

Jan. 12, 1960

H. F. WELSH
PNEUMATIC POPPET VALVE

2,920,651

Filed Jan. 9, 1956

3 Sheets-Sheet 1

FIG. 1A.

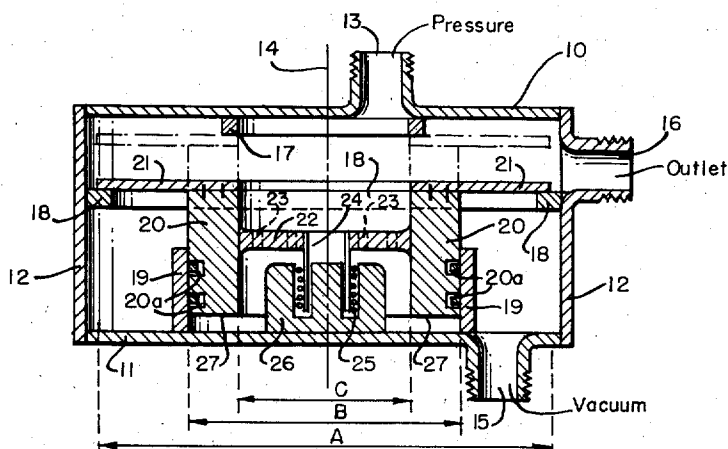
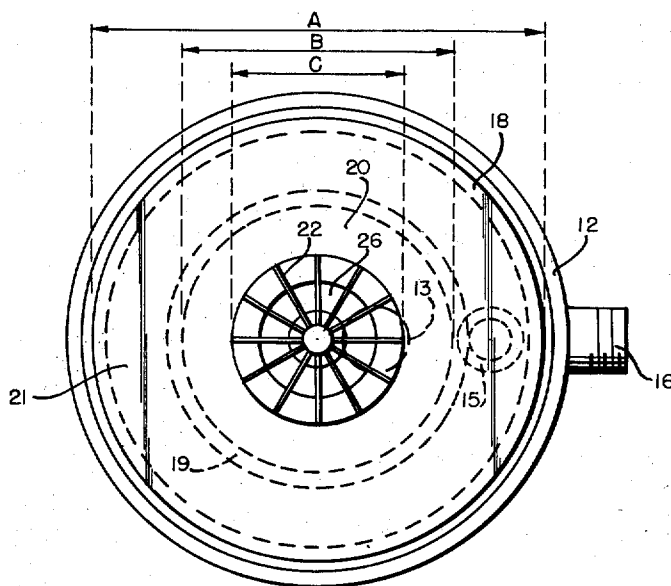


FIG. 1B.

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FIG. 2.

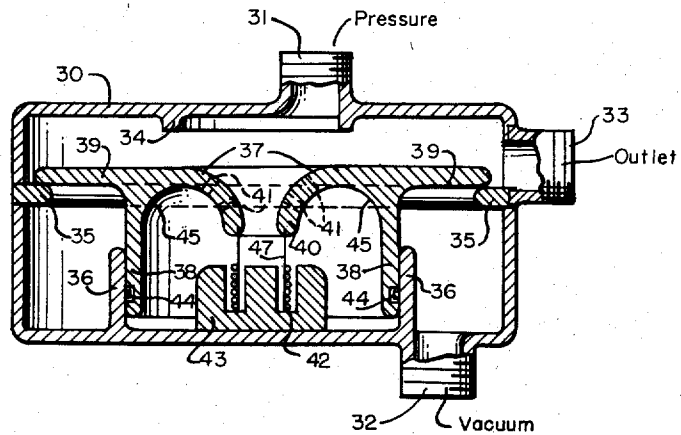
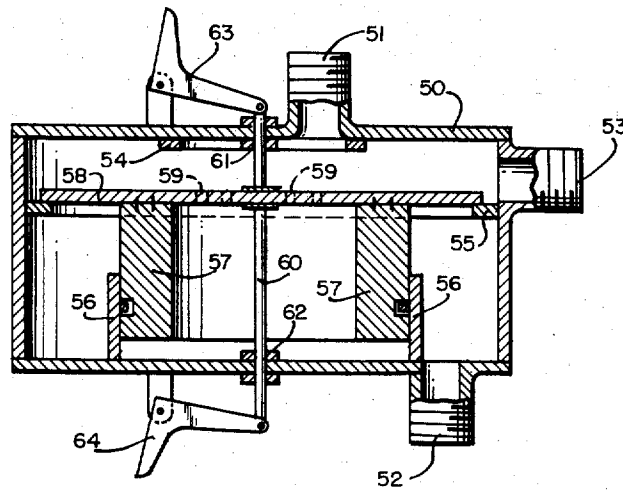


FIG. 3.

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FIG. 4.

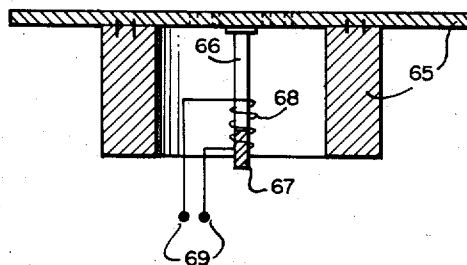
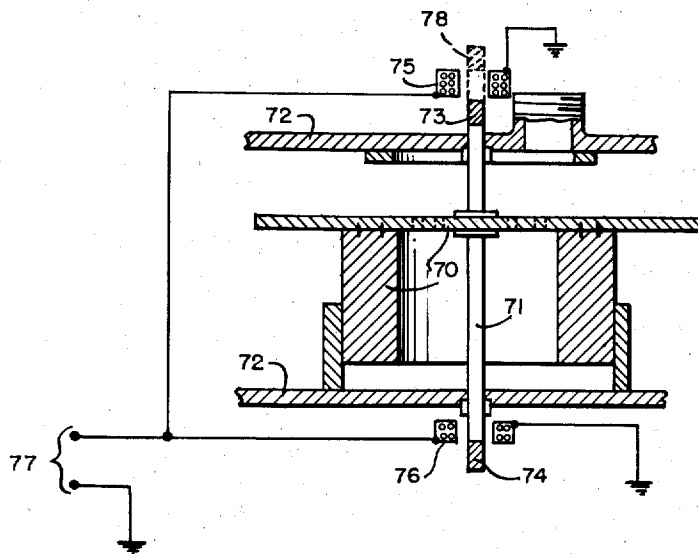


FIG. 5.

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2,920,651

PNEUMATIC POPPET VALVE

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Application January 9, 1956, Serial No. 558,061

19 Claims. (Cl. 137—625.25)

The present invention relates to pneumatic valves, and is more particularly concerned with improved valve structures capable of selectively coupling an outlet port to one or more inlet ports of differing pressures. As will be described, the valves of the present invention may be considered to comprise mechanical bistable devices and exhibit snap action operation, whereby no actuator energy is required to hold the valve in either of two stable positions.

In many devices utilizing pneumatic controls, it is often necessary to rapidly change the pressure on a given line, for instance from a pressure well above atmospheric to one approaching zero pressure. Reference is made, for instance, to my copending application Serial No. 546,643, filed November 15, 1955, for "Tape Handling Machine," wherein an improved system is described for the driving of information tapes in a recording and reproducing apparatus; and this particular tape handling system utilizes pneumatically controlled capstans, for instance, wherein the functioning of said capstans is operatively responsive to the pneumatic pressure applied thereto.

The present invention is primarily concerned with control structures such as may be utilized in such tape handling systems, or in other systems wherein it is desired to impress either a vacuum or a high pressure upon a given line; and wherein it is further required that rapid and complete transition between these different pressures be effected. In order to bring about a rapid transition from a pressure well above atmospheric to one approaching a state of vacuum, it is necessary that the air passages or other pneumatic chambers utilized be relatively large in terms of the molecular mean free path at the pressure sought. At the same time, the total volume of the air or pneumatic passages must be kept at a minimum for the time of transition to be minimum.

The valves of the present invention supply these desiderata by being so constructed that they afford a relatively large cross-sectional area while adding very little volume to the over-all system. The valves to be described exhibit the further advantages that a rapid reversible switching of a pneumatic line from pressure to vacuum can be effected, and the valves can in fact be actuated simultaneously on a plurality of lines. In addition, as will become apparent from the following description, the valves of the present invention exhibit a rapid snap action between two stable states whereby external energy is required only for the transition from one stable state to the other, and no holding energy need be applied. Such external energy for transition purposes may in fact be supplied in accordance with the present invention by either electrical or mechanical means.

Finally, as will become apparent from the subsequent description, the present invention provides improved valve structures which are easier to manufacture than has been the case in the past; which provide very little leakage;

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and which are so constructed that any leakage passes to the inlet ports rather than to the outlet port of the system, whereby such leakage does not affect a system under control.

5 It is accordingly an object of the present invention to provide an improved mechanical bistable device.

Another object of the present invention resides in the provision of improved poppet valves for rapidly switching an outlet line between two sources of differing inlet pressures.

Another object of the present invention resides in the provision of improved actuator means for use in poppet valves.

A further object of the present invention resides in 15 the provision of control valve structures which selectively exhibit rapid snap action shifts between pressure and vacuum supplies.

A still further object of the present invention resides in the provision of an improved valve structure where- 20 in a plurality of valves may be actuated simultaneously in the same or different directions by simple control devices.

Another object of the present invention resides in the provision of a pneumatic valve structure which is bistable 25 in operation and which requires no holding energy to maintain the valve in either of two stable states.

Still another object of the present invention resides in the provision of a valve structure which is simpler to manufacture and which is more easily fabricated within 30 working tolerances.

A further object of the present invention resides in the provision of a pneumatic valve structure having relatively little leakage within the valve itself, and little or no external leakage, the structure of the valve further 35 being such that any leakage actually occurring passes to pressure inlets rather than to an outlet line, thereby to be ineffective in reducing control of such an outlet line.

In providing for the foregoing objects and advantages, the present invention comprises valve structures wherein 40 a valve member exhibits two unequal opposed surface areas; and this valve member is operatively associated with a pair of stop or abutment members respectively disposed adjacent two control positions of the said valve member. The valve member is mounted in a housing, 45 and this housing is in turn supplied with a pair of inlet pressure lines as well as with an outlet pressure line whereby one or the other of said inlets is in communication with the said outlet when the valve member is in one of its positions, and is isolated from the said outlet when the valve member is in the other of its posi- 50 tions. The arrangement is such that when the valve member is in one of its two possible positions, a first resultant area is exposed to the pressure inlets whereby the said pressure inlets impose a force on the said valve member tending to hold the said member in its said position. On the other hand, when the valve member is moved 55 to the second of its two positions, a second resultant area is exposed to the pressure inlets and this second resultant area is in opposition to the first mentioned resultant area, whereby the valve member is held in its second position.

The changes in effective cross-sectional area, as the valve member is moved from one to the other of its positions, are effected through the disposition of the 60 aforementioned stop or abutment means whereby when the said valve member is in contact with a first of the said abutment means, a first total area is exposed to the pressure inlets, and when the said valve member is in contact with the second of its said abutment means, a second effective area is exposed to the said pressure in- 70 lets. The first and second effective areas are in op-

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position to one another whereby the valve member may selectively have either of two opposing forces thereon; each of said opposing forces being supplied from the aforementioned pressure inlets, and the actual direction of the force being dependent upon the position of the valve member relative to the aforementioned abutment means.

The aforementioned pair of pressure inlets supply different pressures respectively, and one of the said inlets may supply a vacuum while the other supplies a high fluid pressure. The arrangement, therefore, is preferably such that the valve member, in one of its positions, couples one of the said pressure inlets to the outlet thereby supplying a first pressure at said outlet, while when in the other of its positions the said valve member permits communication between the other of said pressure inlets and said outlet thereby to supply a second and different pressure at said outlet. Inasmuch as the effective areas of the valve member are so chosen that a valve member is held in both of its positions by pressure forces afforded by the said pressure inlets, external energy need be supplied only to effect a transition from one valve member position to a second valve member position; and this external energy may in fact comprise electrical signal means, such as will be described.

The foregoing objects, advantages, construction and operation of the present invention will become more readily apparent from the following description and accompanying drawings, in which:

Figure 1A is a diagrammatic side view illustration of an improved three-way poppet valve constructed in accordance with the present invention;

Figure 1B is a diagrammatic top view illustration of the valve shown in Figure 1A;

Figure 2 diagrammatically illustrates a modified valve structure of the type shown in Figures 1A and 1B;

Figure 3 diagrammatically illustrates a further embodiment of the improved pneumatic poppet valve of the present invention arranged to respond to mechanical actuator forces;

Figure 4 illustrates an alternative form of electrical control such as may be employed in the valves of the present invention; and

Figure 5 illustrates still another form of electrical control for the actuation of valves in accordance with the present invention.

Referring now to Figure 1, it will be seen that in accordance with the present invention the valve structure may be disposed in a housing which is preferably rectangular in cross-section. The said housing, which is generally cylindrical in configuration, preferably comprises upper and lower circular plates 10 and 11, and a connecting cylindrical plate 12. A pressure inlet 13 is provided in the upper plate 10, the said pressure inlet 13 being disposed to one side of the axial center line 14; and the said housing may further be provided with a vacuum inlet 15 in the lower plate 11 as well as with an outlet line 16 in the annular side wall 12. Located concentric with the center line 14 within the housing are stop members 17, disposed between the pressure inlets 13 and the outlet 16, and stop member 18, disposed between the vacuum inlet 15 and the said outlet 16. As an actual matter, the stops 17 and 18 each take the form of an annular ring attached respectively to the upper plate 10 and to the side walls 12 of the housing, as illustrated in Figures 1A and 1B.

Also disposed within the housing concentric with the center line 14 thereof, is a cylinder 19 which is adapted to receive a slidable hollow piston 20; and the said piston 20 may be supplied with ring seals 20a, for instance, to afford a seal between the outer walls of piston 20 and the inner walls of cylinder 19. Hollow piston 20 carries at one of its ends, an annular disk 21 extending at substantially right angles to the axis 14 of the housing and cylinder 20, and the dimensions of the annular disk

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or plate 21 are so chosen that the outermost boundary thereof may be caused to bear upon abutment or stop means 18 when the valve is in one of its positions (shown in full line), while the innermost boundary thereof may be caused to bear upon abutment or stop means 17 when the valve member is in the second of its positions (shown in dotted line). Hollow cylinder 20 further includes a spider 22 within the center thereof, and this spider 22 has air passages 23 affording pneumatic communication between opposite ends of the piston 20.

In the particular form of the invention illustrated in Figure 1A, the spider 22 may comprise an annular structure having a plurality of elongated passages 23 extending therethrough, as shown. In an alternative structure, shown in Figure 1B, the spider 22 may take the form of a plurality of radial spokes, again providing the aforementioned pneumatic communication between opposed ends of piston 20. The spider 22 serves to support a coil form 24 having an electrical coil 25 thereon; and this coil and coil form cooperate with a permanent magnet 26, disposed within the housing and affixed to plate 11 whereby forces may be selectively applied to the piston 20 and to annular disk 21 by coupling appropriate electrical signals to the coil 25. To simplify the illustration, the external leads which are coupled to coil 25 have been omitted, but it will be understood that such connections may be made in any suitable manner well known in the art. The control structure 24—25—26 is in fact similar to voice coils commonly found in loud speaker devices; and such structures are well known in the art.

Referring now to the operation of the device, it will be seen that when the valve member 20—21 is in its lowermost position in contact with abutment means 18, the pressure inlet 13 is in communication with pressure outlet 16; while the vacuum inlet 15 is isolated from the said outlet 16. For this first possible position of the valve member, the pressure inlet 13 supplies pressure forces on the upper surface of disk member 21, and also supplies opposing forces on the end 27 of piston 20 via passages 23. The dimensions of the piston 20 and annular disk 21 are so chosen that the effective area of disk 21 is larger than the effective area of the piston end 27. A total resultant force is accordingly exerted upon the composite valve structure 20—21 in a downward direction, and this total downward force is proportional to the square of the distance A—A minus the square of the distance B—B. Since the resultant force is in a downward direction, the valve member will tend to be held in contact with abutments 18, when in the position shown in Figure 1A; whereby, once the valve member assumes the position illustrated, the pressure inlet 13 will remain in communication with pressure outlet 16 and the vacuum inlet 15 will be effectively sealed from the pressure outlet 16.

If, now, an electrical signal should be applied to the coil 25, this coil will be expelled from the permanent magnet 26, and the piston 20 as well as the annular disk 21 carried thereby will tend to move upward. As disk 21 leaves abutment 18, the vacuum behind the said disk 21 is broken thereby resulting in a reduction of the force on the upper surface of disk 21. There is, therefore, little net force in the system to oppose the action of the coil 25 on the piston 20 at this state of operation. Piston 20 and the disk 21 carried thereby will accordingly move upward, and as the upper surface of the said disk 21 approaches abutment means 17, the air passages above the said disk 21 reduce in volume. There is, therefore, a decrease in the total force urging the valve member 20—21 in a downward direction without any concomitant decrease in the total force urging the said valve member upwardly whereby, after the valve member traverses a certain distance upward, the pressure forces on the end 27 of piston 20 tend to predominate thereby causing the valve member to snap rapidly into contact with abutments

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For this second position of the valve member 20—21 (shown in dotted representation), the pressure inlet 13 is isolated not only from the outlet 16, but because of the abutments 17, the said pressure inlet is also isolated from the upper surface of disk 21. Thus, pressure forces are imposed on the valve 20—21 only on the lower end 27 of the said piston 20 via passages 23, whereby a resultant force in an upward direction is provided, thereby causing the valve member to remain in its upper position against abutments 17. For this upper stable position the vacuum inlet 15 is in communication with outlet 16, while the pressure inlet 13 is isolated from the outlet 16 and serves only to hold the valve member in its upper position.

It should be noted that the holding forces impressed on the valve member for this second stable position are again supplied by the pressure inlet 13, communicating with end 27 of piston 20 via apertures 23; and that no electrical energy need be supplied to coil 25 to maintain this second stable position. Upon application of a reverse polarity current to the coil 25, however, a force is exerted in a downward direction on the piston 20, and the piston 20 is caused to move away from the stops 17 in a downward direction. This downward movement of the piston 20 and disk 21 causes the pressure to build up against the upper surface of plate 21, whereby, as before, upon passing a certain point in its downward transition, the resultant area of disk 21 and end surface 27 is such that a resultant downward force is imposed upon the valve member 20—21, whereby the said valve member snaps downwardly into contact with abutment means 18, once more to open pressure inlets 13 to outlet 16 and to seal vacuum inlet 15 away from outlet 16.

To summarize the foregoing structure and operation, therefore, it will be seen that the valve member of the present invention describes a first effective area on its upper surface (proportional to the square of the distance A—A minus the square of the distance C—C), and affords a second effective area on its lower surface (proportional to the square of the distance B—B minus the square of the distance C—C). When in one of its two stable positions, both of these effective areas are exposed to a pressure inlet whereby the resultant area is such that a force in a first direction is imposed upon the valve member. When the valve member is in its other stable position, however, only one of these effective areas is exposed to the pressure inlet whereby a resultant force in an opposite direction is imposed on the said valve member.

The cross-sectional view of the cylinder 20, shown in Figure 1A, has been illustrated as substantially rectangular, for purposes of best illustrating the relationship between the areas of end surface 27 and of annular disk 21. As a practical matter, however, the valve member 20—21 may take any configuration, including curved shapes, so long as the ratio of the projected surface representing the area 27 at the end of piston 20 and the area of the projected surface representing the annular disk 21 attached to the upper end of cylinder 20, is not disturbed. The area of surface 21 must be larger than the projected area of the end surface 27, but the ratio between these two areas may vary with the pressure differences between inlets 13 and 15 which are required for any given system. The structural embodiment described in reference to Figure 1A has also included a separate disk 21 attached to the cylinder 20, and such a composite structure has again been illustrated primarily for the ease of fabrication which it represents. As an actual matter, however, the composite valve member 20—21 shown in Figure 1A may take different forms, as mentioned above, and may in fact be fabricated as a continuous casting.

One such alternative arrangement is illustrated, for instance, in Figure 2. Thus, the valve member shown in Figure 2 may comprise a housing 30 having pressure inlet 31, vacuum inlet 32, outlet 33, first abutment means 34, second abutment means 35, and cylinder 36; and the ele-

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ments 31 through 36 comprising housing 30 may be formed, as shown, in a plurality of die-cast parts. A composite valve member 37, operating in the above described manner, may take the configuration illustrated in Figure 2, and may comprise a first downwardly extending piston 38 slidably disposed in cylinder 36, in conjunction with an orthogonally extending section 39 cooperating selectively with abutment means 34 and 35. The valve member 37 may have a central spider 40 integrally formed with the said valve member and defining a plurality of air passages 41, to afford pneumatic communication between opposed sides of the said valve member. Spider 40 may, as before, carry a coil form 47 and a coil 42 cooperating with magnet 43 in the manner described.

It should be noted that ring seals 44 may also be supplied in a manner analogous to ring seals 21 of Figure 1A; but it must be emphasized that such ring seals in the several embodiments of the present invention comprise a refinement only, and are not essential to the operation of the device. Other types of seals may be employed, or no seals at all may be necessary if the piston and cylinder are surface-finished within suitable tolerances.

The particular valve member shown in Figure 2 operates in precisely the fashion described in reference to Figure 1A, with the exception that the lower effective area of the composite valve member is supplied by the projected area of a curved surface 45 rather than by an end surface, such as 27 of Figure 1A.

Before proceeding with the description of other possible embodiments of the present invention, it should be noted that the outlet line, such as 16 and 33 of Figures 1 and 2 respectively, is not affected by leakage within the valve itself. Thus, if something less than a perfect seal should be afforded between the piston, such as 20 and 38, and the cylinder, such as 19 and 36, leakage occurs from one pressure inlet to the other pressure inlet rather than to the outlet line. Such leakage, if not excessively large, thus merely increases the work load on the source pumps without in any way affecting the system under control coupled to the outlet line, such as 16 and 33; and this elimination of leakage effects upon the control line provides an appreciable advantage when valves of the type described and to be described are utilized.

Each of the embodiments described in reference to Figure 1A and Figure 2 affords selective transition between the two possible stable states of the valve member, by coupling electrical signals to a coil carried by the said valve member. Other forms of control may be provided, if desired, and this control may in fact be mechanical in nature, as illustrated in Figure 3. Thus, referring to Figure 3, it will be seen that the valve may comprise again a housing 50 having a pressure inlet 51, a vacuum inlet 52, an outlet 53, first abutment means 54, second abutment means 55, a cylinder 56, a piston 57 and a circular disk 58 defining air passages 59. The structure thus provided operates in the manner described in reference to Figures 1A and 2, since the abutments 54 and 55 cause two opposed resultant areas to be presented to pressure inlet 51 depending upon the position of composite valve member 57—58 relative to those abutments.

In providing transition between one stable position and the other, however, a rod 60 may be attached to the disk 58 and may extend at its opposed ends through the upper and lower surfaces of housing 50 via seals, such as packing glands 61 and 62. The opposed ends of the elongated actuator bar 60 may be pivotally affixed to bell cranks 63 and 64, or to other mechanical translatory mechanisms. The particular valve position shown in Figure 3 is, of course, a stable position; and by applying suitable forces to the bell cranks 63 and/or 64, the rod 60 may be caused to move the valve structure upward toward abutment means 54 until the said valve member snaps home against abutments 54 in its second stable position. Reverse forces may thereafter be employed

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to cause the valve member to return to its original stable position.

Other forms of actuator controls may also be provided; and one such alternative form is shown in Figure 4. For purposes of clarity, only portions of the control system actually under consideration have been illustrated in Figure 4; but it will be appreciated that housings, abutments and pressure lines of the type already described, will be supplied in combination with the structure shown in Figure 4.

Thus, referring to Figure 4, it will be seen that the valve member 65 may have an actuator rod 66 attached thereto; and in the particular form of the invention illustrated in Figure 4, this actuator rod 66 may be disposed entirely within the housing comprising the improved valve of the present invention. Rod 66 is constructed for the most part of a non-ferrous material, and is terminated at one end with a magnetic material 67 of relatively high permeability. A coil 68 is disposed adjacent the rod 66, and the magnetic section 67, and the disposition of elements 67 and 68 is such that one-half the length of magnetic section 67 is always within coil 68. In the particular state of operation illustrated in Figure 4, the valve member 65 may be considered to rest in its lowermost position, and in this position the magnetic section 67 of the actuator bar 66 is disposed in the lower portion of the coil 68 with one-half of the said section 67 extending below the said coil 68.

If a signal should now be applied to terminals 69, current will flow in the coil 68, drawing section 67 by solenoid action into the said coil 68, whereby the valve member 65 is moved upwardly. The length of the magnetic portion 67 is equal to the length of travel of valve member 65; and once this valve member 65 has gone approximately half the distance between its respective abutments, the mechanical forces involved tend to complete the travel whereby the valve member will snap home against the upper abutment, and carry magnetic portion 67 of the actuator bar 66 in an upward direction until the upper half of the said section 67 is out of the coil 68. The application of a second pulse to terminals 69 will now cause the section 67 to be drawn downwardly into the coil 68 whereby a reverse action takes place.

The operation thus disclosed causes the valve to respond to successive pulses applied to the terminals 69 in such a manner that the valve member is caused to move from either one of its stable positions to the other of its stable positions in response to each such input pulse, and without regard to the pulse polarity. The structure thus acts as a mechanical flip-flop, or as a mechanical binary counter.

Still another actuator system is shown in Figure 5, and again the complete valve structure has not been illustrated in the interest of clarity. The valve member 70 may again include an elongated actuator bar 71 and the actuator bar 71 may be caused to extend through both the upper and lower surfaces of housing 72; in a manner analogous to that described in reference to Figure 3. One end of actuator bar 71 is terminated in a first section of magnetic material 73, while the other end of the said actuator bar 71 is terminated in a still further section of magnetic material 74. The length of each magnetic section or core piece 73 and 74 is, in the embodiment of Figure 5, chosen to be approximately equal to half the travel of valve member 70 rather than being equal to the entire valve travel, as was the case with magnetic section 67 of Figure 4; and by choosing this reduced length of magnetic sections 73 and 74, each of these magnetic sections will always be just outside an associated control coil, such as 75 and 76. Coils 75 and 76 may be connected to electrical input terminals 77, whereby signals applied to the said terminals 77 will cause successive mechanical transition of the valve member 70 between its two stable positions.

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In the particular representation of Figure 5, the magnetic sections 73 and 74 are just below their respective coils 75 and 76; and this disposition of elements corresponds to a first stable position of valve member 70 wherein the said valve member 70 is in its lowermost position. Upon application of a first signal to the terminals 77, each of the magnetic sections 73 and 74 will be drawn upwardly by solenoid action into coils 75 and 76 respectively, thereby urging valve member 70 toward its uppermost stable position. Once the said valve member 70 passes a mid-point in its transition, the mechanical forces already described are such that the said valve member is caused to snap home in its upper position whereby the magnetic sections 73 and 74 are moved out of the coils 75 and 76 and reside immediately above those coils in the second stable position.

This latter state of operation has been illustrated diagrammatically by the representation of magnetic section 73 at position 78, which position 78 is representative of the second stable valve location. A second input pulse appearing at terminals 77 will draw the magnetic sections 73 and 74 downward into their respective coils 75 and 76 whereby the valve member 70 is caused to move from its second stable position back to its first stable position.

While preferred embodiments of the present invention have been described, many variations will be suggested to those skilled in the art. The foregoing description is therefore meant to be illustrative only and should not be considered limitative of my invention; and all such variations as are in accord with the principles described are meant to fall within the scope of the appended claims.

Having thus described my invention, I claim:

1. In a pneumatic valve, a housing having first and second pneumatic inlets and having a pneumatic outlet disposed intermediate said inlets, a movable valve member including a substantially planar member movable in said housing between first and second positions, said outlet being open to one of said inlets in one of said valve member positions and said outlet being open to the other of said inlets in the other of said valve member positions, first and second abutment means within said housing, said first and second abutment means being disposed adjacent opposite sides of said planar member respectively whereby one side of said planar member is contiguous with one of said abutment means when said planar member is in one of said positions and the other side of said planar member is contiguous with the other of said abutment means when said planar member is in the other of its said positions, said planar member comprising an annular disk having a first cross-sectional area, said valve member including a hollow cylinder attached to said disk and having a second cross-sectional area, said abutments being so disposed relative to said valve member that in one of said positions both said disk and cylinder are exposed to one of said pneumatic inlets while in the other of said positions one only of said disk and cylinder are exposed to said one of said pneumatic inlets, whereby said valve member has a first effective cross-section when in contact with said first abutment means and has a second and different effective cross-section when in contact with said second abutment means, and means for selectively moving said planar valve member between said first and second positions.

2. The combination of claim 1 wherein said last named means comprises a magnetic element coupled to said valve member, and control means for selectively imposing a magnetic force on said element.

3. The combination of claim 2 wherein said magnetic element comprises a coil of wire, and a magnet adjacent said coil, said control means comprising means selectively passing a current through said coil.

4. The combination of claim 2 wherein said control means comprises a solenoid coil disposed adjacent said magnetic element, and means for selectively passing current through said solenoid coil.

5. The combination of claim 1 wherein said last named means comprises means selectively imposing a mechanical force on said valve member in a selected one of two opposing directions.

6. In a pneumatic valve, a valve member movable between first and second positions, said valve member having a first effective cross-section on one of its sides and having a second effective cross-section on the other of its sides, a pneumatic inlet adjacent said valve member, said pneumatic inlet being exposed to both sides of said valve member when said member is in said first position and being exposed to only one side of said valve member when said member is in its second position whereby pressure at said pneumatic inlet imposes a pressure force on said valve member maintaining said member in one or the other of its positions depending upon the position of said member, said valve member having a planar configuration on said one of its sides and having a hollow piston configuration on the said other of its sides, the area of said planar portion being greater than the cross-sectional area of said piston portion, said hollow piston portion being slidably disposed in a cylinder, a plurality of apertures in said valve member providing pneumatic communication between the opposite sides of said valve member, an outlet port adjacent said valve member, said outlet port being in communication with said pneumatic inlet when said valve member is in a predetermined one of its positions and said outlet port being isolated from said inlet when said valve member is in the other of its positions, and means for selectively urging said member from either one of its positions toward the other of its positions.

7. The combination of claim 6 wherein said last named means comprises means responsive to an electrical signal.

8. The combination of claim 6 including a further pneumatic inlet adjacent said valve member, said further pneumatic inlet being in communication with said outlet port when said first mentioned pneumatic inlet is isolated from said outlet port.

9. The combination of claim 6 wherein said valve member comprising said planar and piston portions is formed as an integral body.

10. In a pneumatic valve, a housing having a first inlet port, a second inlet port, and an outlet port, a cylinder disposed within said housing adjacent said first inlet port, a hollow piston slidably disposed in said cylinder, a planar member carried by said piston adjacent said second inlet port, said planar member having a larger cross-sectional area than the end area of said piston, a first abutment between said first inlet port and said outlet port, a second abutment between said second inlet port and said outlet port, said second inlet port being in communication with said outlet port, with said planar member, and with said piston when said planar member is in contact with said first abutment, and said second inlet port being in communication with only said piston when said planar member is in contact with said second abutment, said first inlet port being in communication with said outlet port when said planar member is in contact with said second abutment, and control means for selectively moving said planar member from contact with either of said abutments into contact with the other of said abutments.

11. The combination of claim 10 wherein said housing is cylindrical in configuration, said planar member comprising an annular surface extending at substantially right angles to one end of said hollow piston.

12. The combination of claim 11 wherein said planar member and said hollow piston are formed integrally with one another.

13. The combination of claim 10 wherein said control means comprises a rod attached to said piston and planar member, said rod extending external of said housing, and means for applying forces to said rod.

14. The combination of claim 13 wherein said means

for applying forces include means responsive to an electrical signal.

15. The combination of claim 10 wherein said control means comprises means for magnetically imposing a force on said planar member in response to an electrical signal.

16. In a pneumatic valve, a housing having first and second pneumatic inlets and having a pneumatic outlet disposed intermediate said inlets, a movable valve member including a substantially planar member movable in said housing between first and second positions, said outlet being open to one of said inlets in one of said valve member positions and said outlet being open to the other of said inlets in the other of said valve member positions, said valve member defining at least one aperture extending therethrough in pneumatic communication with one of said inlets whereby pressure from said one inlet is always applied from one to the opposite side of said valve member, via said aperture, regardless of the position of said movable valve member, first and second abutment means within said housing, said first and second abutment means being disposed adjacent opposite sides of said planar member respectively whereby one side of said planar member is contiguous with one of said abutment means when said planar member is in one of said positions and the other side of said planar member is contiguous with the other of said abutment means when said planar member is in the other of its said positions, said valve member having a first effective cross-section, to pressure from said one inlet, defined primarily by one side of said valve member when said planar member is in contact with the said first abutment means at said first position, and having a second and different effective cross-section, to pressure from said one inlet, defined primarily by the other side of said valve member when said planar member is in contact with said second abutment means at said second position, and means for selectively moving said valve member from one toward the other of said positions.

17. In a pneumatic valve, a valve member movable between first and second positions, said valve member comprising a piston slidably movable in a cylinder, said piston having different end areas whereby said valve member has a first cross-sectional area on one of its sides corresponding primarily to one of said piston end areas, and has a second cross-sectional area on the other of its sides corresponding primarily to the other of said piston end areas, a pneumatic inlet adjacent said valve member, abutment means disposed adjacent one end area of said piston for isolating portions of said end area from said inlet when said piston engages said abutment means, whereby the effective area of said one end of said piston changes as said piston engages and disengages said abutment means, said one end area being disposed adjacent said pneumatic inlet whereby changes in effective area of said one end area during movement of said piston into and out of engagement with said abutment means results in a varying pressure force being imposed on said one end area from said pneumatic inlet, the other end area of said piston being always exposed to said pneumatic inlet whereby a substantially constant pressure force is always exerted on said other end area from said pneumatic inlet, pressure from said pneumatic inlet being thereby operative to impose a resultant pressure force on said piston maintaining said valve member in one or the other of its positions depending upon the position of said valve member relative to said abutment means, an outlet port adjacent said valve member, said outlet port being in communication with said pneumatic inlet when said valve member is in a predetermined one of its positions and said outlet port being isolated from said inlet when said valve member is in the other of its positions, and externally controllable means for selectively applying an auxiliary force to said piston to urge said

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valve member from either one of its positions toward the other of its positions.

18. In a pneumatic valve, a housing having a first inlet port, a second inlet port, and an outlet port; a piston slidably disposed in said housing; one end of said piston defining a planar surface adjacent said second inlet port; said planar surface having a cross-sectional area which differs from the cross-sectional area of the other end of said piston; an aperture extending through said piston to provide pneumatic communication between said planar surface and said other end of said piston; first abutment means adjacent said planar surface; second abutment means adjacent said planar surface and spaced from said first abutment means in the direction of travel of said slidable piston; opposite sides of said planar surface being adapted to engage one or the other of said first and second abutment means as said piston is slidably moved between limits defined by said first and second abutment means; said second inlet port being in communication with said outlet port, with said planar surface, and with the other end of said piston when said planar surface is in contact with said first abutment means; and said second inlet port being in communication with only said

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other end of said piston when said planar surface is in contact with said second abutment means; said first inlet port being in communication with said outlet port when said planar surface is in contact with said second abutment means; and means for initiating movement of said planar surface from one toward the other of said abutment means.

19. The combination defined in claim 18 including a source of fluid having a pressure in excess of atmospheric pressure coupled to one of said inlet ports, and a source of fluid pressure below atmospheric pressure coupled to the other of said inlet ports.

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