting port 8 with the lower outlet 4.

When it is desired to shut off the lower outlet and open the upper one, the solenoid is energized, which causes its core and closure pin to rise. As soon as the pin leaves the top of the control valve, the space above that valve is connected through its central passage 12 with the lower pressure at the upper outlet. This, in combination with the pressure in the upper chamber around the bottom of the control valve, causes it to rise to the top of the chamber as shown and to open the alternate main passage 10 between the port 7 and the upper outlet 3. At the same time, the fluid pressure on top of floating valve 21 is equalized with that below it, because opening 23 connects the upper chamber with the lower chamber above that valve. The floating valve therefore will descend by gravity and close the main passage between the inlet and the lower outlet. The rate of descent of the floating valve can be controlled by the size of opening 23.

As soon as the solenoid is deenergized, its core and closure pin will drop and close the passage through the control valve. The weight of this unit will cause it to descend, because the fluid from the housing inlet will leak up around the control valve and equalize the pressure at its top and bottom. When the control valve reaches block 9 and closes the alternate main passage 10, the fluid pressure from the inlet will again force the floating valve to rise and open the main passage 22.

It will be seen that this valve can be controlled very simply by merely raising and lowering the pin 13 that closes the passage through control valve 11. Fluid pressure in the valve housing or gravity then causes the control valve and floating valve to move to their proper positions. As there are no mechanical connections between the control valve and the floating valve, there is nothing to get out of adjustment, and construction of the valve unit is greatly simplified. Of course, the control valve can be raised and lowered in many other ways, either manually or mechanically, an automatic way of controlling it being illustrated in Fig. 2. Whenever the control valve moves from one of its positions to the other, gravity or the fluid pressure within the valve housing moves the floating valve in the opposite direction. An important feature is that the valves are not moved toward their seats either by or against fluid pressure, but simply by gravity, although springs could be used to assist gravity or even to take its place if the valves moved horizontally instead of vertically. This insures quiet and gentle closing of the valves with little effort. Nevertheless, once the valves reach their seats, the pressure differential between their tops and bottoms imme-

diately increases materially and the valves are held on their seats tightly by fluid pressure. The valves always move in the direction of least resistance.

A three-way valve unit of the type just described can be converted into a four-way reversing valve unit by adding to it another floating valve and another outlet. Such a valve unit is shown in Fig. 2. In the particular one illustrated, the valve housing **26** is taller than before, and the lower part of the vertical passage **27** along one side is provided with a pair of vertically spaced ports **28** and **29**. These ports open into two different chambers **30** and **31**, which are separated by a partition block **32**. The block is provided with a passage **33** through it, the upper end of which normally is closed by the tapered lower part of a control valve **34** that can move up and down in the upper chamber. Like the control valve previously described, this one may have a central vertical passage **36** through it which normally is closed by a closure pin **37** resting on the top of the valve.

Slidable vertically in the lower chamber is a main floating valve **38**, the tapered lower end of which normally closes the upper end of a passage **39** at the bottom of the chamber. The two chambers **30** and **31** are in communication with each other at certain times through a small opening **41** in the bottom of partition block **32**. This opening is closed by the floating valve when it is in its upper position, the top of the valve preferably carrying a gasket **42** that engages the bottom of the block around the opening.

The outlets from the two chambers open into the upper and lower portions of a vertically extending chamber **44**, with which the valve housing is provided at the side opposite to passage **27**. This chamber is connected with the outside of the valve unit by three vertically spaced ports **45**, **46** and **47** designed for connection in a fluid circulating system. Chamber **44** also contains a secondary floating valve **48**, which has opposed upper and lower valve members **49** and **50** rigidly connected by a vertical stem **51** that is considerably smaller than the smallest part of the chamber. A piston **52** is mounted on the lower part of this valve below the lower valve member. The central portion of chamber **44** is reduced in diameter in order to provide valve seats **53** and **54** above and below the middle port **46**, which always serves as an outlet from the housing. When the floating valve is in its lower position, shown in dotted lines, its upper valve member **49** rests on the upper seat **53**, and the lower valve member **50** is located below the lower port **47**, but passage **39** remains in communication with chamber **44** below piston **52**. The middle and lower ports are connected through the chamber around the valve stem. When fluid pressure is admitted to the lower end of the chamber below the valve piston, the secondary floating valve is forced upward until its lower valve member **50** engages the lower seat **54**. This places the upper port **45** in communication with the middle port. As will be shown presently, the upper and lower ports alternate as inlets and outlets.

The control valve **34** may be raised in the same manner as shown in Fig. 1 or in some other way. When this reversing valve unit is used in a reverse cycle refrigeration system, it is preferred to operate the control valve automatically in the manner shown in Fig. 2. It will be observed that closure pin **37** is slidable vertically in a vertical bore **56** in the valve housing above the control valve. Also slidable in this bore is the enlarged lower end of a piston rod **57**, the upper end of which extends up out of the bore and is connected to the bottom of a piston **58** in a cylinder **59**, with which the top of the valve housing is provided. When the piston is in its lower dotted line position, it rests on the bottom of the cylinder beneath an outlet port **61**, which connects the side of the cylinder with the upper part of housing passage **27**. An inlet port **62** to the cylinder is formed in the opposite side of the housing and extends into a recess **63** below the piston. In a refrigeration system this inlet port is connected by a pipe **64** with the outlet of the compressor **65**.

When compressed gas from the compressor is delivered to the inlet of cylinder **59**, it forces the piston towards the top of the cylinder and thereby raises the stem **57** in the bore **56**. The sudden rising of the enlarged lower end of the stem creates a partial vacuum in the bore and thereby draws closure pin **37** up into the bore. As soon as passage **36** through the control valve is opened, the space above it is connected with the lower pressure in the upper part of chamber **44** above the secondary floating valve **48**, which at that time is in its lower position. The compressed gas around the lower part of the control valve forces it up to the top of upper chamber **30**. At this time the main floating valve also is in its lower position, so flow of compressed gas is through port **28** and the alternate main passage **33** to upper port **45**. Due to a loose fit of closure pin **37** in the housing bore, the pin slowly descends and closes the upper end of the passage through control valve **34**. As soon as this happens, the fluid pressure above and below that valve can equalize, and the valve will descend by gravity until it reaches its seat.

With the control valve closed and the top of lower chamber **31** connected by opening **41** with the lower pressure at port **45**, the compressed gas in the lower part of the lower chamber forces main floating valve **38** to rise and admit gas through main passage **39** to chamber **44** below the secondary floating valve. The pressure will raise the secondary valve until its lower valve member **50** engages its seat **54** as shown in full lines, and the flow then will be through the main passage **39** from port **29** to the lower port **47**. The flow is from that port through a pipe **67** to the condenser **68**, a pipe **69**, the evaporator **70**, back through a pipe **71** to upper port **45** and out through middle port **46** through pipe **72** to the inlet of the compressor. Refrigeration will take place as long as the flow is in this direction.

When enough cold has been produced, the compressor will stop and the control piston **58** will descend in its cylinder. The secondary floating valve **48** likewise will drop to its lower position. When the system calls for cold again, the compressor will start operating and that will raise the control piston, resulting as explained before in the rise of the control valve and flow of hot compressed gas through upper chamber **30** and out through upper port **45** in reverse direction through the evaporator and condenser, and then in through lower port **47** and out through the middle port to the compressor. This reversed flow of hot gas will defrost the evaporator by the time the control valve descends and causes the valve unit to reverse so that flow will be through its lower main passage **39** to lower port **47**. The length of the defrosting period is determined by the rate of descent of closure pin **37**, and that depends on the fit of the pin in bore **56**.

The control valve and main floating valve are operated by fluid pressure and gravity in exactly the same way as the corresponding valves in Fig. 1. The secondary floating valve **48**, which likewise is free of any mechanical connections, also is operated by fluid measure and gravity, although in all cases springs could be substituted for gravity if the valve unit is mounted horizontally instead of vertically. The movements of the secondary floating valve also are in the direction of least resistance and never against fluid pressure, but once seated, the valve is held firmly against its seat by fluid pressure.

An important feature of this reversing valve unit when it is used in a reverse cycle refrigeration system or similar fluid pressure system, where there is a sudden backward pressure surge through lower port **47** when control valve **34** opens alternate main passage **33** to reverse the flow, is that the surge is dissipated directly and very quickly to the lowest pressure point in the system. In a refrigeration system that point is the evaporator.

The gas surge from the compressor enters the evaporator without first having to go through the compressor, which would restrict the surge and possibly be damaged by it.

The manner in which our valve unit connects the backward surge from the condenser to the evaporator is as follows. At the moment control valve 34 rises to reverse the valve, the pressure surge entering the lower part of chamber 44 from the condenser will hold the floating valves 48 and 38 in their upper positions momentarily, and the compressed gas therefore will flow backward through main passage 39 and up through vertical passage 27 to port 28 and then through alternate main passage 33 and 45 to the evaporator. As soon as the surge is dissipated in this manner and the pressure above and below main floating valve 38 is equalized, that valve will descend and shut off the main passage 39. This will be followed immediately by dropping of the other floating valve, whereupon the flow from the condenser will be connected with only the compressor through ports 47 and 46 until the valve unit is shifted back to normal flow operation.

A similar backward surge into chamber 44 exists through upper port 45 when the valve unit is restored to normal refrigerating duty. At that time, control valve 34 closes secondary passage 33, and the pressure in passage 27 raises the main floating valve 38 so that fluid pressure will be applied to the bottom of secondary floating valve 48. As the latter valve rises, port 45 will be connected through the central part of chamber 44 with port 47 briefly until valve member 50 engages seat 54. During that brief period, the compressed gas that formerly was leaving the valve housing through port 45 will be free to escape to the lowest pressure point in the system at that moment, the condenser, through port 47. The pressure surge is dissipated in this manner without being required to first go through the compressor. Consequently, regardless of whether the valve unit is being reversed or returned to normal operating condition, the surge pressure is released directly to the lowest pressure point in the system.

According to the provisions of the patent statutes we have explained the principle of our invention and have illustrated and described what we now consider to represent its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. A valve unit for a fluid pressure line, comprising a housing having an inlet and main and alternate main flow passages communicating with the inlet, a control valve biased to close the alternate main passage, a floating valve for the main passage biased forward toward passage-closing position and movable backward by said line fluid pressure against the front surface of the floating valve to open it, means for causing said control valve to move and open said alternate main passage, and means for equalizing the fluid pressure on the opposite ends of the floating valve when the alternate main passage is opened, whereby the floating valve will close the main passage.

2. A valve unit for a fluid pressure line, comprising a housing having an inlet and main and alternate main flow passages communicating with the inlet, a control valve normally closing the alternate main passage, a floating valve normally closing the main passage and movable upwardly by said line fluid pressure beneath the floating valve to open it, the housing having an opening connecting the top of the floating valve with the alternate main passage at the downstream side of the control valve, and means for causing said control valve to move and open said alternate main passage, whereby the floating valve will descend and close the main passage.

3. A valve unit according to claim 1, in which said control valve is movable upwardly by said line fluid pressure beneath it to open the alternate main passage and is provided with a passage extending therethrough from top to bottom, a vertically movable closure member normally resting on the control valve and closing the upper end of its passage, and means for reducing the fluid pressure above said closure member to cause it to rise and open said control valve passage, said member having a loose fit in said housing so that it will slowly descend and close the upper end of the control valve passage again.

4. A valve unit according to claim 1, in which said control valve is movable upwardly by said line fluid pressure beneath it to open the alternate main passage and is provided with a passage extending therethrough from top to bottom, a vertically movable closure member normally resting on the control valve and closing the upper end of its passage, said housing having a vertical bore in which the closure member slides and a chamber above the bore, a piston in said chamber normally at the bottom thereof, and a stem secured to the bottom of the piston and extending down into said bore, said inlet communicating with the bottom of said chamber, and the inlet ends of said main and alternate main passages communicating with that chamber above the lowered piston, whereby when pressure fluid is delivered to said inlet the piston will be raised in its chamber to connect the inlet with said main and alternate main passages and to reduce the fluid pressure in said bore so that said closure member will rise and open said control valve passage, said member having a loose fit in said bore so that it will slowly descend and close the upper end of said control valve passage.

5. A four-way valve unit for a fluid pressure line, comprising a housing having an inlet and a row of three laterally spaced ports for fluid flow, the housing also having a chamber connecting the inner ends of all three ports together and provided with valve seats between the middle port and the outer ports, a main passage connecting said inlet with one end of the chamber, and an alternate main passage connecting the inlet with the other end of the chamber, a control valve normally closing the alternate main passage, a main floating valve for the main passage biased forward toward passage-closing position and movable backward by said line fluid pressure against the front surface of the floating valve to open it, a secondary floating valve in said chamber biased in one direction to close it between the middle port and one of the outer ports and movable in the opposite direction by fluid pressure in the main passage to cut off communication between the middle port and the other outer port, means for causing said control valve to move and open said alternate main passage, and means for increasing the fluid pressure against the back of the main floating valve when the alternate main passage is opened, whereby to move the main floating valve forward into said main passage-closing position.

6. A four-way valve unit according to claim 5, in which the secondary floating valve has valve members spaced apart axially farther than said seats, whereby when either of said valve members engages its seat the other valve member will be spaced from its seat.

7. A four-way valve unit for a fluid pressure line, comprising a housing having an inlet and a row of three laterally spaced ports, the housing also having a chamber connecting the inner ends of all three ports together and provided with valve seats between the middle port and the outer ports, a main passage connecting said inlet with one end of the chamber, and an alternate main passage connecting the inlet with the other end of the chamber, a control valve normally closing the alternate main passage, a main floating valve for the main passage biased forward toward passage-closing position and having a front surface exposed to said line fluid pressure for opening the floating valve, a secondary floating valve in said chamber normally closing it between the middle port and the outer port at said other end of the chamber, the secondary valve

being movable by fluid pressure to close said chamber between the middle port and the other outer port when the main floating valve opens the main passage, means for causing said control valve to move and open said alternate main passage, and means for increasing the fluid pressure against the back of the main floating valve when the alternate main passage is opened, whereby to move the main floating valve forward into said main passage-closing position so that the secondary valve will return to its normal position.

8. A four-way valve unit for a fluid pressure line, comprising a housing having an inlet and three vertically spaced ports for flow of fluid, the housing also having a vertically extending chamber connecting the inner ends of all three ports together and provided with valve seats between the middle port and the upper and lower ports, a main passage connecting said inlet with the lower part of said chamber, and an alternate main passage connecting the inlet with the upper part of the chamber, a control valve normally closing the alternate main passage and movable upwardly to open it, a main floating valve normally closing the main passage and movable upwardly by said line fluid pressure

beneath it to open it, the housing having an opening connecting the top of the main valve with the alternate main passage at the downstream side of the control valve, a secondary floating valve in said chamber having vertically spaced seats facing each other with the upper seat normally closing that chamber between the upper and middle ports, the secondary valve being movable upwardly by fluid pressure below it to close the chamber between the lower and middle ports when the main floating valve opens the main passage, and means for causing said control valve to rise and open said alternate main passage, whereby the main floating valve will descend and close the main passage and the secondary valve will drop to its lower position.

9. A four-way valve unit according to claim 8, in which said middle port is an outlet only and said upper and lower ports are combined inlets and outlets.

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