March 22, 1955 F. R. ELLENBERGER 2,704,649

CONTROL VALVE FOR REVERSIBLE REFRIGERATING SYSTEM

Filed Aug. 16, 1951

Fig. 1

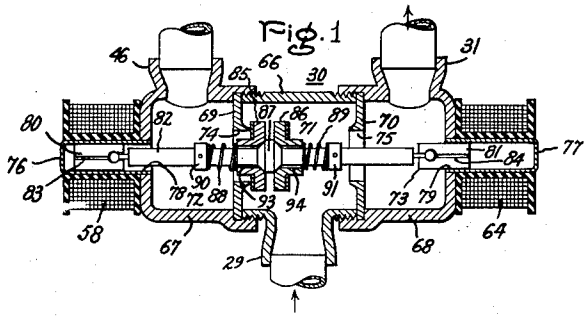


Fig. 2

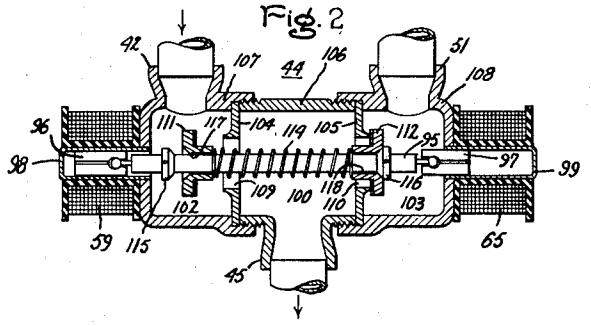


Fig. 3.

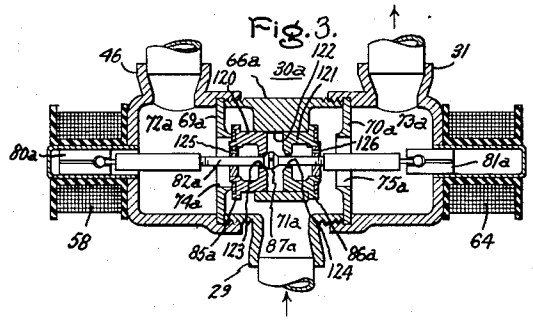
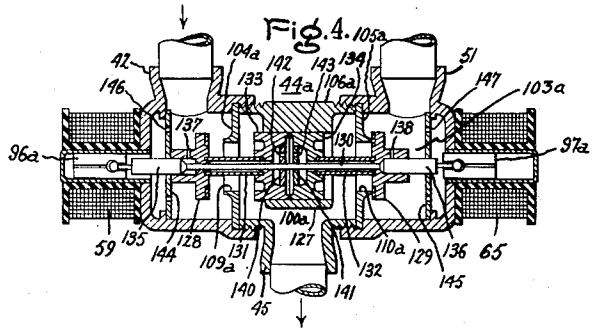


Fig. 4.



Inventor:
Francis R. Ellenberger,
by William B. Edwards, Jr.
His Attorney.

United States Patent Office 2,704,649 Patented Mar. 22, 1955

2,704,649

CONTROL VALVE FOR REVERSIBLE REFRIGERATING SYSTEM

Francis R. Ellenberger, Verona, N. J., assignor to General Electric Company, a corporation of New York

Application August 16, 1951, Serial No. 242,119

2 Claims. (Cl. 251—137)

This invention relates to reversible refrigerating systems and particularly to control valves for effecting the reversal of such systems.

Reversible refrigerating systems, frequently referred to as "heat pumps," may be employed for heating dwellings or other structures in the winter and for cooling in the summer. Various arrangements have been employed for effecting the reversal of the function of the system when it is desired to change over from summer to winter control and vice versa. One such arrangement involves the reversing of the functions of the evaporator and condenser of the refrigerating machine; this requires suitable valves for changing the connections in the refrigerant circuit. It is desirable that the changeover be effected easily and that the control be as simple as possible with sufficient ruggedness to withstand usage over a long period of time without undue service requirements. Systems of this type may be reversed by employing three-way valves arranged to connect the two heat transfer units alternatively to the suction and discharge sides of the compressor. Very substantial forces are required if it is attempted to reverse these valves when the normal high pressure difference prevails between the two sides of the refrigerating system, and various unloading arrangements have been suggested for overcoming this difficulty; however, these arrangements have not been entirely satisfactory from the standpoint of simplification and ruggedness nor for securing proper operation over a wide range of pressure differences in the system. Accordingly, it is an object of this invention to provide for a reversible refrigerating system a three-way valve assembly which is small in size and easy to operate.

It is another object of this invention to provide a three-way valve assembly for reversible refrigerating systems including an improved actuating mechanism for assuring the fully satisfactory valve operation under both high pressure difference conditions and equalized or low pressure conditions.

It is another object of the invention to provide a three-way valve for reversible refrigerating systems incorporating within a single valve body both the changeover valve structure and an unloader for minimizing the pressure difference across the valve for switching purposes.

Further objects and advantages of the invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In carrying out the objects of this invention, a three-way valve structure is provided for reversible refrigerating systems which comprises an intermediate or common fluid connection and two alternative fluid connections arranged to be selected by the opening and closing of two valves by a common changeover control. Each of the valves when closed is held in that position by the pressure difference existing during operation of the refrigerating machine. In order to reduce the pressure difference and render the valves easily actuated to their open positions, each valve is provided with a pilot valve actuated by the main valve operator so that the initial operation of the changeover mechanism opens the pilot valve to reduce the pressure difference across the main valve, whereupon the main valve is easily actuated and the control is shifted to the opposite position.

For a better understanding of this invention, reference may be had to the accompanying drawing in which Figs. 1 and 2 are enlarged detail sectional views of the three-way changeover valves employed in the discharge and suction lines respectively, of a reversible refrigerating machine; and Figs. 3 and 4 are views similar to Figs. 1 and 2 illustrating a modification of the valve construction.

Referring now to Fig. 1 of the drawing, the valve **30** for use in a compressor discharge line includes a body comprising a central or main section **66** and end sections **67** and **68** threaded on the central section and arranged to clamp partitions **69** and **70** respectively in position between the end sections and the section **66**. The valve casing thus provides a central chamber **71** communicating with the connection **29** and end chambers **72** and **73** communicating with the connections **46** and **31** respectively. Communication between the chamber **71** and the chamber **72** is provided through a port **74** in the partition **69**, and communication between the chamber **71** and the chamber **73** through a port **75** in the partition **70**. The coils **58** and **64** for electrical operation of the valve are mounted on the tubular extensions **76** and **77** respectively mounted in openings **78** and **79** in the end casings and thus are in a position to attract armatures **80** and **81** respectively which are slidably mounted within the extensions **76** and **77** and act as guides for a valve shifting rod **82**. The armatures **80** and **81** are provided with longitudinal grooves **83** and **84** respectively to provide communication between the interior of the valve casing and the interiors of the extensions **76** and **77** which are closed by the armatures. The rod **82** carries a valve member or disk **85** for closing the port **74** and a valve member or disk **86** for closing the port **75**. These valve disks are slidably mounted on the rod **82** and are urged against a combined stop and pilot valve element **87** by springs **88** and **89** respectively, the other ends of the springs being retained by collars **90** and **91** attached to the shaft **82**. The stop **87** and the valve disk **85** in the position shown in the drawing are held seated by the pressure difference prevailing between the chamber **71** and the chamber **72** during operation of the refrigerating machine in which the valve is employed, the chamber **71** being connected to the high pressure discharge of the compressor, and the chamber **72** being connected in communication with the heat transfer unit **21** on the low pressure side of the system. It will thus be apparent that the valve disk **85** will be held closed even when the coil **58** is no longer energized, and, if desired, the coil may be deenergized in any suitable manner either manually or automatically after the reversing operation obtained by energization of coil **58** has been completed. Reversal of the valve to connect inlet connection **29** to connection **46** results when the coil **58** has been deenergized and the coil **64** is energized to attract the armature **81** and urge the rod **82** to the right. As soon as the rod moves, the stop **87** uncovers a central opening **93** in the valve disk **85** which provides clearance around the shaft and thus connects the chambers **71** and **72** through a restricted opening. The stop **87** thus constitutes a pilot valve and requires much less force for its actuation than would be required to move the large valve disk **85**. As soon as the pilot valve has been opened, the pressure difference between the chambers **71** and **72** decreases, and when it falls to a predetermined value the force exerted on the disk **85** through the spring **88** moves the disk **85** away from its seat, whereupon the entire valve assembly moves to the right to bring the disk **86** into its seating position to close the port **75**. The pressure difference built up upon operation of the compressor thereafter holds the disk **86** in its position against the partition **70**, the chamber **73** being connected to the low side of the system under this condition of operation. It will readily be apparent that to shift the valve to the position shown in the drawing, the coil **64** has been deenergized and the coil **58** is energized, whereupon the right-hand side of the stop **87** acting as a pilot valve provides initial communication between the chambers **71** and **73** through a passage **94** about the rod **82** corresponding to the passage **93** in the valve disk **85**. This reduces the pressure difference sufficiently to facilitate the shifting of the valve assembly in the same manner as described in connection with the movement to the right upon energization of the coil **64**.

The valve **44** of Fig. 2 which is used in the suction line of a reversible refrigerating system differs from the valve

30 in that the relative positions of the valves and the partition elements are changed since the higher pressures prevail in the end chambers. The valve assembly comprises a rod 95 provided with armatures 96 and 97 for actuation by the coils 59 and 65 respectively, these armatures also acting as guides within tubular extensions 98 and 99 corresponding to the extensions 76 and 77 of the valve 30. The casing of the valve 44 provides an intermediate chamber 100 communicating with the suction connection 45, and end chambers 102 and 103 communicating with the outlet connections 42 and 51 respectively. The chamber 100 is formed by partitions 104 and 105 clamped between a central or main casing member 106 and end members 107 and 108. The partitions 104 and 105 are provided with ports 109 and 110 respectively which are arranged to be closed alternatively by valve disks or members 111 and 112 slidably mounted on the rod 95 and urged away from one another by a helical spring 114. The construction of the disks 111 and 112 is the same as the valve disks 85 and 86 except that they are oppositely mounted and engage separate stops 115 and 116 on the rod 95, these stops each providing pilot valves for closing the passage around the rod when each valve is in its closed position, the passages being indicated at 117 and 118 respectively.

In the position of the valve 44 illustrated, gaseous refrigerant from the heat transfer unit of the system functioning as an evaporator flows from the connection 42 through the chambers 102 and 100 to the suction line connection 45, and the valve disk 112 is held in its closed position by the pressure difference between the chamber 103 and the chamber 104, the chamber 103 being connected to the high pressure side of the refrigerating system.

In order to reverse the valve, the coil 59 has been deenergized and the coil 65 is energized, whereupon the pilot valve or stop member 116 is moved away from its seat on the valve 112 and thus provides restricted communication between the chambers 100 and 103, whereupon the difference in pressure is reduced until the force on the armature 97 is sufficient to move the disk 112 away from its seat, it being understood that upon initial movement of the rod 95 the pilot valve 115 moves up into engagement with the disk 111 and the transmits the force exerted by the armature through the spring 114 to the valve disk 112. Upon movement of the disk 112 away from its seat, the disk 111 is seated and closes the port 109. Thereafter the pressure difference set up by operation of the compressor urges the disk 111 and the valve 115 against their seats and maintains the valve assembly in its right-hand position.

It is thus apparent that an arrangement has been provided which in a simple and effective manner effects the shifting of valves in a reversible refrigerating system without the necessity of providing sufficient valve shifting force to oppose the full pressure difference of the system.

In Figs. 3 and 4 there is illustrated a modified construction of the discharge and suction control valves. These valves function essentially in the same manner as the valves in Figs. 1 and 2, and corresponding parts have been designated by the same numerals with addition of the letter "*a*." The valves of Figs. 3 and 4 differ from those of Figs. 1 and 2 in that a piston actuator is employed between the rod and the valve elements instead of the springs of the valves 30 and 44. Referring now to Fig. 3, the discharge valve 30*a* comprises a casing assembly essentially similar to that of Fig. 1 and providing an intermediate chamber 71*a* and end chambers 72*a* and 73*a* divided by partitions 69*a* and 70*a*. Valve disks or elements 85*a* and 86*a* are provided for closing ports 74*a* and 75*a*. The assembly for shifting the valves comprises a rod 82*a* having armatures 80*a* and 81*a* pivotally mounted thereon. The valve disks or elements 85*a* and 86*a* are mounted on piston members 120 and 121 slidably mounted in a cylinder 122 formed integrally with the central casing member 66*a* of the valve. The pistons 120 and 121 thus act as guides for the valves. The rod 82*a* is slidably mounted in the piston and valve elements and has a pilot valve or stop member 87*a* rigidly secured at its center intermediate the pistons 120 and 121. The rod 82*a* is slidably mounted in guides in the disks 85*a* and 86*a* and passes through openings 123 and 124 in the pistons, these openings constituting the restricted pilot valve ports and being connected in communication with the opposite side of their respective valves through orifices 125 and 126 in the valves.

When the valve of Fig. 3 shifts to the right to close the port 75*a*, the coil 58 has been deenergized and the coil 64 is energized, whereupon the armature 81*a* moves the rod 82*a* to the right and opens the pilot port 123. When this valve is opened, high pressure refrigerant from the space between the pistons passes through the valve 123 and the orifice 125, the valve member 87*a* having closed the port 124. The reduction in pressure between the pistons moves the valve disk 85*a* to the right because the piston area is as great or greater than the portion of the area of the disk 85*a* covering the port 74*a*. The disk 85*a* is thus moved away from its port, and when the pressures have been substantially equalized the valve disk 86*a* is seated by the force of the coil 64 and closes the port 75*a*, whereupon the pressure difference resulting from operation of the compressor will maintain the disk 86*a* seated whether or not energization of the coil 64 is continued. It is thus apparent that the valve 30*a* operates in much the same manner as the valve 30 to effect shifting of the valves from one position to the other alternatively without the necessity of providing solenoids having sufficient force to overcome the pressure difference on the valves.

The suction control valve illustrated in Fig. 4 is similar to the discharge valve of Fig. 3 but with the valves arranged on the opposite sides of the ported partitions in a manner similar to the valves of Fig. 2, so that the pressure difference between the intermediate and the end chamber will maintain the closed valve in its closed position. The valve assembly comprises a pair of valve members or disks 128 and 129 slidably mounted on a longitudinal rod 130 and secured by sleeves or conduits 131 and 132 respectively to guide pistons 133 and 134, which are slidably mounted in a cylinder 127 formed in the internal wall structure of the main body of the valve 44*a* as indicated at 106*a*. Attached to the ends of the rod 130 are enlarged portions 135 and 136 to which are pivotally attached the magnetic armatures 96*a* and 97*a* respectively. The ends of the enlarged portions 135 and 136 are slidably mounted within bores within the valve members 128 and 129, and orifices 137 and 138 are provided to afford communication between the end chambers surrounding the valves and the tubes 131 and 132, there being sufficient clearance about the rod 130 to allow the passage of gas. The rod 130 is slidably mounted in closure disks 140 and 141 in the pistons 133 and 134 respectively, these disks being provided with orifices 142 and 143 respectively to allow the passage of gas to the space between the two pistons. It is thus apparent that the cone-shaped ends of the portions 135 and 136 of the rod 130 constitute pilot valves for closing the communication between the end chambers and the space between the pistons.

When the solenoid 59 has been deenergized and the coil 65 is energized to urge the valve assembly to the right, the pilot valve member 136 opens to allow communication between the right end chamber indicated at 103*a* and the space between the pistons 133 and 134. Because the valve member 128 is held against movement to the left by a partition or stop 144, the pressure between the pistons urges the piston 134 to the right, and since its area is substantially the same as or greater than that portion of the disk 129 which covers port 110*a*, the valve is opened and the valve assembly thereupon moves to its far right-hand position with the valve element 129 in position against a stop or partition 145 within the right-hand chamber 103*a*. The partitions 144 and 145 are provided with openings 146 and 147 to equalize the pressures on the two sides thereof. When the assembly moves to the right the valve disk 128 engages the port 109*a*, and the differential pressure resulting from operation of the compressor thereafter maintains this valve in its closed position until the coil 59 is energized to again reverse the valve.

From the foregoing it is readily apparent that simple and effective arrangements have been provided for reversing the changeover valves of a reversible refrigerating machine without requiring an operating member having sufficient force to overcome the entire pressure difference prevailing between the high and low sides of the system. The changeover valve construction requires relatively few parts and eliminates the need of external by-pass controls to assure effective alternative valve operation to connect

the compressor selectively to either of two heat transfer units or coils.

Although the invention has been described in connection with specific forms of changeover valve mechanisms, other arrangements will occur to those skilled in the art. It is not, therefore, desired that the invention be limited to the particular constructions illustrated and described, and it is intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is :

1. A three-way fluid flow control valve having three external fluid flow connections and comprising a casing having three chambers therein including an intermediate chamber having spaced ports providing communication with each of the others of said chambers, said ports being concentric with respect to an axis therethrough, each of said three chambers communicating with a respective one of said connections, means including a valve member for each of said ports movably mounted on a shaft extending along said axis for closing said ports alternatively, said valve members and said shaft being arranged to provide pilot valves centrally of said members about said shaft whereby limited communication may be provided between the two sides of said valve members, solenoid means for moving said shaft axially for selectively actuating said valve members, each valve member being arranged to be retained in its closed position by a difference in pressure between said intermediate chamber and the corresponding one of said other chambers, means for holding each of said valves in its open position on said shaft when the other valve is in its closed position, each of said pilot valves being retained in its closed position by the pressure difference when its corresponding valve is in its closed position and being opened upon actuation of said solenoid means to reduce the pressure difference across its corresponding valve member in its closed position to afford

ready release and actuation of the valve member by said solenoid means.

2. A three-way fluid flow control valve having three external fluid flow connections and comprising a casing having three chambers therein including an intermediate chamber having spaced ports providing communication with each of the others of said chambers, said ports being concentric with respect to an axis therethrough, each of said three chambers communicating with a respective one of said connections, and a valve assembly for closing said ports alternatively, said assembly comprising means providing within said intermediate chamber a cylinder and a pair of pistons movable therein and with respect to one another along said axis and transfer valves connected to said pistons for closing said ports, a solenoid actuated shaft for moving said pistons to actuate said valves, pilot valves actuated by said shaft for providing communication between the space in said cylinder between said pistons and the others of said chambers for effecting movement of said pistons upon the change of pressure difference between said cylinder and said intermediate chamber when the closed one of said pilot valves is opened to facilitate shifting of said transfer valves by said solenoid means.

References Cited in the file of this patent

UNITED STATES PATENTS

829,120	Mumford	Aug. 21, 1906
1,223,584	Huesbsch	Apr. 24, 1917
2,392,741	Hurlburt	Jan. 8, 1946
2,441,201	Ludwig	May 11, 1948
2,496,553	Littlefield	Feb. 7, 1950
2,553,940	Quartullo	May 22, 1951

FOREIGN PATENTS

13,881	Great Britain	1893