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(54) IMPROVEMENTS IN OR RELATING TO A MULTIWAY VALVE

(71) We FESTO - MASCHINENFABRIK GOTTLIEB STOLL, a Company organised under the Laws of the Federal Republic of Germany, of Ulmer Strasse 48, Esslingen.a,N, Germany do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention is concerned with improvements in or relating to a multiway valve.

According to the present invention there is provided a multiway valve including a regulating member which is axially movable in a bore of a valve body to control communication between a plurality of ports opening into said bore, and which carries a diaphragm, the latter forming an internal seal where it engages against the regulating member and defining a seating area for sealing engagement with a valve seat internally of said bore, the bore opening into a chamber formed in said housing, the diaphragm being mounted in said chamber so as to divide said chamber into two and having a lip to form a radially effective lip seal with said bore to separate said bore from said chamber, the diaphragm controlling movement of the regulating member.

Preferably the diaphragm is movable between two end positions, being biased into one of said end positions and being movable into the other of said end positions by means of an electromagnetic apparatus.

Preferably also the valve includes a double-seat sealing member defined by two sealing lips spaced axially apart by a distance substantially equal to the distance between valve seats, against which the lips engage on movement of the regulating member.

Further the diaphragm may have an integral, substantially cylindrical extension located for movement in a section of the bore of the valve body and in sealing engagement with the latter.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawing, the single Figure of which shows an axial section through a multiway valve according to the present invention.

Referring to the drawing, a diaphragm-operated, multiway valve 11 which has an approximately rectangular cross-section, comprises a sectioned valve body 12 which comprises tapped bores 14, 16 and 17 in one of its narrow sides 13 to serve respectively as a pressure connection P and venting connections R and S, and tapped bores 18 and 19 in the opposite narrow side 21, to connect with two consumer units A and B. Depending on the position of an axially adjustable regulating member 22 inside a multi-stepped axial control bore which extends centrally through the valve body 12, the pressure connection P may be connected with the consumer unit B as shown in the drawing, the consumer unit A being connected with the venting system R while the venting system S is closed; or the pressure connection P may be connected with the consumer unit A, the consumer unit B being connected with the venting system S, and the venting system R being closed.

The regulating member 22, one end of which is supported against a helical compression spring 27 in a plug 26 which closes the end of the control bore 23, is axially adjustable against the load of the spring 27 by a diaphragm 28 which is rigidly connected with the other end of the member 22. The regulating member 22, or the diaphragm 28 respectively, is

indirectly controlled through an electromagnetic apparatus 31 which is located on an upper side 29 of the valve body 12; the drawing shows only a casing for the apparatus 31 with a passage extending therethrough, and fixing means therefor.

The diaphragm 28 comprises at its upper end an annular projection 32 with an enlarged end portion on its circumferential edge, said end portion being held in conjugate contact between adjacent sections of the body 12. The annular projection 32 may be either elastically deformable to such an extent that its deformation, caused by the displacement of the diaphragm 28 from its position of rest, is constant throughout the displacement, or the annular projection 32 may produce, during this movement, a snap effect which assists the movement of the diaphragm 28, acting approximately in the second half of this displacement. In a central zone, the diaphragm 28 is provided with a radial sealing lip 33 which enters into intimate sealing contact with corresponding wall sections of the multi-stepped control bore 23. In addition to this the diaphragm 28 is provided with an axial annular sealing area 34, which rests against a first valve seat 36 in a transition zone between the venting bore 16 and an annular space 37 which leads into the consumer bore 18 when the valve 11 is connected — a condition which is not shown in the drawing. The regulating member 22 is provided with a transverse bore 35 in the region of the annular space 37. A second valve seat 39 is located at the transition between this annular space 37 and a second annular space 38 connected with the supply bore 14, one ring- or plate-shaped sealing lip 41 at one axial end of a double-seat sealing element 42 being in sealing contact with the seat 39 when the valve 11 assumes its position of rest as shown in the drawing.

The double-seat sealing element 42, which is designed as a ring gasket comprises at its other axial end another ring- or plate-shaped sealing lip 43 which, relative to a transverse median plane through the element 42 constitutes a mirror image of the sealing lip 41. The two sealing lips 41 and 43 are separated by a groove 44 around the outer circumference of the ring gasket 42, the groove, in the unstrained state of the gasket 42, being approximately Vee-shaped, and the lips, because of the Vee-shaped groove 44, steadily decreasing in axial width towards their outer edges. In the unstrained state of the gasket 42 the parallel outer surfaces of the sealing lips 41, 43 extend at right angles to the longitudinal median axis, each sealing lip having a small annular groove (not shown) near the inner bore. The double-seat ring gasket 42 is clamped between two discs 46 which are fixed to the regulating member 22 so that the gasket 42 is held immovably by the regulating member 22 both axially and radially. The ring gasket 42 consists either of a plastics material with resilient properties, or of rubber. The material of the sealing lips 41, 43, and their thickness are such that the sealing lips 41, 43 are elastically deformed when resting against corresponding valve seats 39, 47, the case where contact is made between the sealing lip 41 and the valve seat 39 being shown in the drawing. The cross-sectional diameter of the root of the circumferential groove 44 is considerably smaller than the diameter of the second or third valve seat 39 or 47, respectively, with which it is associated. In this manner it has been achieved that the sealing lips 41, 43 are drawn, at least in part, into the opening inside the annular valve seat 39 or 47 respectively and that they therefore rest against the corrseponding valve seats under tension. The sealing effect of the lips in contact with the valve seat is intensified by the pressure admitted through the annular space 38. Independently of manufacturing tolerances and the clearances evolving during operation it thus has been ensured that both sealing lips on the ring gasket safely rest against the corresponding valve seats.

The third annular valve seat 47 extending into the second annular space 38 is defined by a projection which is integral with the casing and defines a third annular space 48 which is connected with the consumer bore 19. The regulating member 22 comprises — at the level of the third annular space 48 — an enlarged section 49 with a plurality of axially continuous slots 51 distributed around its circumference. In the state of rest of the valve depicted in the drawing, compressed air admitted through the supply bore 14 therefore flows through the second annular space 38, the slots 51, and the third annular space 48 to the consumer bore 19, while the connection between the second annular space 38 and the second consumer bore 18 is cut off, the first sealing lip 41 and the second valve seat 39 being in sealing contact.

A fourth annular valve seat 52 provided at the lower end of the third annular space 48 at a position remote from the third valve seat 47, is in sealing contact with a ring gasket 53 when the valve 11 is in its position of rest, this gasket 53 like the sealing lip 41 at the second valve seat 39, being under the effect of the helical compression spring 27. The ring gasket 53 is sunk into a groove in an

annular collar 54 supporting the regulating member 22 against the spring 27. The venting bore 17 opens into a fourth annular space 56 between the collar 54 and the wall of the control bore 23.

When the regulating member 22, which is shown in the state of rest, is caused to move downwards as indicated by the arrow D, airtight seals are established between the axial sealing surface 34 of the diaphragm 28 and the first valve seat 36, and between the second sealing lip 43 of the double-seat seal 42 and the third valve seat 47. The second sealing lip 43 may thereby be drawn into the opening of the annular valve seat 47, as is the sealing lip 41 in the valve seat 39 in the starting position, and the lip 41 is released from the valve seat 39. On completion of this movement, the ring gasket 53 has also been released from the fourth valve seat 52 so that a compressed air connection is established from the supply bore 14 through the annular spaces 38 and 37 or the transverse bore 35 respectively, to the consumer bore 18, while a venting connection is established between the consumer bore 19 and the venting bore 17 through the annular spaces 48 and 56, as indicated by the chain-dotted arrows. The sealing contact between the sealing elements and the corresponding valve seats is established in this state by the effect of a pressure induced by an operating element and it is maintained while this pressure is available, after which the regulating member 22 will be caused to return into its starting position under the load of the helical compression spring 27.

The operating element used may be the medium admitted through the supply bore 14 and may be compresed air as in the illustrated example. The supply bore 14 is accordingly connected with a control chamber 67 located in the valve body 12, above the diaphragm 28, through an impulse line or channel 59. The impulse line 59 commences at a small bore 61 at the circumfreence of the supply bore 14 and, using channels or bores through the casing 12, which are not shown in the drawing, leads to another bore 62 and a jet shaped nozzle 63 which extends upwards coaxially with the longitudinal median axis of the valve so as to prevent unbalancing forces, opening into a coaxial blind bore 64 which is drilled into the body 12 from its upper side 29, opposite to the electromagnetic apparatus 31. Another channel 66 of the impulse line 59, which connects with the annular control chamber 67, opens into the base of the blind bore 64, eccentrically to the nozzle 63. The blind bore 64 accommodates an axially adjustable, piston shaped, sealing element 68, supporting it over an O-ring 70 which is in effective connection with the electromagnetic apparatus 31 which drives this element 68. In its position of rest, the piston 68 is maintained centrally and closely at the mouth of the nozzle 63, using for example a compression spring in the apparatus 31 for its control, thus preventing any pneumatic control impulse from being received at the control chamber 67 from the supply bore 14, through the impulse line 59. When the electromagnetic apparatus 31 is energised in order to reverse the system, the piston 68 is displaced upwards by an armature as indicated by the arrow C, lifting off from the nozzle 63. As a result, compressed air is forced into the control chamber 67 from the supply bore 14 though channels which are not shown in the drawing, the nozzle 63, the space 69 between the base of the blind bore 64 and the piston 68, and through the channel 66 of the impulse line 59, so that the diaphragm 28, together with the regulating member 22, responding to the pneumatic pressure, moves downwards as indicated by the arrow D.

When the magnet 31 is de-energised the piston 68 is once more pressed against the nozzle 63, and seals the same. No pressurised air is therefore applied to the diaphragm 28, and the regulating member 22, responding, due to leakage of air from the control chamber 67, to the effect of the helical compression spring 27, resumes its inital poston.

A radial bore 72 opens into a recess 71 which is provided in the blind bore 64 on the side remote from the channel 66. This radial bore 72 extends to the outside and accommodates a pivotal bolt 73 which supports an O-ring and is axially fixed by a pin. An end section 74 of this bolt 73 projecting into the recess 71 is flattened to act as an eccentric. The flattened end section 74 fits into the recess 71 which has a circular bottom, the flattened portion preferably extending up to the longitudinal median plane. The plane, flat area of the end section 74 is thereby adjacent to the piston 68 when the system is in its state of rest. The piston 68 may be controlled by hand if, for example, the electromagnetic apparatus 31 breaks down and fails to move the piston 68, causing thereby failure of the entire valve 11. With the manual control, a screwdriver is passed through an operating slot, to reach the bolt 73 from the outside, turning it round so that the circular side of the flattened end section 74 ies in contact with the piston 68 and therefore able to lift it up. As soon as the piston 68 is lifted out of its end position, compressed air may flow through the impulse line 59, and operate the valve 11 in the manner described above. It is

evident that the operating and/or control medium need not be compressed air and that any gaseous or even liquid medium supplied under pressure may be used. In addition to this, different means may be applied for isolation of the impulse line 59, using for example an air-pulse operated flap or the like.

It follows from above that the diaphragm 28 of the valve has a number of functions: it serves by virtue of a flexing part X4 as a drive for the valve spindle which constitutes the regulating member 22, participating at the same time in the control of the regulating member in the bore 23 in the zone X6 by means of an upper cylindrical part X5; it also has the function of an internal seal as indicated at X1, as it surrounds the regulating spinidle as a seal from the outside; in the zone X2 the diaphragm serves as a seating area on axially effective poppet valve seat 36; and the diaphragm serves as a radially movable sealing lip between the regulating element and the control bore, the lip 33 being effective in the zone X3; and it has finally the usual functions of a restrained diaphragm.

In the chosen embodiment shown in the drawing the valve spindle is operated externally through an electromagnetic apparatus 31.

Finally the diaphragm is provided with a stabilising ring 60 which serves, as it were as a supporting disc for the multifunctional diaphragm. This stabilising ring may for example be an elastically resilient element consisting of metal which is located on the side adjacent to the impulse line and preferably vulcanised on to the diaphragm.

A multiway valve as hereinbefore described functions smoothly and practically frictionless, is operable in numerous ways, and is based on a design as simple as possible so as to eliminate the danger of losses.

Known valves of similar type, which would be suitable for the envisaged functions, generally comprise a ring gasket serving as a double-seat seal which is axially adjustable between two stops. It is therefore possible for the gasket to assume a central position between its two end positions, jeopardising the sealing function. Apart from this it is necessary with these known valves to adhere to the very narrow manufacturing tolerances allowed for the sealing element and the valve body in order to ensure that the sealing effect remains satisfactory.

The double-seat seal of the valve hereinbefore described retains its sealing properties even in the event of using valves and valve casings manufactured without the strict observance of the specified tolerances and/or preparing and mounting the gaskets and the valve seats with which they are assembled without observation of the respective tolerances, and wherein therefore relatively wide tolerance limits are acceptable without causing the danger of lowering the sealing standards.

The double-seat valve seal retains its sealing power even in those cases where the tolerances are wide, because the respective sealing lip will be axially deformed in the normal sealing position. This effect will be more or less pronounced, depending on the given tolerance or rather on the position of the sealing element relative to the corresponding valve seat, and the sealing lip will in any case be in intimate contact with the valve seat and extend into the annular valve seat more or less appreciably, depending on the force which pulled it into the seal. The circumferential groove not only guarantees that the sealing lip may be elastically deformed, it also ensures that the sealing lip is pressed into the valve seat as soon as pressure is applied. The diameter, measured at the root of the groove, which is smaller than the diameter of the valve seat, makes the elastic deformation of the sealing lips simple.

Since all that is required for sealing, is to provide a compressive load capable of overcoming the pressure of the operating medium, the electromagnetic drive can be relatively small. However, it is a feasible alternative to actuate the sealing element by means of a pressure applied by a suitable medium such as the pressure medium used with the valve. Operating- and control media suitable for the valve include by preference compressed air but also any gaseous or liquid pressure medium.

Various modifications may be made without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

1. A multiway valve including a regulating member which is axially movable in a bore of a valve body to control communication between a plurality of ports opening into said bore, and which carries a diaphragm, the latter forming an internal seal where it engages against the regulating member and defining a seating area for sealing engagement with a valve seat internally of said bore, the bore opening into a chamber formed in said housing, the diaphragm being mounted in said chamber so as to divide said chamber into two and having a lip to form a radially effective lip seal with said bore to separate said bore from said chamber,

the diaphragm controlling movement of the regulating member.

2. A valve according to Claim 1, wherein the diaphragm is movable between two end positions, being biased into one of said end positions and being movable into the other of said end positions by means of an electromagnetic apparatus.

3. A valve according to Claim 1 or 2, including a double-seat sealing member defined by two sealing lips spaced axially apart by a distance substantially equal to the distance between valve seats against which the lips engage on movement of the regulating member.

4. A valve according to Claim 3, wherein the sealing lips of the double-seat member, in an unstrained condition, define an annular gasket having a Vee-shaped groove around its outer periphery.

5. A valve according to Claim 4, wherein the cross-sectional diameter of the root of the groove is smaller than the diameter of the valve seats.

6. A valve according to any of Claims 3 to 5, wherein the double-seat member is integrally formed of an elastomeric material, the lips being axially elastically deformable against the respective valve seats on movement of the regulating member.

7. A valve according to any of Claims 3 to 6, wherein that one of the valve seats, betwee nwhich the double-seat member is located, which is remote from the diaphragm, communicates with a respective one of consumer outlets through flow restricting means.

8. A valve according to any of the preceding claims, wherein the diaphragm includes an elastically deformable annular projection by means of which the diaphragm is floatingly suspended inside the valve body.

9. A valve according to any of the preceding claims, wherein the diaphragm has an integral, substantially cylindrical extension located for movement in a section of the bore of the valve body and in sealing engagement with the latter.

10. A valve according to Claim 9, wherein an end zone of the cylindrical extension defines the seating area on an end face and has a reduced diameter relative to the remainder of the cylindrical extension.

11. A valve acocrding to Claim 10, wherein the diameter of the end zone decreases with increasing distance from said end face.

12. A valve according to Claim 10 or 11, wherein the lip seal is located on the remainder of the cylindrical extension.

13. A valve according to any of the preceding claims, wherein an annular space is defined between the diaphragm and an impulse line which is connected in a closable manner with a pressure connection for an operating medium, the impulse line opening eccentrically into said annular space.

14. A valve according to Claim 13, when dependent on Claim 2, wherein the impulse line communicates with the pressure connection through channels extending through the valve body, one of the channels opening through a jet shaped nozzle into a blind hole which accommodates an adjustable sealing member, the latter being controlled by means of the electromagnetic apparatus or an impulse provided by the medium, or by hand.

15. A valve according to Claim 14, wherein said impulse line opens at one end into said annular space and opens at its other end into the blind hole at the bottom thereof.

16. A valve according to Claim 14 or 15, wherein an eccentric which is rotatable from the outside of the valve body is engageable with the adjustable sealing member, a radial bore which opens into the blind hole accommodating a pivotal bolt, an end section of the latter extending into the blind hole up to the longitudinal median plane of the valve body, to define said eccentric, and being flattened.

17. A valve according to any of the preceding claims, wherein the diaphragm is provided with a stabilising ring to which it is vulcanised.

18. A multiway valve substantially as hereinbefore described with reference to the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*