

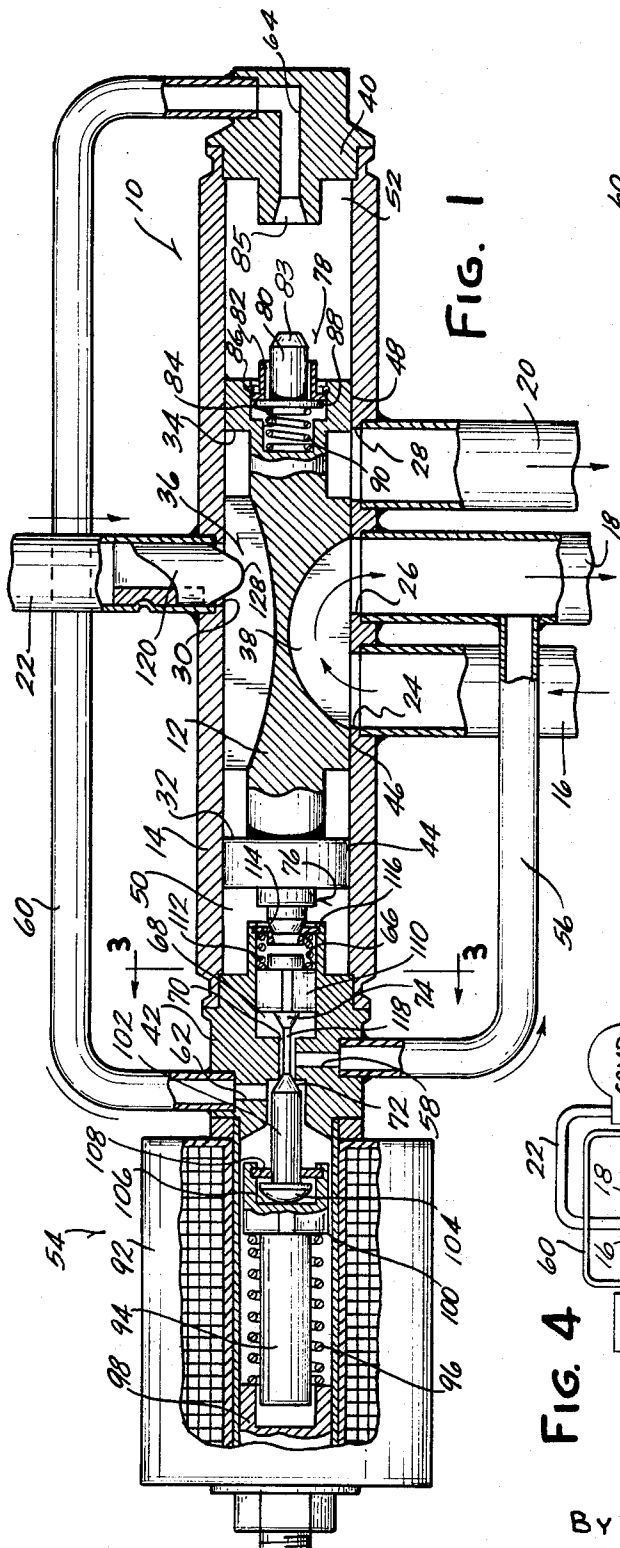
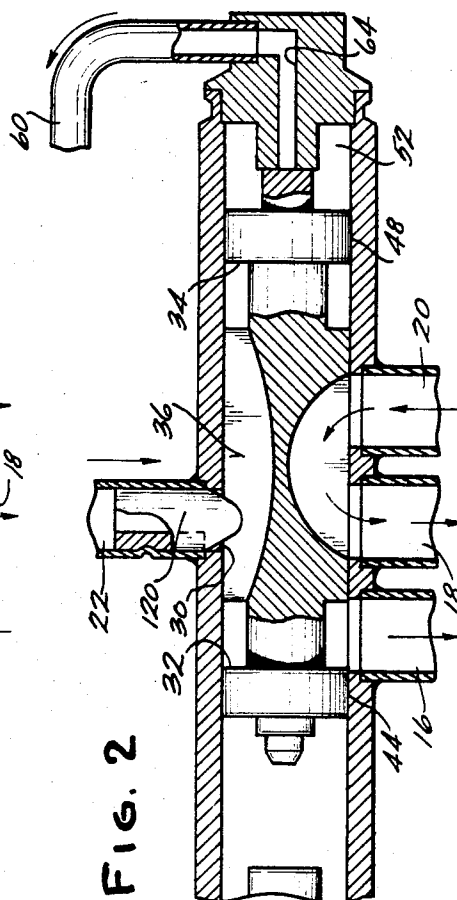
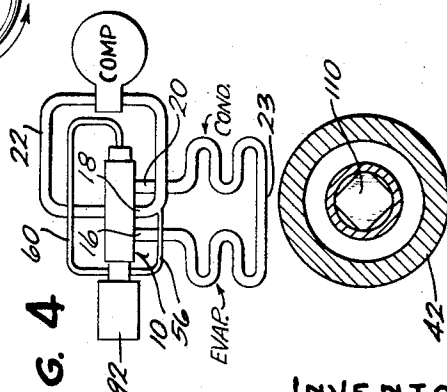
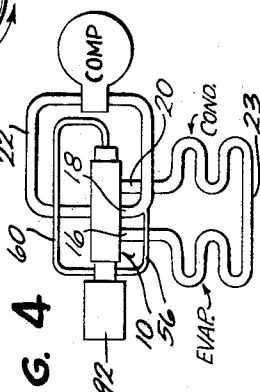
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3,400,736

REVERSING VALVE

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3,400,736

REVERSING VALVE

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ABSTRACT OF THE DISCLOSURE

This disclosure relates to a reversing valve for a refrigeration system which includes a valve member arranged for movement to determine the direction of refrigerant flow through the evaporator and condenser of the system. A control valve is provided which selectively connects system suction line pressure to one side or the other of the valve member of the reversing valve to achieve valve member movement. The control valve is mounted directly on the body of the reversing valve and the passage in the control valve through which the suction line communicates with the reversing valve opens directly into the valve body on one side of the movable valve member. The passage is also connected to the other side of the valve member. A solid lubricant is provided between the interengaging surfaces of the valve member and the reversing valve to act as a sealing lubricant between areas which are at different pressure levels.

This invention relates to reversing valves and, more particularly, to reversing valves of the type most commonly used in a heat pump system to provide selectively a cooling or heating cycle with the same system or as used in a refrigeration system to provide a defrost cycle as well as the normal refrigeration cycle.

In a broad sense, valves of this type are well known and examples of prior designs can be found in U.S. Patent No. 2,708,561, issued to Edward C. Ehlke and Patent No. 2,976,701, issued to Frederick A. Greenawalt. Basically such valves are selectively operable to control the direction of flow through the evaporator and condenser of the system. In one valve setting the area associated with the evaporator is cooled by directing the refrigerant through the evaporator and condenser in the conventional manner of a refrigeration system. The valve has another setting wherein the conventional evaporator becomes in effect a condenser and the condenser an evaporator, this commonly being designated as the reverse cycle. The reverse cycle can be of relatively short duration to merely defrost the evaporator or it can be of extended duration in which case the area in association with the "evaporator" (now a condenser) will be heated.

In one effective and accepted form, valves of this type include a pressure operated piston-like valve spool which moves with respect to system ports to determine the direction of refrigerant flow through the evaporator-condenser. Movement of the valve spool is achieved by providing different pressures on opposite sides of the valve spool and control over valve spool movement is achieved by selectively connecting one side or the other of the valve spool to the suction line of the compressor through a system of bleed lines. The selective connection of the suction line to opposite sides of the valve spool is achieved through an additional control valve. An example of such a control valve can be found in the aforementioned Greenawalt patent. Such valves, although generally providing effective system control require a relatively complex conduit system including auxiliary bleed lines and control tubing in addition to the main refrigeration system tubing or conduit. The complex tubing required increases the space necessary for the overall system and also the

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number of connections which must be made upon installation, i.e. by the technician installing the system control.

A general object of this invention is to improve the operation of and simplify the construction of reversing valves of this type.

Another object is to simplify installation of the reversing valve and its control.

For the achievement of these and other objects, this invention contemplates an improved reversing valve wherein the selector control, that control which determines exposure of the valve spool to the suction line and correspondingly movement of the valve spool, is connected directly on the reversing valve body thereby providing a compact and integral assembly which reduces the space required as well as the parts and assembly connections necessary in installing the control system. In one form of reversing valve of this type closure members are provided on the spool valve to interrupt communication between the selected side of the spool valve and the suction line after the spool valve has moved to the desired position. The arrangement of this invention has provided yet another advantage in the simplification of the overall valve construction and affords an improvement in its operation in that it permits combining into a single orifice or port the function of one of the bleed line orifices and the seat for one of the spool valve closure members.

Another, more specific, object of this invention is to improve spool valve operation by coating the valve with a solid lubricant effective both to the seal between valve passages and also to reduce the resistance to spool valve movement. This arrangement provides effective action by allowing free movement of the valve and more accurate response to pressure differentials.

Where the spool valve is generally circular in transverse cross section this invention further proposes that the valve be held against rotation by a simplified key and keyway arrangement which uses an extension of one of the system ports, preferably the port connected to the compressor discharge, to engage a suitable opening in the spool valve to prevent disturbing the desired orientation between the spool valve passages and the system ports.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the embodiments shown in the drawings, in which:

FIG. 1 is a view, partially in section, illustrating a reversing valve embodying this invention and as set to produce a refrigeration cycle;

FIG. 2 illustrates an alternative embodiment of this invention and with the reversing valve set to provide a heating or defrost cycle;

FIG. 3 is a section view taken generally along line 3-3 of FIG. 1; and

FIG. 4 is a generally schematic view of a system including the reversing valve of this invention.

With particular reference to the drawings, a reversing or four-way valve 10 includes valve spool 12 arranged for sliding movement within tubular shell 14 of valve 10. Conduits 16, 18, 20 and 22 register with openings or ports 24, 26, 28 and 30, respectively, in shell 14. As labeled and illustrated in FIG. 4, conduit 16 is connected to the evaporator, conduit 18 is connected to the compressor intake, conduit 20 is connected to the condenser and conduit 22 is connected to the compressor discharge (not shown). To complete the system the evaporator and compressor are connected by conduit 23 and all of the conduits are suitably connected to their respective system members.

Valve spool 12 includes a system of passages for selectively connecting either the evaporator or condenser to the compressor intake (or suction line 18) to establish either a

refrigeration or heating cycle. Annular passages 32 and 34 are spaced axially on the valve spool and are connected by an axial passage 36 which communicates with opening 30. In the illustrated embodiment a generally axially extending passage 38 is arranged between annular channels 32 and 34 and on the side of the valve spool which is diametrically opposite to passage 36. The axial length of passage 38 is sufficient to span two of the three aligned openings 24, 26 and 28 and thereby selectively connect either conduit 16 or 20 to conduit 18 and, when so positioned, the other of conduit 16 or 20 is registered with its respective annular passage 32 or 34. As illustrated in FIG. 1, conduits 16 and 18 are connected through passage 38 and conduit 20 communicates with conduit 22 through annular passage 34 and axial passage 36. In this arrangement refrigerant is directed from the compressor through the condenser and evaporator and back to the compressor intake to provide a conventional refrigeration cycle.

Spool valve 12 is freely movable in axial direction within tubular shell 14 and this movement is achieved by varying the pressure acting on one or the other of axial ends of the valve spool. More particularly, the axial ends of tubular shell 14 are closed by end caps 40 and 42 and generally cylindrical surfaces 44, 46 and 48 of the valve spool are in engagement with the inner surface of tubular shell 14 to provide a bearing surface for the axial movement and to divide the interior of the tubular shell into variable volume chambers 50 and 52. The spool valve is thus free to move axially in the tubular shell in accordance with differential in pressure acting on the axial ends of the spool valve, which ends together with their respective end caps 40 and 42 define the variable volume chambers or areas 50 and 52.

The pressures in the variable volume chambers acting on the axial ends of the valve spool are controlled by selectively connecting one or the other of the chambers to suction line 18 through a selector control valve 54. Structurally, conduit 56 is connected to suction line 18 and communicates with a common passage 58 in end cap 42. A second conduit 60 is connected between passage 62 in end cap 42 and a passage 64 in end cap 40, passage 64 opening into variable volume chamber 52. Variable volume chamber 50 communicates through a restricted opening 66 and chamber 68 in end cap 40 with a common passage 70 which also communicates with both passages 58 and 62. Also disposed within end cap 42 are a pair of conical valve members 72 and 74 arranged adjacent the opposite ends of common channel 70 and, in a manner to be described more particularly hereinafter, are movable selectively to close one or the other of the axial ends of the common channel to establish communication between suction line 18 and either one or the other of variable volume chambers 50 and 52. As illustrated in FIG. 1, conical valve 72 is seated in the left end of common passage 70 thereby connecting the suction line to opening 66 and, to variable volume chamber 50 so that the pressure in chamber 50 is reduced with respect to the pressure in chamber 52 thereby producing a pressure differential between the chambers which causes spool valve 12 to move to the left until its closure member 76 engages in opening 66 as illustrated in FIG. 1. The construction and function of closure member 76 will be explained more completely hereinafter. This also establishes the limit of movement of spool valve 12 to the left and with the valve spool so positioned passage 38 connects conduits 16 and 18 as illustrated.

The purpose of closure member 76, and closure member 78 which is disposed at the right end of the spool valve, is to interrupt communication between the suction line and the particular chamber 50 or 52 after the spool valve has completed its movement in either direction. Again with reference to FIG. 1, when the spool valve assumes the position illustrated wherein closure member 76 engages opening 66 the pressure in chamber 50 will initially be quite low as compared to the pressure in chamber 52 and also in annular passages 32 and 34 in passage 36. This differential

in pressure across cylindrical surface 44 will produce some leakage which increases the pressure in chamber 50 until it equalizes with the other pressure within tubular shell 14. When the pressure is equalized leakage across surface 44 ceases. Equalization of the pressures acting on spool valve 12 also permits the spool valve to remain in the desired position.

Closure members 76 and 78 are of identical construction and only closure member 78 has been illustrated in detail. More particularly, closure member 78 includes a movable member 80 having a conical end 83 which is adapted to be engaged in conical end 85 of passage 64. Movable member 80 is positioned in a cup-shaped member 82 which is held in an opening 84 in the spool valve by retaining ring 86. Coil spring 90 biases the movable member 80 outwardly to insure secure seating of the member in opening 85 and member 80 includes an enlarged flange portion 88 which engages the inner end of cup 82 to hold the member 80 in the spool valve.

Turning now to control valve 54, this valve structurally includes a coil assembly 92, an armature 94 and coil spring 96 seated between closed end 98 of the coil assembly and shoulder 100 on armature 94. Conical valve 72 is part of a rod 102 which has an enlarged head 104 positioned in an opening 106 in armature 94. The rod 102 is restrained in opening 106 for movement with armature 94 by washer 108. With this arrangement coil spring 96 will seat valve 72 on the left end of common passage 70 and energization of coil assembly 92 draws armature 94 to the left and lifts valve 72 from that seat.

The other conical valve member 74 is formed as a part of a rectangular plug 110 arranged in cylindrical passage 68 for sliding movement. Coil spring 112 is seated between plug 110 and cap 114, in which the opening 66 is formed. The coil spring biases plug 110 and valve member 74 to the left and toward engagement in the right end of common passage 70. Cap 114 is mechanically connected in end cap 42 by rolling edge 116 over the cap. A connecting member 118 extends between valves 72 and 74 and provides a driving connection therebetween. The size of member 118 has been exaggerated in the drawing and actually is in the form of a wire which has approximately a .030 inch diameter. The use and arrangement of a wire of this type, and in this type of valve is conventional. Briefly the wire extends into clearance holes (not shown) in the ends of valve members 72 and 74 and has a given amount of lost motion with each of the valve members. Accordingly, when solenoid assembly 92 is de-energized spring 96 moves rod 102 toward engagement with common passage 70, this movement is transmitted through pin 118 to valve member 74 moving that valve away from common passage 70. On the other hand when the solenoid assembly is energized and valve member 72 is lifted from engagement with common passage 72 this also releases valve member 74 permitting spring 112 to move valve member 74 into secure engagement in passage 70. This particular type of valve arrangement is recognized as having particular advantage for use with a solenoid of this type which is only capable of providing a pulling force.

In operation, if a refrigeration cycle is desired solenoid assembly 92 is de-energized and valve member 72 moves into engagement with common passage 70. Assuming spool valve 12 to have been displaced to the right of the position illustrated in FIG. 1, opening 66 will be opened and the pressure in variable chamber 50 will be reduced due to communication with suction line 18. This will create a pressure drop across chambers 52 and 50 and spool valve 12 will move to the left until closure member 76 is engaged in opening 66 terminating spool valve movement and interrupting communication between chamber 50 and suction line 18. At this point leakage will occur across surface 44 until the pressure in chamber 50 equalizes with that throughout the remainder of the interior of tubular shell 14. Spool valve 12 will remain in

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this position until solenoid assembly 92 is energized. Also, it will be noted that should the spool valve become displaced from the position illustrated in FIG. 1, for example due to vibration or impact, the connection of chamber 50 to the suction line will be immediately re-established and again the pressure drop will occur in chamber 50 and the spool valve will re-assume its position to the left and in engagement in opening 66.

Should it be desired to provide a heating cycle, solenoid control valve 92 is energized lifting valve member 72 from engagement with common passage 70 and releasing valve member 74 for movement into engagement with the common passage under the influence of spring 112. This establishes communication between variable volume chamber 52 and suction line 18 through passages 58, 70, 62, conduit 60 and passage 64. The pressure in chamber 52 will be reduced and in this instance producing a pressure drop from chamber 50 to chamber 52 causing spool valve 12 to move to the right until closure member 78 engages in end 85 of passage 64. This terminates movement of the spool valve to the right at which time again leakage occurs across surface 48 until pressure throughout the interior of the tubular shell is equalized. In this position passage 38 connects conduits 18 and 20 and conduit 16 communicates with annular passage 32 so that refrigerant is now conducted from the compressor to the condenser, which now functions as the evaporator, and then to the evaporator, which now functions as a condenser, and heats the area associated with the evaporator. The reversing valve can be utilized to provide a heating cycle as just described or the heating cycle can be of relatively short duration to effect a defrost cycle on the evaporator. Where the defrost cycle is to be provided and the reversing valve is not intended to provide an extended heating period, closure member 78 need not have the biased member 80 but, as illustrated in FIG. 2, can merely be in the form of a blunt end which closes over the opening of passage 64 into chamber 52. The biased closure member is advantageous as it reduces leakage and, although its elimination will result in some leakage from variable chamber 52 to passage 64, leakage can be tolerated because it is relatively minor and because the defrost cycle is of relatively short duration.

It will be noted that the thickness of head 104 of rod 102 is less than the depth of opening 106 between washer 108 and the inner end of the opening. This provides lost motion between armature 94 and rod 102. When valve member 72 is seated on passage 70 clearance occurs between the underside of head 104 and washer 108 and when valve member 74 seats on passage 70 clearance occurs between the upperside of head 104 and the inner end of opening 106. Movement of rod 102 in either direction moves one or the other of the valve members 72 or 74 from engagement with passage 70. More specifically, energization of coil assembly 92 lifts valve member 72 from engagement with the passage and on de-energization of coil assembly 92 spring 96 pushes valve member 74, through connector 118, off of passage 70. In either case the lost motion permits the armature to have accelerated before engaging and driving the rod, thus rod movement is started with an impact and will free the valve members should they tend to stick.

Since the pressure in passage 38 will at all times be relatively low with respect to that existing in passages 32, 34 and 36, it is also contemplated that surface 46 will be coated with a solid lubricant, for example resin bonded solid lubricant commonly known by the commercial name "Molykote." The solid lubricant is applied to this surface and prevents leakage from the higher pressure passages 32, 34 and 36 to the relatively low pressure passage 38 and serves an additional function of providing a lubricant to reduce the friction opposing spool valve movement.

Conventionally spool valve 12 is circular in transverse cross section and in order to maintain accurate alignment of passage 38 with the axially aligned conduits 16, 18

and 20, it is preferred that spool valve 12 be held against rotation in shell 14. The valve constructed in accordance with this invention contemplates an improved method of preventing this rotation in that it utilizes an insert 120 in conduit 22 which includes a pair of inwardly extending ears 122, only one of which is illustrated in FIG. 1, which project into axial passage 36. In this manner ears 122 act in the nature of a key and passage 36 in the nature of a keyway to hold the spool valve against rotation and maintain the desired axial orientation of passage 38 with the conduits and their respective openings.

Although this invention has been illustrated and described in connection with particular embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. A valve comprising, in combination
 - a an elongated body having an open end, means defining inlet and outlet openings in said body,
 - a valve member in said body having spaced portions exposed to first and second areas in said body and being movable between first and second positions in said body in accordance with the pressure differential between said first and second areas acting on said valve member to thereby control flow between said inlet and outlet openings,
 - a control valve mounted on said body closing said open end of said body and defining, with said valve member, said first area as a first variable volume chamber, said control valve including means defining passage means in said control valve opening directly into said first chamber and valve means in said passage means,
 - means closing the end of said body opposite to said open end and defining, with said valve member, said second area as a second variable volume chamber,
 - means at said opposite end of said body defining an opening into said second chamber,
 - means for connecting said passage means to said opening into said second chamber,
 - said control valve also including means defining an inlet to said passage means and operating means for moving said valve means to connect said inlet selectively for communication with said first and second chambers through said passage means opening and said opening into said second chamber whereby said first and second chambers can be selectively exposed to a pressure condition through said passage means to position said valve member accordingly,
 - and closure means on and movable with said valve member into and out of selective engagement with said passage means opening and said opening into said second chamber so that said control valve can be used to connect said first and second chambers to a pressure determining source and said closure means will interrupt said connection when said valve member reaches one of said first and second positions thereof.

2. The combination of claim 1 wherein

- said valve member is movable along the longitudinal axis of said body between said first and second positions which positions are relatively spaced in an axial direction,

- said operating means includes a member movable in a direction parallel to said longitudinal axis, spring means biasing said movable member in one axial direction and means for moving said movable member in an opposite axial direction against said spring means,

- and including lost motion means having axially spaced, confronting generally radial surfaces connected to and movable with said movable member, a radial projection disposed between said radial surfaces and

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connected to and movable with said valve means, and said radial projection being alternately in engagement with one of said confronting surfaces and spaced from the other whereby relative movement is provided between said movable member and said valve means upon initial movement of said movable member in both axial directions and, after initial movement of said movable member sufficient to take up said lost motion, a driving connection is established between said movable member and valve means so that said movable member is in motion at the time said driving connection is made.

3. The combination of claim 1 wherein said body includes means defining first, second, third and fourth openings into said body providing said inlet and outlet openings, and said valve member includes means defining first and second passage means, said first passage means operative to connect said second opening selectively to said first and third openings, and said second passage means operative to connect said fourth opening selectively to said first opening when said first passage means connects said second and third openings and to said third opening when said first passage means connects said first and second openings.

4. The combination of claim 3 wherein one of said closure means includes a closure member movable with and projecting from said valve member and means connected between said closure member and said valve member biasing said closure member away from said valve member, the opening in said first variable volume chamber defined by said control valve passage means arranged axially in the path of movement of said closure member and said closure member being engageable in that opening against said bias.

5. A reversing valve comprising, in combination, an elongated hollow tubular body having open axial ends, means defining first, second, third and fourth openings into said body,

a valve member in said body and having oppositely directed portions facing respective ones of said open ends,

a control valve mounted in and closing one end of said body and defining, with one of said valve member portions, a first variable volume chamber,

said control valve including means defining an inlet, means defining a passage communicating with said inlet and opening directly into said first chamber, valve means in said passage, and operating means connected to and operative to move said valve means in said passage,

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means closing the other end of said body and defining, with the other one of said valve member portions, a second variable volume chamber,

means at said other body end defining an opening into said second variable volume chamber,

said valve member being movable axially in said body in accordance with the pressure differential between said first and second chambers acting on said valve member to thereby assume first and second positions within said body,

said valve member including a passage connecting said first and second openings in said first valve member position and connecting said second and third openings in said second valve member position, said third and fourth openings communicating with each other when said valve member is in said first position and said first and fourth openings communicating with each other when said valve member is in said second position,

means for connecting said control valve passage to said opening into said second chamber,

said operating means operative to move said valve means in said passage to connect said inlet selectively for communication with said first chamber and said second chamber so that said first and second chambers can be selectively exposed to the pressure condition at said inlet to position said valve member accordingly,

and closure means at the opposite ends of said valve member adapted to engage and close respective ones of said openings into said first and second chambers to interrupt the communication between said inlet and the chamber to which it is connected.

6. The combination of claim 5 wherein at least one of said closure means comprises a closure member biased outwardly from said valve member and engageable against said bias in a respective one of said openings into said first and second chambers.

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