Sept. 23, 1952 J. SAINSBURY ET AL 2,611,391

VALVE

Filed Dec. 14, 1945 2 SHEETS—SHEET 1

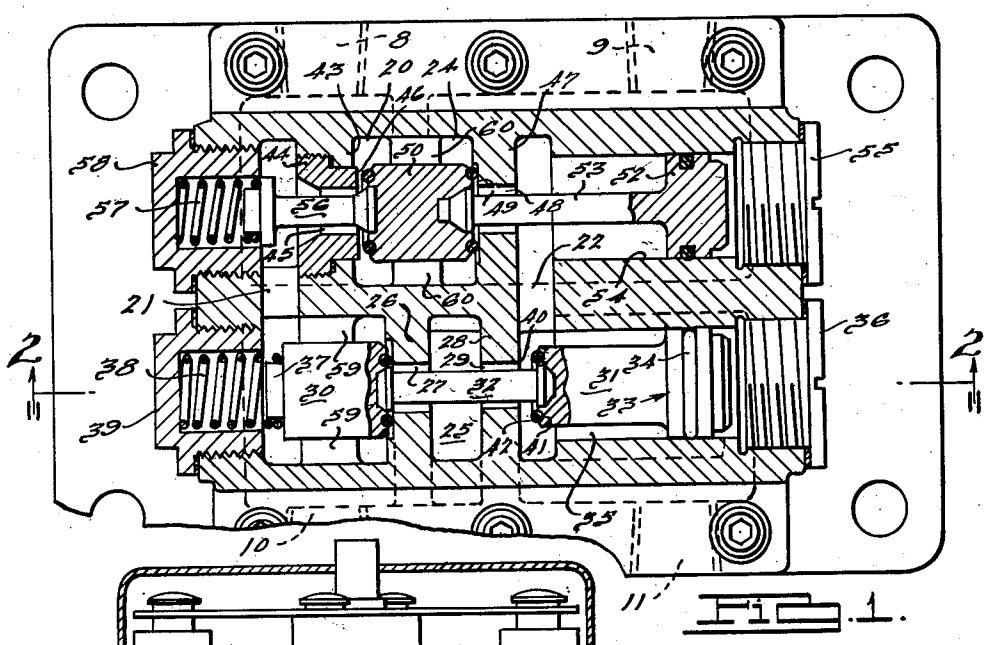


Fig. 1.

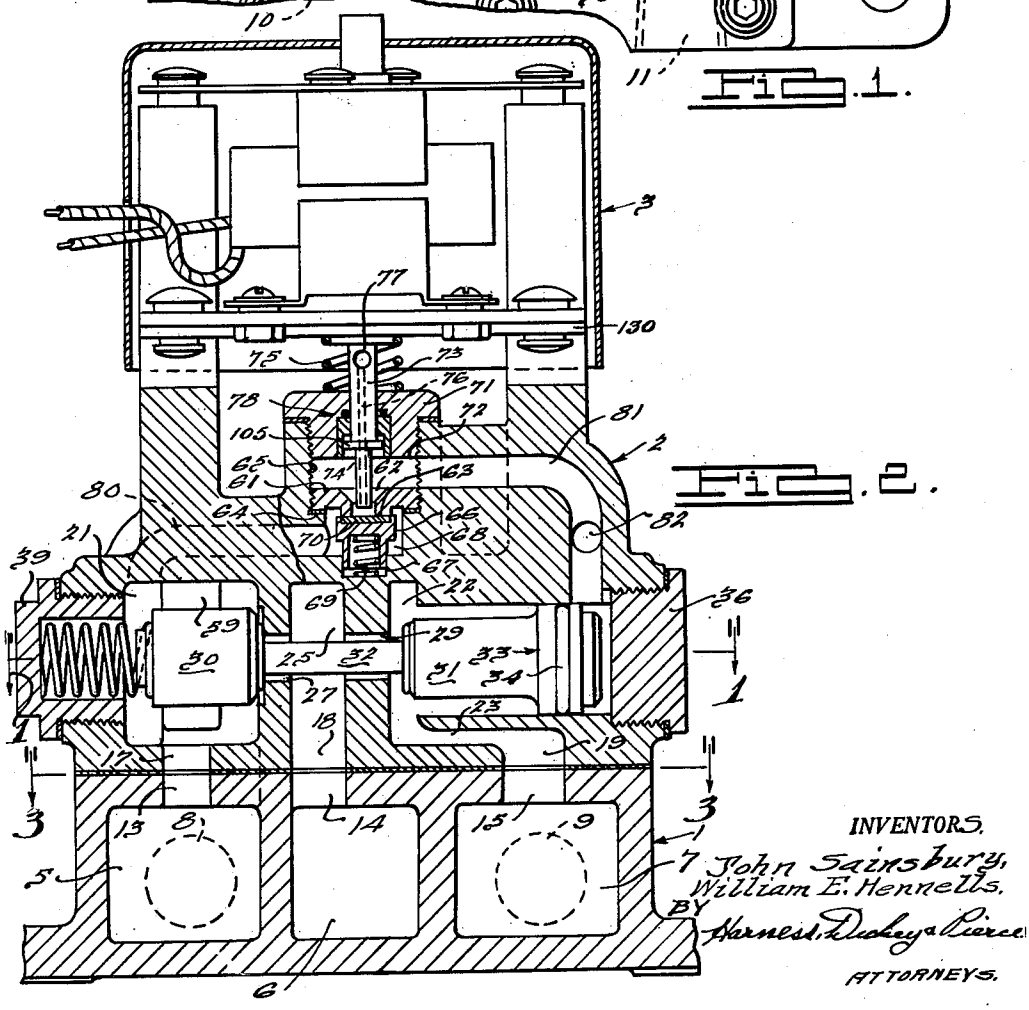


Fig. 2.

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VALVE

Filed Dec. 14, 1945 2 SHEETS—SHEET 2

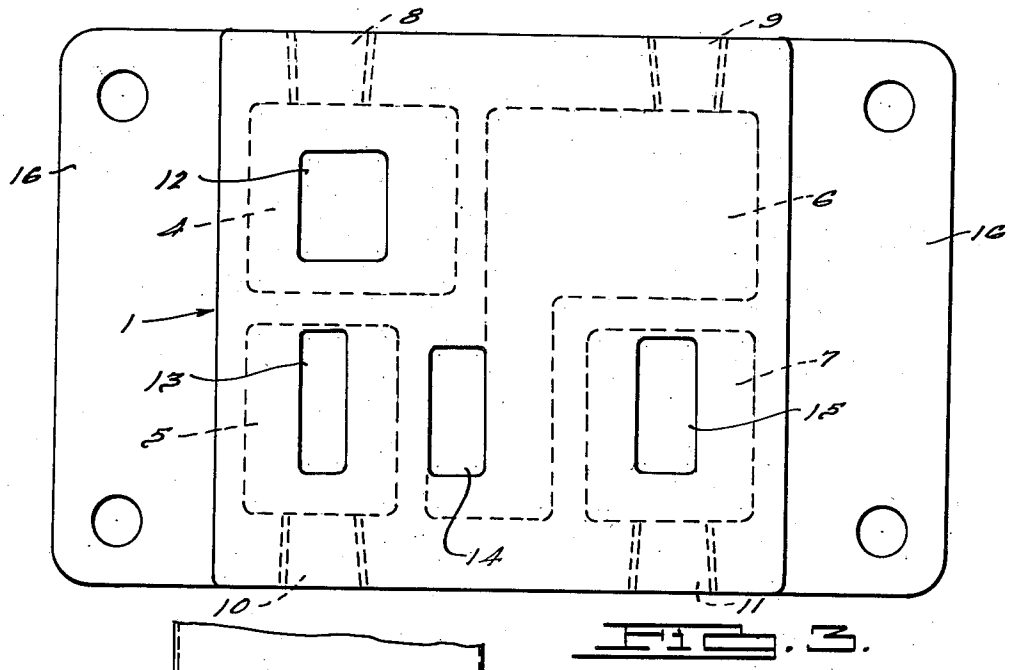


Fig. 3.

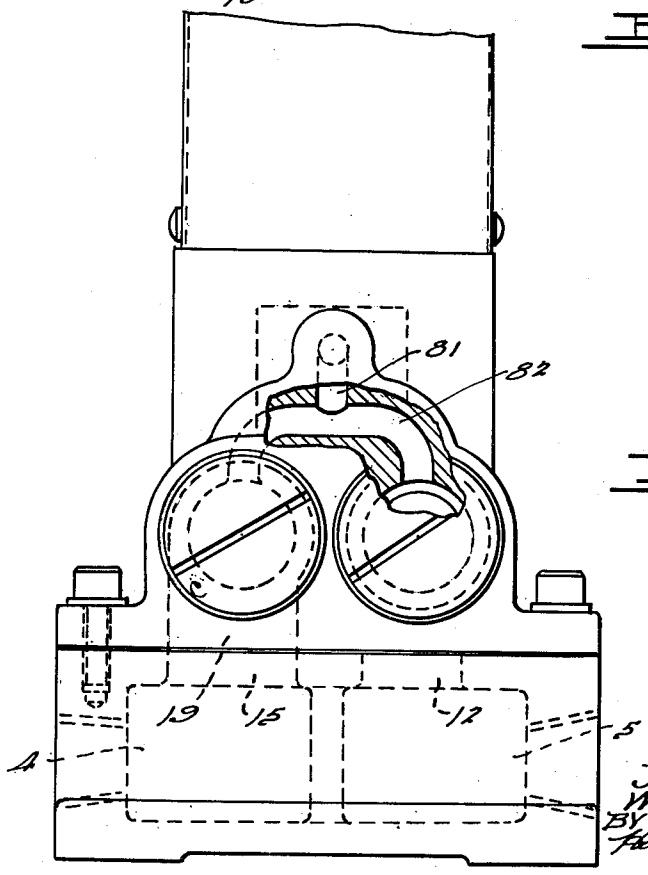


Fig. 4.

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VALVE

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4 Claims. (Cl. 137—623)

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The present invention relates to pilot operated valves of the type employed in controlling the operation of air cylinders.

For some purposes, such as for actuating the electrodes of spot welding machines, it is desirable to reciprocate air cylinders at very high speeds. This must be done by a control valve which reverses the pressure and exhaust connections to the cylinder. The requisite rapid reciprocation of the control valve gives rise to destructive hammering effects which shorten the life of the valve and particularly the valve seats. In addition, the only practical method of reciprocating such valves at high speeds and at accurate intervals is by the use of solenoids. These must be of excessive size if they are to operate the valve directly and accordingly, the use of solenoid controlled pilot operated valves has been proposed. Prior solenoid controlled pilot operated valves have been exceedingly complicated and expensive.

Accordingly, it is the general object of the present invention to provide an improved and more rugged and simple form of pilot operated control valve capable of high-speed operation.

Another object of the invention is to provide a valve of the above type for controlling double-acting air cylinders.

Another object is to provide an improved form of pilot valve for operation by a solenoid.

Other objects and advantages of the invention will become apparent from the following specification, the accompanying drawings and the appended claims.

In the drawings:

Figure 1 is a longitudinally horizontal section through a four-way valve mechanism constructed in accordance with the presence invention, said section being taken on the line 1—1 of Figure 2;

Figure 2 is a vertical section taken on the line 2—2 of Figure 1;

Fig. 3 is a plan view of the base casting of the valve shown in Figures 1 and 2;

Figure 4 is a right-end view of the valve shown in Figures 1 and 2 with part of the end of the casing broken away to show the interior construction;

The invention, as illustrated in Figures 1 to 4 inclusive, is embodied in a novel form of poppet type four-way valve adapted for use in controlling the action of double-acting air cylinders. This form of the invention comprises three principal parts; namely, a base casting indicated generally at 1; a valve body indicated generally at 2; and an electromagnetic actuator or solenoid mechanism indicated generally at 3.

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As best shown in Figures 2, 3 and 4, the base casting is cored out to provide four chambers indicated in dotted lines in Figure 3 by the numerals 4, 5, 6 and 7. Chamber 4 is provided with a port 8 which is adapted to communicate with one end of the air cylinder. Chamber 6 is provided with a port 9, adapted to communicate with the opposite end of the same cylinder. Chamber 5 is provided with a port 10, adapted to communicate with a source of air or gas under pressure. Chamber 7 is provided with a port 11, adapted to communicate with the atmosphere or a low pressure region for exhaust purposes. While the major portion of chamber 6 is in longitudinal alignment with chamber 4, it has an arm projecting laterally into a position in longitudinal alignment with and between the chambers 5 and 7.

The top surface of the base casting 1 is provided with four ports; port 12 communicating with chamber 4; port 13 communicating with chamber 5; port 14 communicating with chamber 6; and port 15 communicating with chamber 7. The base casting is also provided with apertured ends or flanges 16, by means of which it may be mounted.

The valve body 2 has a flat under surface provided with ports 17, 18, 19 and 20 which are aligned and communicate respectively with the previously mentioned base casting ports 13, 14, 15 and 12. The valve body is provided with a transverse cored chamber 21 communicating with port 17; a second transverse cored chamber 22 communicating with port 19 by means of a passageway 23, shown best in Figure 2; and a cored chamber 24 communicating with the port 20. The valve body is also provided with the cored chamber 25 which is in communication with the port 18. The wall 26, which separates chambers 21 and 25, is provided with a port 27, and the wall 28, which separates the chambers 25 and 22, is provided with a port 29 aligned with port 27. The ports 27 and 29 are adapted to be controlled by a poppet valve assembly having a pair of valve heads 30 and 31 which are held in spaced relation by means of a stem 32. The valve head 31 is provided with a piston 33 formed with a pair of annular ribs between which is fitted to a torus-shaped ring 34 formed of rubber-like material which acts as a seal. The piston fits within a cylindrical bore 35 which is aligned with the ports 27 and 29. The outer end of bore 35 is counter-bored and threaded to receive a closure plug 36.

The valve head 30, which is positioned within a longitudinal extension of chamber 21, is

provided with a reduced projection 37 adapted to receive a compression spring 38, the opposite end of which is fitted within a closure cap 39 that is threaded into a suitable opening located in alignment with the ports 27 and 29.

A novel form of valve seat and sealing elements are employed in conjunction with the valve heads 30 and 31. Thus it will be noted that the valve seating surface 40 of the port 29 is a flat surface extending at right angles to the axis of the stem 32 and that the valve head 31 is provided with an annular recess 41 in which is positioned a torus-shaped sealing element of rubber-like material. The sealing element 42 is preferably secured against displacement in the recess 41 by peening over the outer rim of the recess. The sealing element projects beyond the end of the valve head and is adapted to cooperate with the valve seat 40. This form of valve seat and sealing element is simple and inexpensive to construct and has been found to have remarkable endurance under the rapidly repeated pounding action incident to operation of the valve under the most severe condition. The seat and sealing element of valve head 30 provided for controlling port 27 is identical in construction and hence need not be further described.

The wall 43, which separates chamber 21 from chamber 24, is provided with an opening in which is secured a removable valve seat element 44 having a port 45 and a flat seating surface 46 located within the chamber 24. The wall 47 which separates chambers 24 and 22, is provided with a port 48 having a valve seating surface 49. A cylindrical valve element 50 is positioned within the chamber 24 and is provided at its ends with a pair of sealing elements similar in construction and operation to previously mentioned element 42 and which cooperate with seating surface 46 and 49 respectively to control the ports 45 and 48. The valve element 50 is held in spaced relation with respect to a piston 52 by a rod 53; and the piston 52 is similar in construction to piston 33. Piston 52 is mounted within a cylindrical bore 54 which is aligned with the ports 45 and 48; and the outer end of the bore 54 is threaded to receive a closure plug 55. The left-hand end of the valve element 50 is provided with an extension 56, which passes through port 45 and bears against one end of a compression spring 57. The opposite end of the spring is seated within a pocket in a closure plug 58 which is threaded in a suitable opening formed in the valve body.

The valve head 30 is guided by four circumferentially spaced inwardly projecting longitudinal ribs 59 formed within the axial extension of chamber 21. Valve element 50 is similarly guided by four circumferentially spaced radially projecting longitudinal ribs 60 formed on the walls of chamber 24.

As best shown in Figure 2, a pilot valve is provided for controlling the admission of operating pressure to the right-hand ends of the cylinders 35 and 54 to effect a shift of the valves to the left from the positions illustrated in the drawings. The pilot valve includes a valve seating ring 61 provided with a port 62 and an annular seating surface 63. The seating element 61 is threaded into position against shoulder 64 in a threaded opening 65 which extends vertically above the center of the valve body 2. The port 62 is normally held closed by a valve element 66 having a stem which slidably fits a cylinder recess 67 in the bottom wall of an air inlet chamber 68 and is normally urged upwardly by means of a spring 69. In a closed position a seating pad 70 on valve 66 engages the seat 63 and seals the port 62. The valve seating element 70 is preferably of a rubber-like material which is yielding in character.

The upper end of the threaded bore 65 is closed by means of a plug 71, thereby forming an air outlet chamber 72 communicating with the port 62. The plug 71 has a central opening which receives an operating pin 73 having a reduced lower extremity 74 adapted to project into the port 62 and engage and open valve 66 against the force of spring 69 and any air pressure which may be acting on the valve element. A spring 75 normally acts to hold the solenoid armature portion 130 up, while the solenoid 3, when energized, operates to force the pin downwardly to open the pilot valve. The pilot valve is held open during the interval in which the solenoid is energized. When the solenoid is de-energized, the armature portion 130 ascends, permitting pilot valve 66 to close under the influence of spring 69 augmented by fluid pressure. It will be seen that this drives the pin 73 upwardly, and when the upward movement of the pilot valve is arrested by engagement of its pad 70 with the valve seat 63, the pin 73 continues upwardly due to the fluid pressure on the flange 105 of the pin and also due to the momentum of the pin. This frees the lower end of the tubular pin from engagement with the upper surface of the pad 70. After the pressure in the passage 81 and in the connected right end portions of cylinders 35, 54 is dissipated, the pin 73 may again fall to re-engage the pad 70, depending upon the friction with which the pin 73 is fitted, but this is of no particular importance. If the pin falls, it will be struck a sharp blow by the armature when the solenoid is energized to drive the pilot valve from its seat, while if the pin is still raised or in an intermediate position when the armature is driven downwardly, the pin is driven sharply against the valve pad 70 to knock the valve quickly from its seat. When the pin 73 is in the upper position illustrated, the outlet chamber 72 of the pilot valve is connected to atmosphere by means of an axial bore 76 extending through the pin 73 and communicating with an atmospheric port 77 formed in the upper portion of the pin. When the pin is moved downwardly by the solenoid, the lower end of the reduced portion 74 seats against the sealing pad 70, thereby closing the lower end of the bore 76 and disconnecting the chamber 72 from atmosphere, very slightly before but substantially at the same time that valve 66 is opened. The air inlet chamber 68 is connected by means of a passageway 80 with a previously mentioned chamber 21, while the air outlet chamber 72 is a connected by means of a passageway 81 to a cross-passageway 82 which, as best shown in Figure 4, communicates with the right-hand ends of both of the cylinders 35 and 54.

Since the details of construction of the solenoid 3 form no part of the present invention, they need not be described in detail. Any desired form of electromagnetic means for depressing the operating pin 73 to open the pilot valve may be employed.

The operation of the device is as follows: With ports 8, 9, 10 and 11 connected as described, operating pressure entering port 10 will exist in chambers 5, 21 and 68 at all times, while chambers 7 and 22 and the left-hand ends of the cylinders 35 and 54 will be connected to the exhaust outlet 11 at all times. The outlet chamber 72 of

the pilot valve is constantly in communication with the right-hand ends of both of the cylinders 35 and 54. With the parts in the position illustrated, the valve elements 30, 31 and 50 will be held in their right-hand positions by the action of springs 38 and 57, and by the pressure in chamber 21. In that position ports 27 and 48 are closed and ports 29 and 45 are open. The air inlet chamber 68 of the pilot valve is connected to the air under pressure in chamber 21 by a passageway 80. The right-hand ends of the cylinders 35 and 54 are connected to the atmosphere through passageway 81 and 92 and the bores 76 and 77 in pin 73. As a result, air under pressure flows from port 10 through chamber 5, ports 13 and 17, chamber 21, port 45, chamber 24, ports 20 and 12 and chamber 4 to the cylinder port 8. At the same time, cylinder port 9 is connected to atmosphere or exhaust through chamber 6, ports 14 and 18, chamber 25, port 29, chamber 22, passageway 23, ports 19 and 15, chamber 7 and port 11.

When solenoid 3 is energized, pin 73 is depressed, and the right-hand ends of the cylinders 35 and 54 will be disconnected from the atmosphere and connected through bores 82 and 81, port 62, chamber 68 and passageway 80 to the pressure existing in chamber 21. Since the diameters of the pistons 33 and 52 are greater than the seating diameters of the valves 30 and 50, the pressure acting on the right-hand ends of the pistons will force the valves to the left, as viewed in the drawings, compressing springs 38 and 57. This will close ports 29 and 45 and open ports 27 and 48. In that position of the parts, pressure from port 10 passes through chamber 5, ports 13 and 17, chamber 21, port 27, chamber 25, ports 18 and 14 and chamber 6 to the cylinder port 9. At the same time cylinder port 8 is connected through chamber 4, ports 12 and 20, chamber 24, port 48, chamber 22, passageway 23, ports 19 and 15 and chamber 7 to the exhaust port 11.

As soon as the solenoid is de-energized, the pin 73 will be lifted upwardly by pressure acting on the shoulder on the pin thereby permitting valve element 66 to close port 62 under the influence of spring 69 and any differential pressure acting on the valve. At the same time the pilot outlet chamber 72 is connected to atmosphere through bores 76 and 77, thereby discharging the air under pressure at the right-hand ends of the pistons 33 and 52. As soon as the air at the right-hand ends of the pistons is discharged, which occurs almost instantaneously, the valves will be shifted into the position illustrated in the drawings by means of springs 38 and 57, plus air pressure in chamber 21.

It will be apparent that there is provided in accordance with the present invention, a solenoid controlled four-way pilot operated pneumatic valve of the type employing two poppet valve assemblies, each of which is in effect a three-way valve. An important feature of the present invention resides in the utilization of a single relatively small pilot valve for controlling the simultaneous reciprocation of two relatively large poppet valve assembiles. The construction of the valves and seats and the general arrangement of the parts is such that the valve may be operated continuously for long periods at exceedingly high speeds without injury. In actual tests, reciprocations at speeds in excess of 400 cycles a minute for sustained periods have not produced failure of any part of the mechanism.

The design or construction of the pilot valve is particularly suited for operation by a relatively small and therefore inexpensive solenoid. This results not only from the small size of the pilot valve, but from the principles upon which it operates. Thus, it will be noted that when the parts are in the position illustrated in the drawings, the high pressure existing in chamber 68 is acting to hold the pilot valve closed, while the pin 73 is elevated in spaced relation to the seating pad 70 of the pilot valve. When the solenoid is energized, the pin is driven downwardly and the initial downward movement is unopposed except by the relatively light spring 75 until such time as the end of the pin 73 strikes pad 70. By that time, the pin 73 and the associated moving parts in the solenoid have considerable kinetic energy which is effective to drive the valve element 66 off its seat by a hammer-like blow. As soon as the valve 66 is open, the pressure on the opposite sides of the valve element is substantially balanced and relatively little force is required to hold it in an open position against the relatively light spring 69. The hammer-like blow applied by the pin to the valve is cushioned by the pad 70 and consequently will not cause injury to any of the parts.

While the invention is illustrated and described as embodied in a four-way valve adapted to connect a pair of control ports alternately to a source of pressure and exhaust, respectively, the principles of the invention are equally applicable to any form of valve incorporating two double-acting poppet three-way valve elements regardless of the manner in which the ports of the valve are connected to each other or to the pressure supply or exhaust port or ports. Moreover, the main valves may be utilized to control the flow of liquids rather than gases while the pilot valve mechanism remains pneumatic without departing from the broad principles of the invention.

While only one embodiment of the invention is illustrated and described herein, it will be apparent that variations in the details of construction and arrangement of the parts may be indulged in without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A four-way pneumatic valve assembly comprising a base, said base having four passageways each of which extends through the base and is connected to one of a plurality of ports, all of which ports are located in one surface of the base, the opposite ends of said passageways terminating in openings located in substantially parallel side surfaces of said base, a substantially sealed valve housing having a ported surface secured in sealing relation to the said surface of the base and coacting with the aforementioned ports in the base, a pair of axially shiftable double poppet valves in said housing with their axes extending parallel to each other and in a common plane parallel to said surface of the base, means including a pilot valve within said housing for simultaneously shifting said valves in the same direction, means also within said housing for returning said valves, said housing having ports controlled by said valves and communicating with the passages through said base.

2. A pilot-controlled, fluid-operated four-way valve and motor unit comprising a housing having a pressure supply chamber and an exhaust chamber, a pair of substantially parallel rec-

tilinearly slidable three-way valves therein arranged side by side and relatively close to one another, each of said valves having an independent outlet chamber, a pair of pistons, one such piston being operatively connected to each of said valves, each piston forming in effect a substantially coaxial continuation of its valve, and said pistons also being arranged side by side and relatively close to one another, said pressure supply chamber being located near the ends of said valves opposite to the ends to which the pistons are connected, outlet chamber of said valves being located closer to said pistons, intercommunicating cylinder head chamber portions in pressure-conductive communication with the ends of the said pistons remote from their respective valves, and a pilot valve for controlling communication between said pressure supply chamber and said cylinder head chamber portions, said pilot valve comprising a two position valve element movable to interrupt or permit communication between said pressure supply chamber portions and said cylinder head chamber portions, a stem for actuating said valve element including a portion having limited independent movement with respect to said element and an exhaust port portion connectable to and disconnectable from said cylinder head chamber portions in response to such independent movement of the stem with respect to the valve element.

3. A valve and motor unit as defined in claim 2 wherein each piston is coaxial with its valve and the axes of the two three-way valves and of the two pistons being parallel to one another, said pilot valve being movable in a path perpendicular to the plane which contains the axes of said three-way valves and pistons.

4. A four-way fluid valve including a housing having four ports located in one surface thereof, one of said ports being a pressure supply port, another being an exhaust port and the remaining ports being controlled ports, means including four axially movable poppet valves whose axes are parallel to said surface for connecting one of said controlled ports to the pressure supply port while the other controlled port is connected to the exhaust port and vice versa, said poppet valves being arranged in pairs of axially aligned valves and the axes of said pairs being parallel, means for shifting all of said poppet valves simultaneously in the one direction, means for returning said valves, a base on which said valve housing is mounted and in which are formed four passageways leading respectively from ports in a single surface which are aligned and communicate with said ports in the valve housing to two pairs of ports opening on opposite sides of the base in external base side surfaces which extend substantially parallel to the axes of said poppet valves, the ports on one side of said base being connected to the passageways which lead to the pressure and exhaust ports of the valve housing and the ports on the opposite side of said base being connected to the passageways which lead to the controlled ports of the valve housing.

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