United States Patent [19]

Davis et al.

[11] **3,753,447**

[45] **Aug. 21, 1973**

[54] **PNEUMATIC VALVES**

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[22] Filed: **Nov. 29, 1971**

[21] Appl. No.: **202,813**

[30] **Foreign Application Priority Data**

Nov. 27, 1970 Great Britain 56,607/70

[52] **U.S. Cl.** **137/596,** 91/433, 91/448

[51] **Int. Cl.** **F16k 11/10,** F16k 11/14

[58] **Field of Search** 137/596, 596.1, 636.1; 9/356, 445, 448, 433, 434

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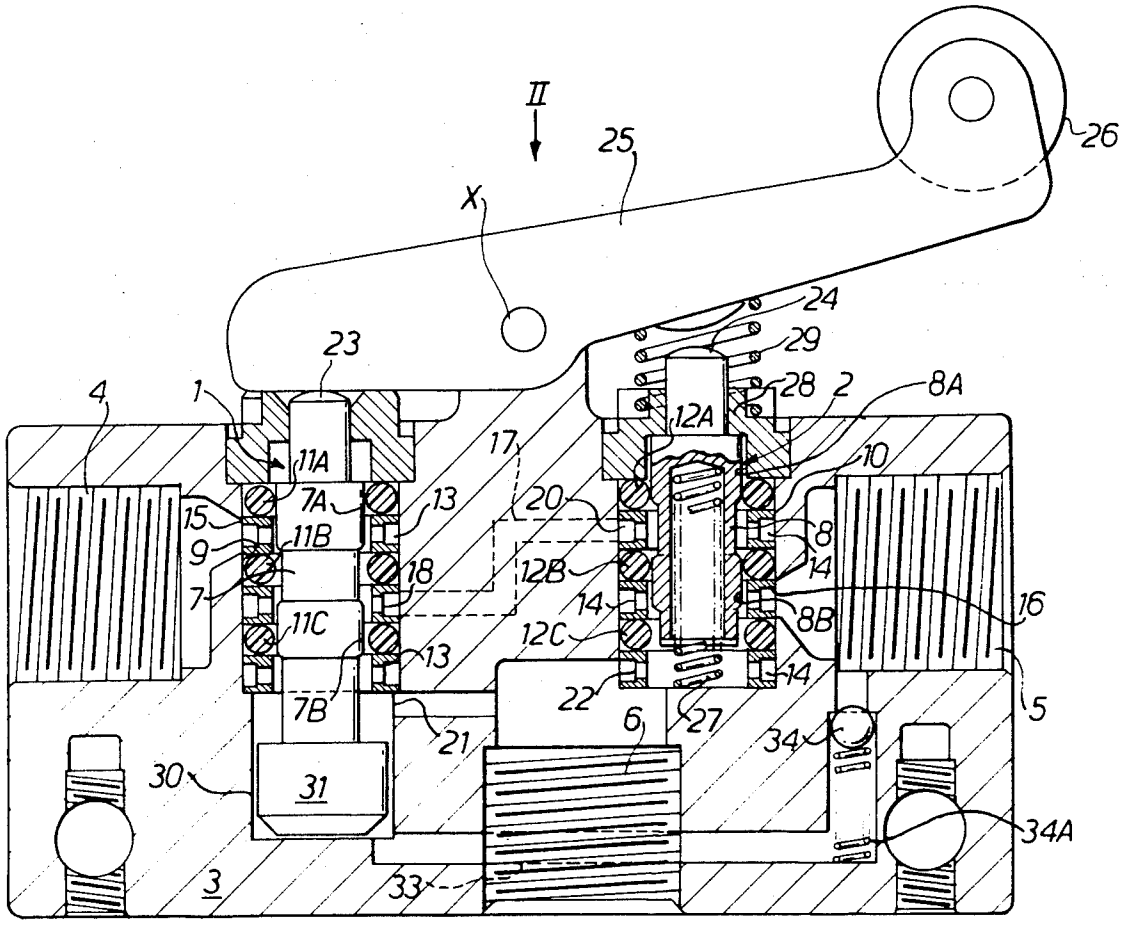
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[57] **ABSTRACT**

A pneumatic control valve assembly has two valves in a common housing interconnected by a transfer duct. A first valve controls communication between an inlet and the transfer duct while the second valve controls communication between the transfer duct and an outlet. Operation of the second valve, for example by a lever, causes input pressure to be delivered to a point of use — e.g. an actuator. Back pressure is tapped from the outlet and operates an actuator in the housing which closes the first valve, so that a pressure pulse is delivered. The closure of the first valve ensures that subsequent interruption or failure of the supply pressure has no effect on the state of the valves.

13 Claims, 6 Drawing Figures



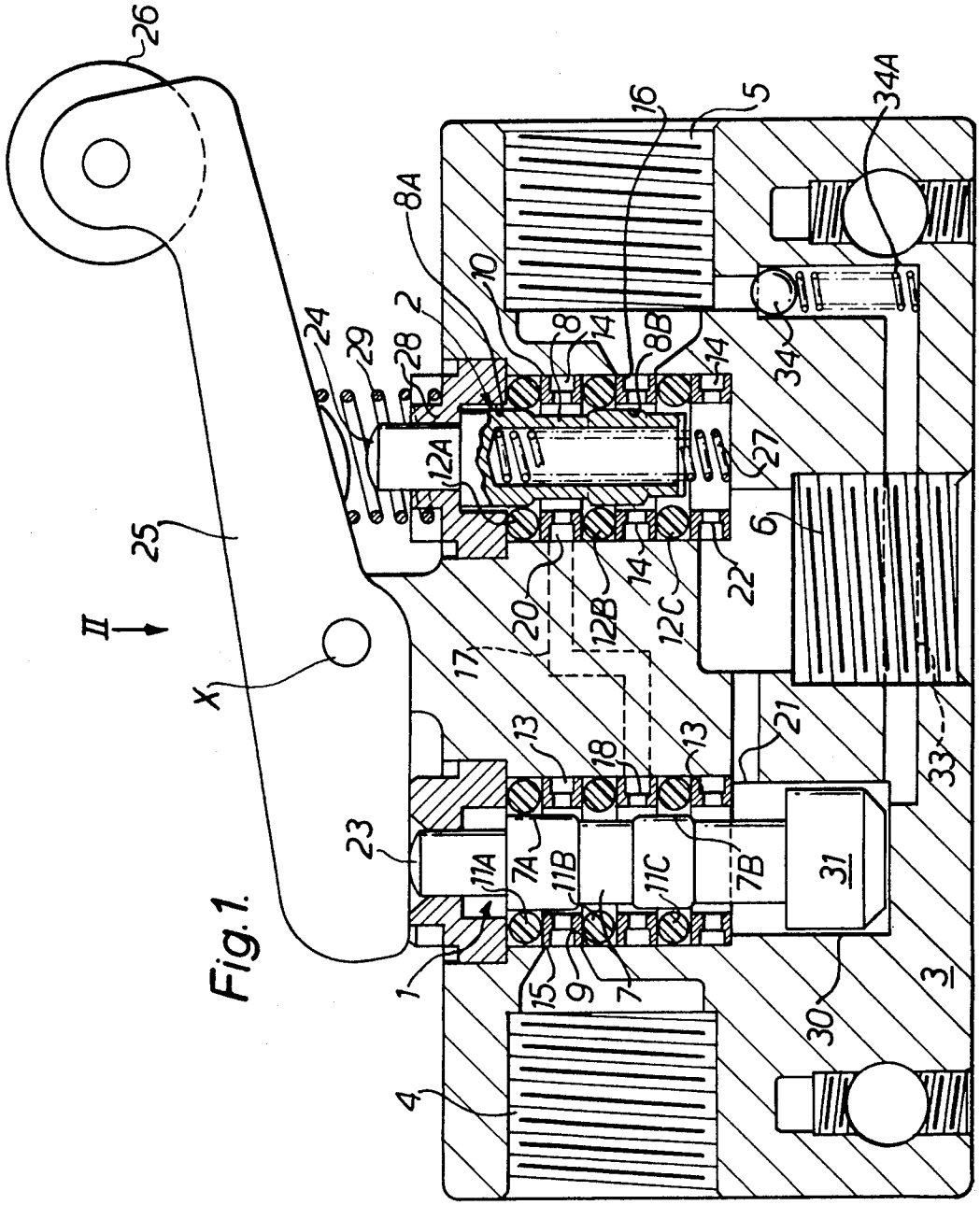

26
25
II
X
24
29
28
2
10
8A
8
14
8B
16
5
34A
34
12A
27
6
22
20
12B
12C
17
13
18
21
33
23
11A
7A
11B
11C
7B
31
1
15
9
7
4
30
3

Fig. 1.

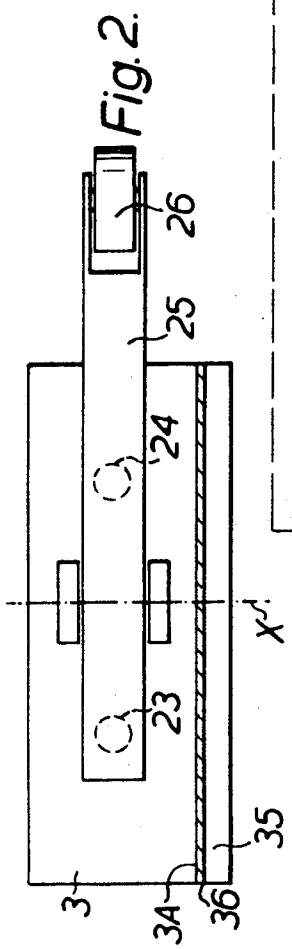


Fig. 2.

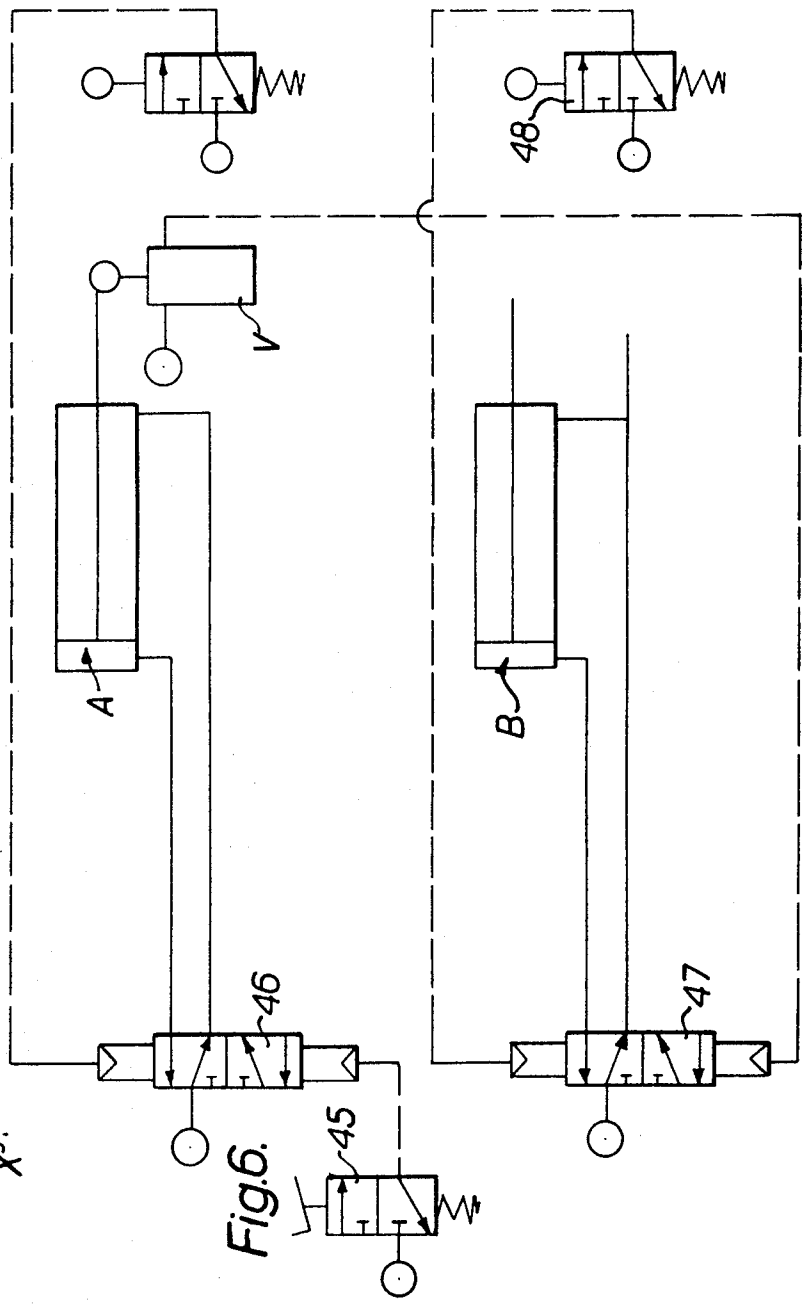
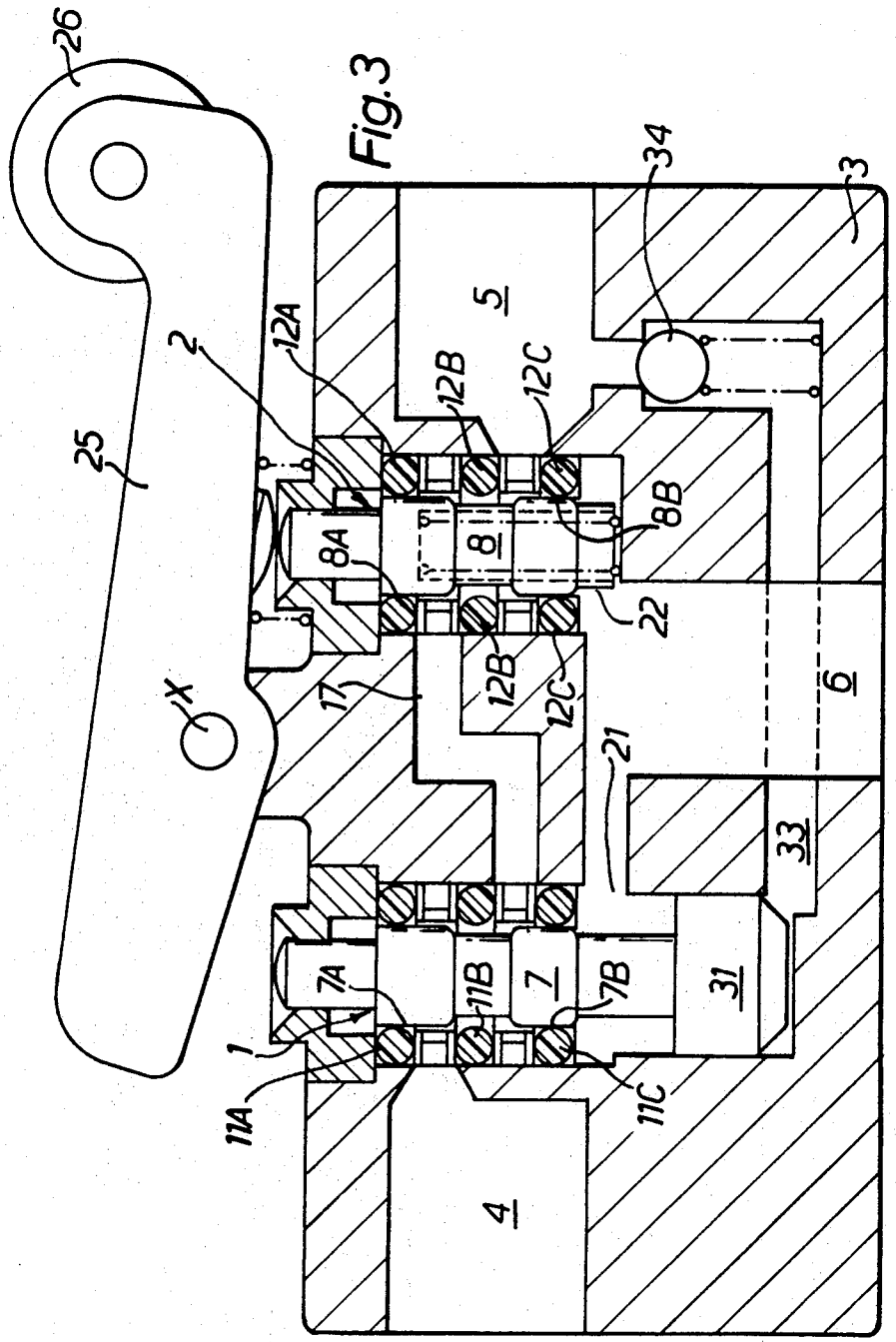


Fig. 6.

Fig. 3


26
25
2
12A
12B
12C
5
34
3
8A
8
8B
22
6
17
X
21
33
7A
11B
7
7B
31
1
11A
11C
4

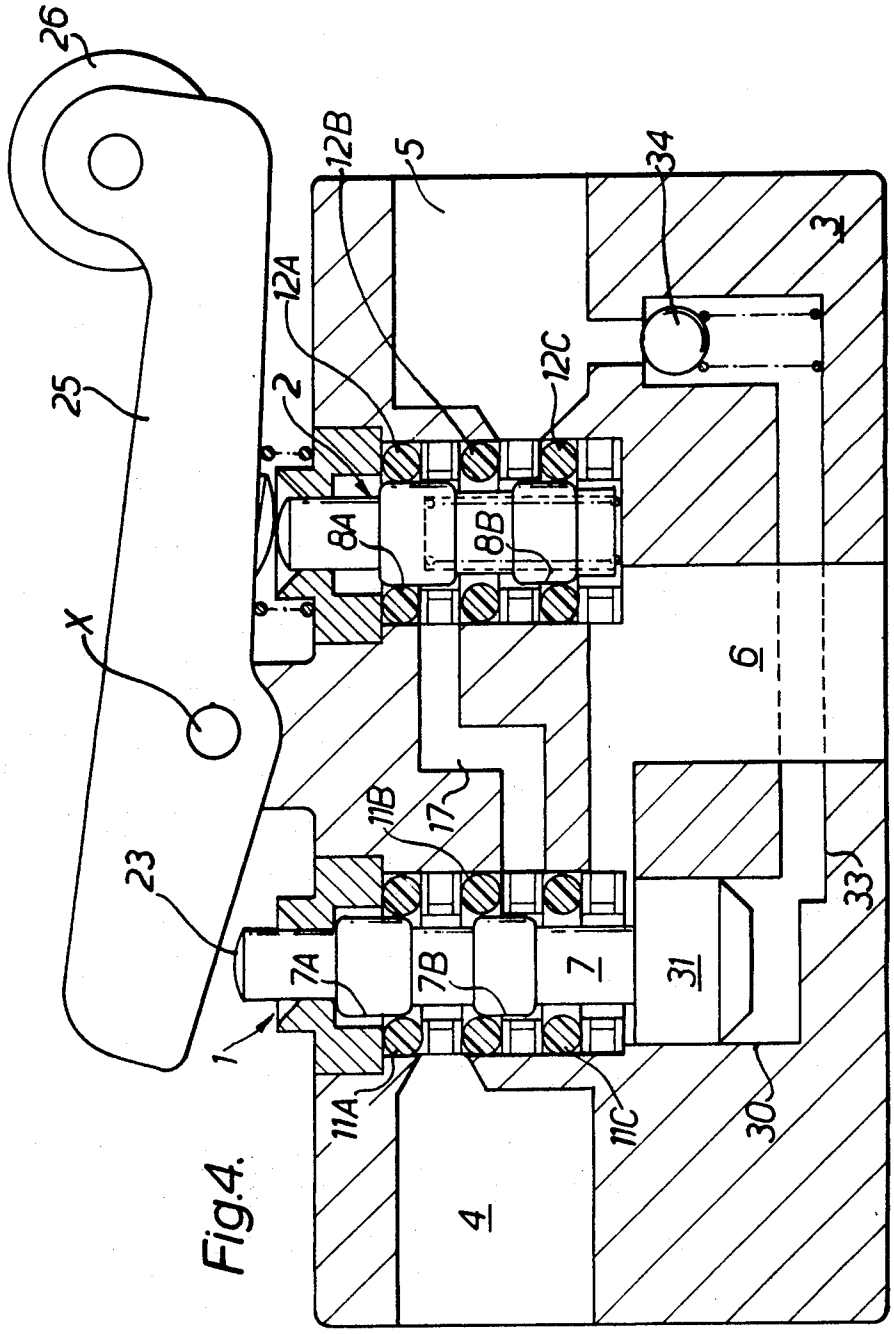

26
25
X
23
1
12B
5
34
3
12A
2
12C
8A
8B
6
11B
17
33
7A
7B
7
31
11A
11C
30
4

Fig.4.

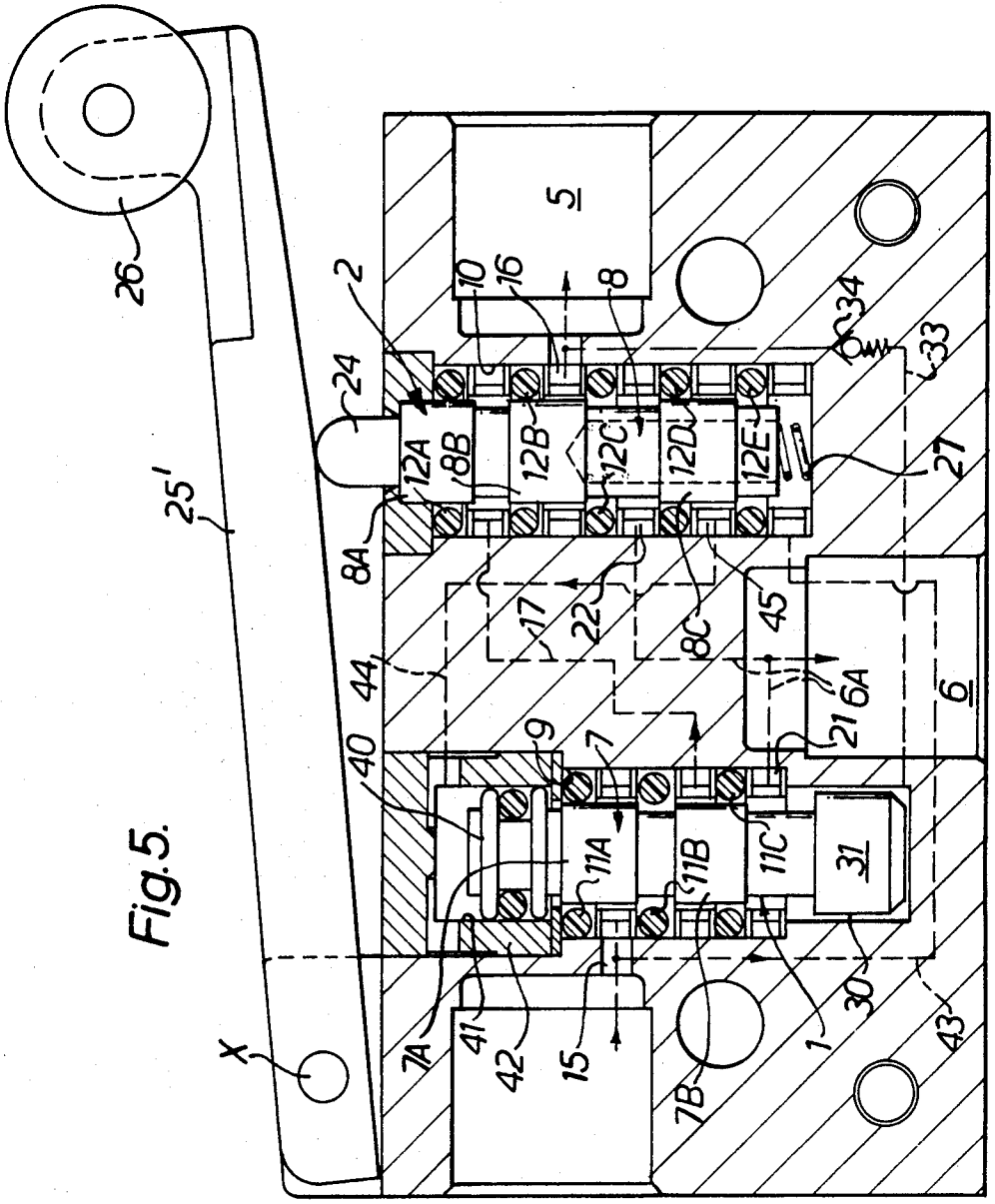

26
25'
X
2
24
5
10
16
8
34
33
27
12A
8B
12B
12C
12D
12E
8A
17
22
8C
45
44
6
16A
21
40
9
7
11A
11B
11C
31
30
43
1
7A
41
42
15
7B

Fig.5.

PNEUMATIC VALVES

BACKGROUND OF THE INVENTION

This invention relates to pneumatic valves.

A common type of pneumatic valve is a so-called trip valve having a valve housing with inlet and outlet ports and a movable valve element controllable, for example, by means of a displaceable operating lever, between closed and open positions in which the outlet port is respectively cut off from and in communication with the inlet port. Additionally, an exhaust port is commonly provided in the housing for communication via the valve with the outlet port when the valve element is in its closed position.

In a typical mode of use of such a known pneumatic trip valve the outlet port is connected to an actuator, referred to herein as the controlled actuator, for example a pilot port of a pneumatic control valve, to pilot the latter into a given position, the inlet port being connected to a source of fluid pressure, for example a compressed air supply line. When the valve is operated, or tripped, to bring the inlet port into communication with the outlet port, a constant pneumatic pressure is applied to the controlled actuator so long as the valve element is maintained in its open position. Consequently the actuator cannot revert to its original state so long as the pneumatic valve is tripped. In pneumatic systems employing such control valves it is often necessary to connect the valve to a further control valve, usually arranged in a "cascade" with other control valves, which has the function of removing the pressure signal applied to the controlled actuator when it is desired to return the actuator to its original state. This, particularly in a complex pneumatic system, can considerably complicate the pneumatic circuit of the system.

To avoid such complexity it has been proposed to employ impulse generating valves in pneumatic control circuits. An impulse generating valve is responsive to an applied pneumatic pressure to produce a pressure signal. The back pressure which results when this pressure signal is applied to a controlled actuator, for example, a pilot operating piston, is utilised to terminate the pressure signal, so that the impulse-generating valve produces a pressure signal of a specific duration, which is then exhausted. Since the signal is subsequently exhausted it is not necessary to complicate the pneumatic circuit with further valves for removing the pressure signal.

The term "pressure signal" as used herein is understood to mean a flow of air from a high pressure source to a low pressure region.

The known impulse generating valve of the above-described type suffers from a drawback which can manifest itself when the pneumatic pressure supply to the valve is removed, for example in an emergency or upon shutting down the pneumatic supply overnight, in that the valve generates a spurious pressure signal when the pressure supply is subsequently reconnected to the valve. This in turn may change the setting of the controlled actuator, with possibly undesirable consequences.

The present invention provides a pneumatic valve assembly of particularly simple construction which is capable of operating as a pressure impulse generator.

SUMMARY OF THE INVENTION

According to the invention there is provided a pneumatic valve assembly comprising first and second valves arranged in a common housing and interconnected by way of a transfer duct, the first valve controlling communication between the transfer duct and an inlet and the second valve controlling communication between the transfer duct and an outlet, means responsive to closure of the second valve to open the first valve, and pneumatic actuator means responsive to pneumatic back pressure at the said outlet when the second valve is open to close the first valve.

It will be appreciated that back pressure appears at the outlet only when a component, for example a controlled actuator, is connected thereto, the back pressure resulting when the pressure in the component rises to substantially that at the said outlet.

Upon opening the second valve a pressure signal is supplied through the outlet, and in response to the back pressure generated by this pressure signal, the first valve is automatically operated to cut off the inlet from the transfer duct and, therefore, from the second valve. Consequently, any reduction in the pneumatic pressure applied to the inlet, for example upon shutting down of the pressure supply, has no effect whatsoever upon the controlled actuator connected to the valve outlet.

In one embodiment of the invention the means responsive to closure of the second valve comprise a further pneumatic actuator acting on the first valve and operative to open the first valve in response to pressure tapped from the inlet and applied to said further actuator through the second valve when the latter is closed.

In an alternative embodiment of the invention the means responsive to closure of the second valve comprise a mechanical interconnection between the two valves, preferably in the form of a lever pivotally mounted on the housing and engageable with respective movable elements of the respective valves. Preferably the respective valve elements engage the lever on opposite sides of the pivot axis of the latter.

The movable elements of the two valves preferably comprise respective spools arranged for axial displacement in respective bores in the housing. Thus in a preferred embodiment of the invention a first port in the bore containing the first valve spool communicates via the transfer duct with a second port in the bore containing the second valve spool, the said first and second ports being in open communication with the inlet and outlet respectively when the respective valves are open, and being cut off by the respective valve spools from the inlet and outlet respectively when the respective valves are closed.

The housing of the valve assembly may comprise a single body, for example a machined metal block, or two or more bodies interconnected by bolts or by other means.

The transfer duct may be formed, at least in part, by a channel provided by a gasket or sealed plate secured to one face of the valve housing.

The housing is preferably further provided with an exhaust port which communicates via the second valve with the outlet when the second valve is closed and which, when the first valve is closed and the second valve is open, communicates with the said outlet via the said transfer duct.

Preferably the pneumatic actuator means comprises a piston which is formed with or bears against the movable element of the first valve and which is supplied with pneumatic pressure by way of a bleed duct

adapted to communicate with said outlet. The bleed duct may also be formed, at least in part, by a channel in said gasket or sealed plate secured to one face of the housing. A pressure relief valve is preferably provided in said bleed duct, said relief valve being normally closed and being adapted to open, to connect the bleed duct to said outlet, when the pneumatic pressure at said outlet exceeds a predetermined value.

If the valve assembly is so connected that the back pressure at the outlet does not rise to the predetermined value the valve assembly acts as a simple trip valve delivering a steady pressure signal upon operation.

Preferably the second valve is spring-biased into its closed position.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic sectional view of a valve assembly according to one embodiment of the invention;

FIG. 2 is a diagrammatic plan view of the valve assembly shown in FIG. 1, viewed in the direction of arrow II of FIG. 1;

FIGS. 3 and 4 are diagrammatic sectional views corresponding to FIG. 1 and showing the valve assembly in two successive stages of operation;

FIG. 5 is a diagrammatic sectional view, corresponding to that of FIG. 1, of a valve assembly according to an alternative embodiment of the invention, and

FIG. 6 is a diagrammatic illustration of a simple pneumatic circuit incorporating a valve assembly in accordance with the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The pneumatic valve assembly according to the invention as illustrated in FIGS. 1 to 4 comprises first and second valves 1, 2 arranged in a common housing and operatively interconnected as hereinafter described. The valve housing consists of a body 3 having an inlet port 4, an outlet port 5, and an exhaust port 6, each of these ports comprising internally screw threaded bores, as known per se.

The first and second valves 1, 2 comprise respective valve spools 7, 8 movable axially in respective parallel cylindrical bores 9, 10 formed in the body 3 between the inlet port 4 and outlet port 5, the exhaust port 6 being located between the bores 9, 10. Each of the valves 1, 2 in the embodiment of FIG. 1 is a three port valve, and is provided, in a known manner, with three resilient captive O-rings 11, 12, spaced apart at substantially equal intervals along the respective bores 9, 10 and positioned therein at fixed axial positions by respective spacers 13, 14. The three O-rings 11, 12 in the respective bores 9, 10 are designated 11A, 11B, 11C and 12A, 12B, 12C respectively, starting in each case from the upper (open) ends of the respective bores 9, 10, as illustrated in FIG. 1.

The respective first and second valve spools 7, 8 are formed with two axially spaced apart cylindrical lands 7A, 7B and 8A, 8B respectively, the diameter of each said land being slightly greater than the internal diameters of the O-rings 11, 12, so that the respective lands can form effective seals when engaged in the respective O-rings.

As an alternative to providing the respective valve bores 9, 10 with captive O-rings each valve spool 7, 8 may be provided with captive O-rings cooperating with respective internal shoulders in the respective bores.

Inlet port 4 communicates with a port 15 in the bore 9 of the first valve 1, the port 15 being located between the O-rings 11A and 11B. The outlet port 5 communicates with a port 16 in the bore 10 of the second valve 2, the port 16 being located between the O-rings 12B and 12C.

A transfer duct 17 interconnects the two valves 1, 2. The transfer duct 17, which is indicated diagrammatically by a broken line in FIG. 1, may be formed in the body 3 itself, but is in practice conveniently formed at least in part by a channel in a gasket or plate secured to one face of the body 3, as hereinafter described.

The transfer duct 17 interconnects a first port 18 in the first valve bore 9, between the O-rings 11B and 11C, and a second port 20 in the second valve bore 10, between the O-rings 12A and 12B.

The exhaust port 6 communicates with respective ports 21, 22 in the respective valve bores 9, 10 at the lower (blind) ends of the respective bores 9, 10 as illustrated by broken lines.

The valve spools 7, 8 have respective rounded ends 23, 24 which project axially beyond the open upper ends of the respective bores 9, 10 from one face of the body 3. An actuating lever 25 is pivotally mounted on this face of the body 3 for rocking movement about an axis X which is located between and substantially equidistant from the axes of the two valve spools 7, 8, and is perpendicular to the said valve spool axes. The operating lever 25 carries at its free end a roller 26 which is adapted to cooperate with a valve operating member (not shown). The actuating lever 25 bears against the rounded projecting ends 23, 24 of the two valve spools 7, 8 on either side of the pivot axis X, and substantially equidistantly therefrom.

A biasing spring 27 is located in a central bore in the second valve spool 8 and urges the latter upwardly so that the annular shoulder at the upper end of the land 8A is normally maintained in contact with a stop ring 28 at the upper end of the bore 10. In this position of the valve spool 8 the rounded upper end 24 of the spool 8 is spaced from the lever 25. The lever 25 itself is biased by a spring 29 coaxially surrounding the upper end of the spool 8 externally of the body 3 into engagement with the first valve spool 7 to urge the latter into its lowermost position (FIG. 1).

A counter-bore 30 is formed as a coaxial extension of the lower end of the first valve bore 9, the counter-bore 30 having a smaller diameter than the valve bore 9. The counter-bore 30 houses a pneumatic actuator comprising a piston 31 formed of nylon which slides with radial clearance within the counter-bore 30, permitting slight leakage of fluid between the piston 31 and the counter-bore 30. The piston 31 bears against the lower end of the first valve spool 7, as illustrated in FIG. 1. Alternatively the piston 31 may be formed as an integral extension of the first valve spool 7.

A bleed duct 33, shown in broken outline, communicates with the outlet port 5 of the second valve 2 via a pressure relief valve 34 which is biased by a spring 34a into a normally closed position. The spring 34a is such that the valve 34 opens when the pressure in the outlet port 5 is of the order of 48 p.s.i. The bleed duct 33

opens into the lower (blind) end of the counterbore **30**, as shown diagrammatically.

To facilitate manufacture of the valve assembly shown in FIG. **1**, and in particular the formation of the various internal ducts, including the transfer duct **17** and the bleed duct **33**, the body **3** is formed with a flat machined lateral face **3A** (FIG. **2**) to which a cover plate **35** of metal or plastics (e.g. nylon) is secured, by means of, for example, bolts or adhesive, with the interposition of a gasket **36**. The transfer duct **17** and the bleed duct **33** are formed in part as respective channels in the face of the plate **35** which is adjacent the gasket **36**, the gasket **36** and the body **3** being formed with respective apertures (not shown) by which these channels communicate with respective ports of the first and second valves **1**, **2** to effect the desired interconnections, as illustrated diagrammatically in FIG. **1**. A suitable sealing compound may be interposed between the gasket **36**, the body **3** and the plate **35**. For some materials of the body **3** and plate **35** satisfactorily sealing can be effected without the gasket **36**.

The operation of the valve assembly of FIGS. **1** and **2** will now be described with reference to FIGS. **1**, **3** and **4**.

Each valve **1**, **2** is movable between a closed position and an open position. The first valve spool **7** is biased into its lower position, illustrated in FIG. **1** by the action of the spring **29** on the lever **25**. In this position the first valve **1** is open and the lands **7A** and **7B** are in sealing contact with the O-rings **11A** and **11C**. This affords communication, through the O-ring **11B** and the first port **18**, between the inlet port **4** and the transfer duct **17**. When the first valve spool **7** is in its upper position the first valve **1** is closed and the land **7B** makes sealing contact with the O-ring **11B**, cutting off the inlet port **4** from the transfer duct **17**. At the same time, the land **7B** is removed from contact with the O-ring **11C** and communication is therefore established, through the O-ring **11C**, between the transfer duct **17** and the exhaust port **6**.

In the normal or inoperative state of the valve assembly the spool **8** of the second valve **2** is biased by the spring **27** into its uppermost position, shown in FIG. **1** in which the second valve **2** is closed. In this position the lands **8A** and **8B** are in sealing engagement with the O-rings **12A** and **12B**, and the transfer duct **17** is cut off from the outlet port **5**, the latter being in open communication, through the port **16** and the O-ring **12C**, with the exhaust port **6**. When the second valve spool **8** is in its lower position the second valve **2** is open and the transfer duct **17** communicates with the outlet port **5** through the O-ring **12B**, and the land **8B** makes sealing contact with the O-ring **12C**, cutting off the exhaust port **6** from the outlet port **5**.

It will be appreciated that the effect of the lever **25** is to ensure that, when the second valve **2** is closed, with its spool **8** in its uppermost position (FIG. **1**) the action of the lever **25** on the first valve spool **7**, assisted by the spring **29**, is to depress the latter and ensure that the first valve **1** is opened.

Under normal operating conditions pneumatic pressure from a convenient source is applied to the inlet port **4**, and a controlled actuator (not shown), for example a pilot operating piston of a pneumatic control valve, is connected to the outlet port **5**. In the inoperative, normal, position of the valve assembly, illustrated in FIG. **1**, the first valve **1** is open and the second valve **2** is closed. Consequently the applied pneumatic pressure reaches the port **20** of the second valve **2**, but is prevented from reaching the outlet port **5** to operate the controlled actuator.

When a valve operating member (not shown) engages the roller **26** to cause rocking movement of the operating lever **25** in a clockwise direction, as viewed in FIG. **1**, the actuating lever **25** depresses the second valve spool **8** against the action of its biasing spring **27**, opening the second valve **2** (FIG. **3**). The transfer duct **17** is then placed in communication with the outlet port **5**, as a result of the land **8B** moving out of sealing engagement with the O-ring **12B**. The pneumatic pressure is therefore applied through the inlet port **4**, the open first valve **1**, the transfer duct **17**, the open second valve **2** and the outlet port **5** to the controlled actuator to operate the latter.

When the actuator, for example a pneumatic piston, has been operated, which usually takes place very quickly, the continued application of the pneumatic pressure will create a back pressure in the outlet port **5**. This back pressure rapidly builds up to a value, typically 48 p.s.i., sufficient to open the relief valve **34** and the back pressure is then transmitted through the bleed duct **33** to the counter-bore **30**. The actuator piston **31** is then displaced upwardly by the back pressure, displacing the first valve spool **7** upwardly into its closed position (FIG. **4**). The upward movement of the first valve spool **7** is permitted by the earlier clockwise rocking movement of the lever **25** out of engagement with the projecting end **23** of the first valve spool **7**. The upward movement of the first valve spool **7** brings the projecting end **23** back into engagement with the lever **25** and closes the first valve **1**, cutting off the inlet port **4** from the transfer duct **17**, while at the same time opening the transfer duct **17** to the exhaust port **6** through the O-ring **11C**.

It will be seen that in the position shown in FIG. **1**, with the valve **2** closed (in its uppermost position) the outlet port **5** communicates with the exhaust port **6** directly through the O-rings **12C** and in the position shown in FIG. **4**, with the valve **2** open (in its lowermost position) the exhaust port **6** communicates with the outlet port **5** through the O-ring **11C** of the first valve **1**, the transfer duct **17** and the O-ring **12B**. Thus the outlet port **5** is connected to the exhaust port **6** both before and after the pressure impulse has been delivered. Return of the controlled actuator to its original position is, therefore, permitted after the pressure impulse has been applied thereto, and no separate control valve is necessary for removing the pressure signal at the outlet port **5**.

Closure of the first valve **1** in response to back pressure developed after operation of the controlled actuator ensures that the valve assembly provides a pressure pulse for operating the controlled actuator, regardless of the length of time for which the operating lever **25** is depressed. In some cases the valve operating member which engages the roller **26** assumes a "rest on" position in which the lever **25** is held in a depressed state so that the valve **2** is maintained open: regardless of this, the output signal delivered through the outlet port **5** consists of a short pressure pulse sufficient to operate the actuator, and after the latter has been operated the outlet port **5** is vented to exhaust and the first valve **1** is closed, as described previously. This subsequent closure of the first valve ensures, that, if the supply of pres-

sure is cut off with the valve operating member "resting on," for example if the associated pneumatic circuit is shut down, or if the pressure supply is cut in an emergency, the state of the valve assembly and its controlled actuator is unchanged. No change in the setting of the associated controlled actuator therefor takes place upon subsequently reconnecting the supply of pressure.

FIG. 5 illustrates an alternative embodiment of the invention. Those parts corresponding directly to component parts of the embodiment of FIG. 1 have been designated by the same reference numerals: these parts, and their function, will not require further explanation.

In the embodiment of FIG. 5, the operating lever 25' is pivoted at one end of the body 3 and its function is solely to operate the second valve 2. The first valve 1 is enclosed completely within the body 3 and has no mechanical connection with the operating lever 25'. In order to open the first valve 1 in response to closing movement of the second valve 2, as described previously, the embodiment of FIG. 5 employs a further pneumatic actuator. This further pneumatic actuator comprises a piston 40 which slides in a cylinder 41 in a tubular insert 42 located in a counter-bore communicating with the upper end of the first valve bore 9. The piston 40 engages the upper end of the first valve spool 7, and may alternatively be formed integrally with the valve spool 7.

The piston 31 is a plain piston, typically of nylon as in the embodiment of FIG. 1, permitting slight leakage of fluid between itself and the wall of the counterbore 30.

The piston 40 is shown in FIG. 5 as having a sliding O-ring seal with the wall of the cylinder 41, but the piston 40 could alternatively be made of plastics material, without a sliding seal.

The second valve 2 in the embodiment of FIG. 5 is a five port valve, in contrast to the three port valve 2 employed in the embodiment of FIGS. 1 to 4. The two additional ports are defined between two further resilient O-rings 12D, 12E in a conventional manner, and the second valve spool 8 has a further land 8C which cooperates with the O-rings 12D and 12E. In addition to the bleed duct 33 there is provided a second internal bleed duct 43 (broken lines) providing communication between the port 15 of the first valve, that is, the inlet port, and the bottom (blind) end of the second valve bore 10. Moreover, in addition to the transfer duct 17 there is provided a second internal transfer duct 44 providing communication between a port 45 located in the second valve bore 10 between the O-rings 12D and 12E and the upper end of the cylinder 41 in which the actuator piston 40 slides. Both the ducts 43 and 44 are conveniently formed, at least in part, by channels in a plate or gasket (not shown) attached to a side face of the body 3, as previously described.

When the second valve 2 is closed, as shown in FIG. 5, cutting off the transfer duct 17 from the outlet port 5, the O-ring 12D is in sealing engagement with the land 8C, and communication is afforded through the O-ring 12E between the inlet port 4 and the cylinder 41 through the internal passages 43 and the second transfer passage 44. Accordingly, piston 40 is forced downwardly, urging the first valve spool 7 into its lower position, and opening the first valve 1, as shown in FIG. 4.

When the second valve 2 is opened, with its valve spool 8 in its lower position, by depression of the lever 25', the land 8C makes sealing contact with the O-ring 12E and cuts off the bleed duct 43 from the second transfer duct 44, at the same time opening communication between the latter and the exhaust port 6 through the O-ring 12D and the port 22, the connection to the exhaust port 6 being indicated by broken lines 6a. The first valve spool 7 is then movable upwardly by means of the actuator piston 31 under the influence of back pressure, as described previously. It will be seen, therefore, that the pneumatic actuator piston 40 serves the same purpose as the mechanical interconnection of the valve spools 7 and 8 by means of the lever 25' in the embodiment of FIG. 1.

FIG. 6 illustrates a typical simple pneumatic circuit, employing a valve assembly in accordance with the invention. The notation used in the circuit is the usual notation for pneumatic valves, and the operation of this circuit will be clear to those skilled in the art from the drawing. The circuit includes two double-acting pneumatic rams A, B which are to be operated in an automatic cycle which consists first of extension and retraction of A followed by extension and retraction of B. The cycle is commenced by operation of a manual valve, for example a pedal-operated pneumatic three port valve 45 which connects the compressed air supply indicated, conventionally, as a circle with a central dot, to pilot a double-acting three port control valve 46 into a position in which it supplied pressure to the ram A to cause extension of the latter. When the ram A has fully extended it engages a conventional trip valve which in turn causes piloting of the control valve 46 into its other position, so as to initiate retraction of the ram A if the valve 45 has been released. When the ram A has fully retracted a valve operating member carried thereby engages and 'rests on' the operating lever of a valve assembly V according to the invention. As a result of this the valve assembly V produces a pressure signal which is exhausted, after a specific time interval, by the operation of the valve assembly V in response to back pressure in the output line of the valve assembly V, leading to a pilot operating piston of a second control valve 47. This pressure signal is sufficient to pilot the valve 47 into a position in which it causes extension of the second ram B. Retraction of the second ram B is initiated by a second trip valve 48 which pilots the second control valve 47 to its opposite position, permitting retraction of the second ram B. This piloting of the second valve 47 into its opposite position is permitted by the fact that the pressure signal earlier applied to the valve 47 from the valve assembly V has been short-lived. Consequently, a cascade system of control valves for removing pressure signals applied to the various valve piloting actuators is not necessary when using the valve assembly according to the invention.

We claim:

1. Pneumatic valve assembly comprising:
a housing having an inlet and an outlet;
first and second valves arranged within the housing and having respective open and closed positions;
a transfer duct interconnecting said valves within said housing, said first valve controlling communication between the inlet and the transfer duct and said second valve controlling communication between the transfer duct and the outlet;
operating means for said second valve;
a bleed duct within said housing communicating with said outlet, and

pneumatic actuator means connected to said bleed duct and acting upon said first valve, said actuator means being responsive to back pressure at said outlet to close said first valve.

2. A valve assembly according to claim **1,** including means responsive to closure of the second valve to open the first valve.

3. A valve assembly according to claim **2,** wherein the means responsive to closure of the second valve comprise a further pneumatic actuator acting on the first valve, and further bleed duct means tapping pressure from the inlet, flow through said further bleed duct means being controlled by said second valve so that then the latter is closed pressure tapped from said inlet acts on said further actuator to open said first valve.

4. A valve assembly according to claim **2,** wherein the means responsive to closure of the second valve comprise a mechanical interconnection between the two valves.

5. A valve assembly according to claim **4,** wherein the valves have respective movable valve elements and wherein said mechanical interconnection between the two valves comprises a lever pivotally mounted on the housing and engageable with the movable elements of said valves.

6. A valve assembly according to claim **5,** wherein said lever constitutes the operating means for said second valve.

7. A valve assembly according to claim **1,** wherein said first and second valves comprise respective first and second bores in the housing and first and second spools arranged for axial displacement in said bores.

8. A valve assembly according to claim **1,** including a plate sealed to one face of the valve housing the transfer duct being formed, at least in part, in said plate.

9. A valve assembly according to claim **1,** wherein said housing is further provided with an exhaust port which communicates via the second valve with the outlet when the second valve is closed and which when the first valve is closed and the second valve is open communicates with the said outlet via the said transfer duct.

10. A valve assembly according to claim **1,** wherein said pneumatic actuator means comprise a piston which acts on the first valve and which is supplied with back pressure through said bleed duct.

11. A valve assembly according to claim **1,** including a plate sealed to one face of the housing, the bleed duct being formed, at least in part, by a channel in said plate.

12. A valve assembly according to claim **1,** including a pressure relief valve in said bleed duct, said relief valve being normally closed and being adapted to open, to connect the bleed duct to said outlet, when the pneumatic pressure at said outlet exceeds a predetermined value.

13. A pneumatic valve assembly according to claim **1,** wherein the second valve is spring-biased into its closed position.

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