

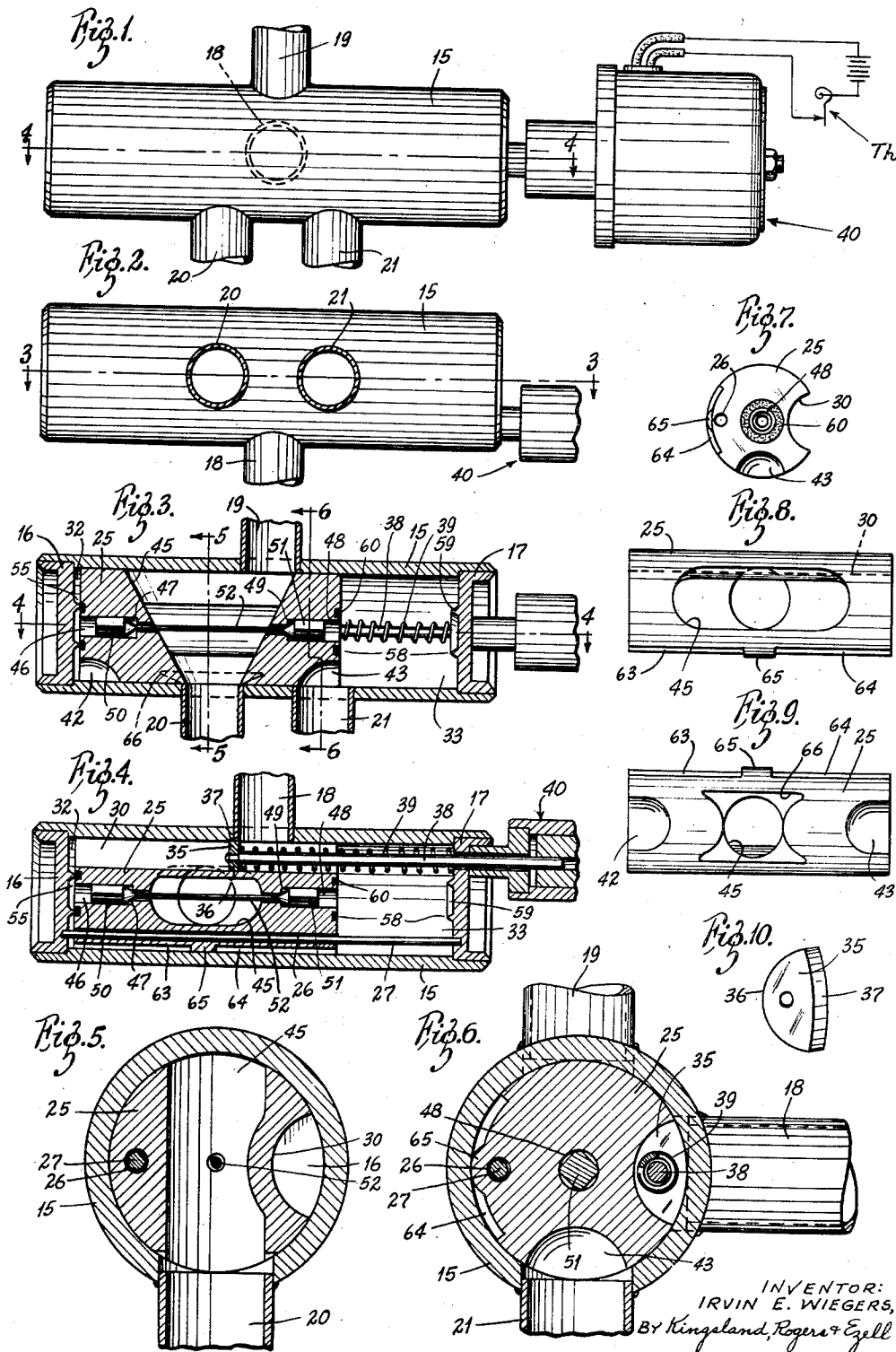
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FOUR-WAY REVERSING VALVE

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FOUR-WAY REVERSING VALVE

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The present invention relates to a four-way reversing valve. A characteristic use of this valve is with reverse cycle refrigeration systems of the type having a compressor, an inside and an outside coil, and an expansion device, all being connected in series with the expansion device between the two coils, and wherein each coil may alternatively be a condenser and an evaporator. In this type of system, one of the coils is located outside of the space to be regulated and the other coil is inside that space. Each coil can act as a condenser or an evaporator. The inside coil can be a condenser for purposes of heating the space and an evaporator for purposes of cooling the space.

The present valve has a closed-ended casing with four passages. The first passage is a high-pressure passage leading from the high-pressure side of the compressor or receiver, the second passage is connected to the low-pressure side leading into the suction end of the compressor. The third and fourth passages lead, respectively, to the two coils. The valve has a slide in it that moves to a first position in which it can connect the high-pressure first passage to the third coil passage at the same time it connects the low-pressure second passage to the fourth coil passage. The slide is movable to another position in which it reverses these connections and connects the high-pressure first passage to the fourth passage and the low-pressure second passage to the third passage.

This valve of the present construction is designed to be pressure operated by the fluid pressures of the system being regulated, but to be piloted under an external regulation, preferably that of a solenoid. It is designed to reduce the unbalanced pressures on the slide so that the power required to move the slide is not excessively great. It is also designed to minimize the effect of leakage which results in loss of refrigerant pressure in the system that can be used for refrigeration, because such loss is actually bypassed from the high-pressure to the low-pressure side of the valve. It is also designed to eliminate hang-up in a mid-position, which can occur with some four-way valves that are pressure operated.

Other advantages will appear from the description to follow.

In the drawings:

Figure 1 is a front elevation of the valve;

Figure 2 is a bottom plan view thereof;

Figure 3 is a longitudinal vertical section taken on the line 3—3 of Figure 2;

Figure 4 is a longitudinal horizontal section taken on the lines 4—4 of Figures 1 and 3;

Figure 5 is an enlarged transverse section taken on the line 5—5 of Figure 3;

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Figure 6 is an enlarged transverse section taken on the line 6—6 of Figure 3;

Figure 7 is an end view of the valve slide;

Figure 8 is a top plan view of said valve slide;

Figure 9 is a bottom plan view of said slide; and

Figure 10 is a view of the pilot valve or baffle.

The valve includes a cylinder 15 having end closures 16 and 17. Midway of the ends of the valve, there is a high-pressure inlet 18, sometimes referred to as the first passage. 90° around from the first passage 18, there is a second or low-pressure passage 19, also midway between the ends of the cylinder 15. 180° around from the low-pressure passage 19 are third and fourth passages 20 and 21.

A piston slide 25 fits within the cylinder 15 to slide back and forth between the ends 16 and 17. The slide 25 is in the nature of a piston and preferably has a fit sufficient to provide gas seals to prevent escape of gas along its periphery. The slide 25 has a passage 26 extending from end to end and receiving a guide rod 27 that is mounted between and spans the space from the closure 16 to the closure 17. The passage 26 should provide a free, but close, sliding fit for the rod 27. This arrangement prevents the slide 25 from being displaced about its own axis within the cylinder 15, yet minimizes the leakage from end to end of the cylinder.

The piston or slide 25 has a recess or groove 30 extending from end to end thereof, this groove being of a size to register with the first or high-pressure passage 18. The grooved passage 30 thereby constitutes means to transmit high pressure to both ends of the cylinder to the pressure chambers 32 and 33, the two pressure chambers 32 and 33 being, respectively, those between the cylinder head 16 and the corresponding left head of the piston 25, and that between the other cylinder head 17 and the right-hand head of the slide or piston 25. It is desirable that this fluid transmitting passage be within the slide rather than to be in or connected to the cylinder.

The groove 30 is regulated by a baffle type slide valve 35 shown separately in Figure 10 that constitutes a control valve. It has an arcuate edge 36 that enables it to fit closely against the surface of the groove 30, and it also has an arcuate edge 37 that enables it to fit closely within the cylinder 15. By this shaping, it has a fit within the groove and cylinder that enables it substantially to block flow along the groove, although it need not provide a tight seal. It is mounted on the end of a valve rod 38, surrounded by a spring 39 normally urging the valve 35 to the left, which is the position it occupies in Figure 4. The valve rod 38 can be operated to the right upon energization of a solenoid 40. Upon deenergization of the solenoid, the spring 39 will return the valve 35 to the position shown. When so operated by the solenoid and spring, the valve can be placed just to the left of the high-pressure passage 18 or just to the right thereof. When it is to the left, as illustrated, it admits the high pressure to the right pressure chamber 33, while substantially excluding it from the left pressure chamber 32. When the solenoid is energized, the conditions are reversed, the high-pressure passage 18 being connected to the left pressure chamber 32 and cut off from the right pressure chamber 33.

The piston slide 25 is notched at its opposite ends as illustrated at 42 and 43. When the slide 25 is to the left, the notch 43 puts the pressure chamber 33 in communi-

cation with the fourth passage 21 from the cylinder. In similar manner, when the slide 25 is in its right position, the notch 42 will register with the outlet passage 20 from the cylinder 15, thereby producing registration between the pressure chamber 32 and the outlet passage 20.

The piston slide 25 has a transverse opening 45 through it. At its forward end, the passage 45 is narrow, being just wide enough to register across one of the cylinder passages 20 or 21. It flares toward the back and at its back side is wide enough so that it can register with the passage 19 throughout the movement of the slide 25. By this arrangement, the cross passage 45 may alternately register the passage 19 with the passages 20 and 21. Ordinarily, 25 will constitute a low-pressure passage.

There is a passage from each of the pressure chambers to this transverse passage 45, and hence connected to the low-pressure outlet 19 at all times. These two passages are preferably located in the slide along the axis thereof. They comprise a passage 46 which has a reduced portion to provide a valve seat 47, and a passage 48 that has a reduced portion providing a valve seat 49.

A pair of exhaust valves 50 and 51 are connected by a valve rod 52 so that they slide together within the passages 46 and 48. They have reduced facing ends to cooperate with the two valve seats 47 and 49. The rod 52 insures that, when one valve is seated on its valve seat, the other will be open. As illustrated, the valve 50 is displaced from the seat 47, whereas the valve 51 is closed against the seat 49. These two valves are non-circular (see Figure 6) so that they do not prevent flow through the two passages. Consequently, with the valve 50 displaced from its seat, the pressure chamber 32 is connected through to the transverse passage 45. At the same time, the valve 51 being engaged against the seat 49 closes off flow from the pressure chamber 33 to the transverse passage 45. The two valves are pressure operated, as will appear.

The passages 46 and 48 are also regulated by cut-off valves. The left end of the piston 25, as it appears in Figure 3, has a valve 55 at its end consisting of a raised circular valve seat formed on the inner surface of the cylinder head 16, and adapted to register with a valve seating element also of ring shape embedded within the face or head of the piston. A similar valve 58 is located at the other end, it comprising a valve seat 59 on the cylinder head 17 and a valve ring 60 on the piston. Hereafter it will be called the valve 58.

On the side of the piston slide 25, opposite the high-pressure inlet and opposite the groove 30, there are balancing pressure recesses 63 and 64 that extend from each end toward the middle of the piston slide 25, but are separated by a sealing part 65 at the middle. In the absence of such recesses connected to the high-pressure side, the loading of the high pressure on one side only of the piston 25 causes such high and unequal loading of the piston as to make its movements difficult. For like reasons, a recess 66 is extended about the smaller end of the passage 45, to balance as nearly as possible the lateral forces on the suction side. The recess 66 has longitudinal extensions at its four corners, but they are spaced around the slide enough so that, as the slide moves slightly beyond the opening 20 or the opening 21, the opening is cut off.

Operation

Assuming that the valve is connected into a refrigeration system consisting of a compressor, a first coil, an expansion device, and a second coil, all connected in series, the pipe 18 is permanently connected to the high-pressure line from the compressor. Similarly, the pipe 19 is always connected to the suction or low-pressure side of the compressor. The pipe 20 will be assumed to be connected to the inside coil and the pipe 21 connected to the outside coil. The two coils communicate through the expansion device.

With the piston slide 25 to the left, as illustrated in Figures 3 and 4, the high-pressure connections deliver to the outside coil by way of the pipe 21 and the inside coil is connected by the pipe 20 back to the suction side. Under these conditions, the apparatus would be on a room-cooling setting. If, however, the piston slide 25 is moved to the right, it will connect the high-pressure line 18 to the third connecting pipe 20 leading to the inside coil, while it would connect the fourth pipe 21 to the suction line 19 from the outside coil. In this case, the apparatus would be on a heating cycle because the inside coil would be acting as a condenser.

Since reverse cycle valves are well known in the art, it is not necessary to describe the foregoing in detail.

This is particularly true because the reversing valve of the present invention can be used with other things than reverse cycle refrigeration, although it is of particular value therein. The operation of the valve itself will now be described.

In the conditions illustrated in Figures 3 and 4, the high-pressure from the pipe 18 is delivered into the groove 30 and is caused by the baffle 35 to be delivered to the pressure chamber 33. (It also acts on the opposite side of the slide 25, by way of the recesses 63 and 64.) Pressure in the chamber 33 acts on the right end of the valve 51, urging it against the seat 49 and displacing the valve 50 from the seat 47. At the extreme leftward position, the valve 55 closes off so that any leakage of high pressure fluid past the arcuate baffle valve 35 in the groove 30 cannot bleed into the low-pressure side. It is also evident that, when this valve 55 is closed and the center part of the piston 25 is connected to low pressure, the effective pressure-receiving area of the left-hand end of the piston slide 25 is less than that of the right-hand end, so that there is an imbalance of pressure holding the slide to the left. If for any reason the piston should move to the right far enough to open the valve 55, such pressure would immediately exhaust past the open valve 50; and the piston 25 would again be returned to its left-hand position.

If, through some appropriate external control which may be automatic (and there is a diagrammatic illustration of the thermostat T_h in Figure 1), the solenoid 40 is energized, the baffle valve 35 in the groove 30 is then pulled across the end of the high-pressure pipe 18 to the right-hand side thereof. This immediately deflects the full line pressure from the compressor to the pressure chamber 32 at the left-hand end of the piston. It also, of course, cuts the pressure off from the two coils, so that the pressure decays from the suction line 19 backwardly through the pipe 20, the two coils, and into the chamber 33, at the same time it builds up in the chamber 32.

The build-up of the pressure in the chamber 32 moves the piston slide 25 to the right. As soon as it moves the piston sufficiently to open the valve 55, the full line pressure is exerted upon the left-hand end of the valve 50, at a time when the right-hand end of the valve 51 is subjected to low-pressure conditions. The pressure drop across the valve 50 moves the valves 50 and 51 to the right until the valve 50 closes against the valve seat 47, at the same time opening the valve 51 from the valve seat 49. Thus, initially the valve 50 is set to movement by the pressure drop produced by the somewhat restricted fluid flow past its head, but when once seated the valve is held closed by static pressure conditions. Reversal of the positions of the valves 50 and 51 produces a reversal of the pressure conditions in the two chambers 32 and 33 from that illustrated in Figures 3 and 4. It causes the piston slide 25 to move to the right freely, the pressure chamber 33 now being readily able to exhaust past the valve 51 to the low-pressure passage 45 of the slide 25 and ultimately to the suction line 19.

These pressure imbalances will continue to exist, driv-

ing the slide to the right, regardless of the change in porting as the transverse passage 45 moves from the pipe 20 to the pipe 21 and the notch 43 withdraws from the pipe 21 to let the notch 42 register with the pipe 20. As soon as the valve 58 closes, the leakage through the now open valve 51 is cut off, regardless of whether or not the baffle valve 35 is entirely tight within the groove 30. It is, of course, intended to have the exhaust passage past the valves 50 and 51 greater than the bleeding past the baffle valve 35.

It can be seen that the two cut-off valves 55 and 58 are designed to prevent continuous leaking past the baffle valve 35 and through the open one of the two valves 50 and 51, which is to say, leakage through the de-energized one of the two pressure chambers 32 and 33. Since, when the piston slide 25 is in one extreme, such as that illustrated in Figure 3, the valve 55 closes some of the area of the piston away from the high pressure in contrast with the total area subjected to high pressure in the chamber 33, a build-up of leakage pressure into the chamber 32 will not ordinarily displace the piston slide.

What is claimed is:

1. In a four-way valve: a housing having closed ends and wall means between the ends; a first high-pressure inlet passage through the wall means; a second low-pressure outlet passage through the wall means, transversely spaced from the first passage; third and fourth passages through the wall means, longitudinally separated one from the other, both transversely spaced from the first and second passages; a piston slidable back and forth within the housing, and forming pressure chambers in the opposite ends of the cylinder; fluid conduit means connecting the first passage with both pressure chambers; the piston being formed to communicate the third and fourth passages with their respective adjacent pressure chambers when the piston has moved to enlarge such respective chamber and to reduce the opposite chamber; a transverse opening through the piston for connecting the second passage selectively with the one of the fourth or third passages, when the piston has moved to connect the other of said fourth or third passages to the pressure chamber as aforesaid; means including passages from each of the two pressure chambers communicating with the second low-pressure outlet passage to exhaust each of the two pressure chambers into the low pressure second passage; said means being operative to exhaust the chamber subjected to low pressure and being rendered inoperative by the high pressure to exhaust the chamber subjected to high pressure; and control valve means for selectively connecting the first passage with each of the two pressure chambers.

2. The valve of claim 1, wherein the exhaust means comprises a passage through the piston from each of the two pressure chambers to the transverse opening; exhaust valves for each exhaust passage; said valves having means to close the valve subjected to high pressure in its chamber and to open the valve subjected to low pressure in its chamber.

3. The four-way valve of claim 2, wherein there are two cut-off valves, one operated to close each exhaust passage from its pressure chamber when the slide moves its maximum distance toward that end of the housing.

4. The four-way valve of claim 3, wherein the control valve means includes a valve in the fluid conduit means having a free fit therein, leakage by which is controlled by the cut-off valves.

5. The four-way valve of claim 2, wherein the housing comprises a cylinder and the cylinder is provided with a fixed longitudinal element slidably engaging the slide for maintaining the latter against rotative movement about its own axis, within the cylinder.

6. The four-way valve of claim 2, wherein the control valve means has a solenoid actuating device and a valve element moved thereby.

7. The four-way valve of claim 2, wherein there is a high pressure fluid space between the housing and the slide on the side opposite the first passage, connected with said passage and disconnected from the low-pressure outlet passage, to provide a pressure acting on the slide oppositely from the pressure at the inlet.

8. The four-way valve of claim 7, wherein the fluid conduit means, the high-pressure fluid space opposite the first passage, and the exhaust passages are all in the slide.

9. In a valve: a closed-ended housing and a piston slide operated within the same and providing pressure chambers in the housing at its opposite ends; a first opening into the housing between its ends, a second opening into the housing between its ends and spaced from the first; both openings being regulated by the slide; first passage means from the first opening to the opposite pressure chambers; valve means operable to connect the first passage means to one chamber and disconnect it from the other; first and second work ports opening into the housing; means controlled by said slide for connecting one of said work ports to said second opening and the other of said work ports to said one chamber; additional valve means between the pressure chambers and the second opening, including other passages from each chamber to the second opening, flow-responsive valve devices in each of said other passages, and means connecting the valve devices so that when one is closed the other is opened, the flow-responsive valve devices being operated when flow between one chamber and the second opening past one valve device produces a greater pressure difference than exists on the other valve device.

10. The valve of claim 9, wherein the other passages controlled by the additional valve means are located in the piston slide, and wherein said other passages have openings through the opposite end faces of the slide.

11. The valve of claim 10, wherein the slide and cylinder have space in their inter-surfaces opposite the first opening, and connectible with it, to counter the lateral pressure effects on the piston of pressure at the first opening.

12. The valve of claim 10, wherein the first passage means is located along the interface of the housing and piston slide, and wherein there is opposite recess means along the interface between the cylinder and the slide.

13. The valve of claim 10, wherein the slide has a transverse passage through it, connectible to the second opening, and extending outwardly and across the slide therefrom, and a recess on the piston surface connected to said transverse passage to provide a pressure-receiving area on the piston similar in area to that afforded by the transverse passage, the recess having a shape along the slide extending longitudinally beyond the opening but the longitudinal extensions being spaced around the slide beyond the extent of the opening around the slide.

14. The valve of claim 10, wherein there is an end cut-off valve at each end of the housing, each comprising a valve ring and a seat element, one on each housing end and one on each end of the piston, so that each such cut-off valve is closed when the slide reaches one end of its travel, each cut-off valve being operative to cut off communication through its chamber between the first passage means and each other passage adjacent each cut-off valve, the aforesaid first passage means having direct communication with one side of the cut-off valves and the aforesaid other passages having direct communication with the other side of the cut-off valves.

15. In a four-way valve: a closed-ended cylinder having a first high-pressure, inlet passage through its wall, a second low-pressure, outlet passage through its wall and spaced around the cylinder from the first passage; third and fourth passages through the wall in longitudinal alignment on opposite sides of the second passage; a piston slide operable back and forth within the cylinder, and forming pressure chambers in the opposite ends

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of the cylinder; fluid conduit means connecting the first passage with both pressure chambers; the piston slide being formed to communicate the third and fourth passages with their respective adjacent pressure chambers when the slide has moved to enlarge such respective chamber and to reduce the opposite chamber; a transverse opening through the slide for connecting the second passage selectively with the one of the fourth or third passages, when the slide has moved to connect the other of said fourth or third passages to the pressure chamber as

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aforesaid; exhaust passages from each of the two pressure chambers communicating with the low pressure second passage, exhaust valves for each exhaust passage, the valves having means to close the valve subjected to high pressure in its chamber and to open the valve subjected to low pressure in its chamber, and control valve means operable from outside the cylinder selectively to connect the first passage with each of the two pressure chambers.

No references cited.