United States Patent [19]

Nussbaumer

[11] **3,850,082**

[45] **Nov. 26, 1974**

[54] **FLUID FLOW CONTROL ELEMENTS**

[75] Inventor: **Thomas Nussbaumer,** Zug, Switzerland

[73] Assignee: **Adeola AG,** Zug, Switzerland

[22] Filed: **Nov. 28, 1972**

[21] Appl. No.: **310,008**

[30] **Foreign Application Priority Data**

Nov. 30, 1971 Switzerland 17398/71

[52] **U.S. Cl.** **91/461,** 137/102, 137/596.14

[51] **Int. Cl.** **F15b 11/08**

[58] **Field of Search** 91/461, 418; 137/596.1, 137/596.14, 102

[56] **References Cited**

UNITED STATES PATENTS

3,076,477 2/1963 Brandenberg 91/461

3,093,153 6/1963 Horowitz 137/102

Primary Examiner—Edgar W. Geoghegan

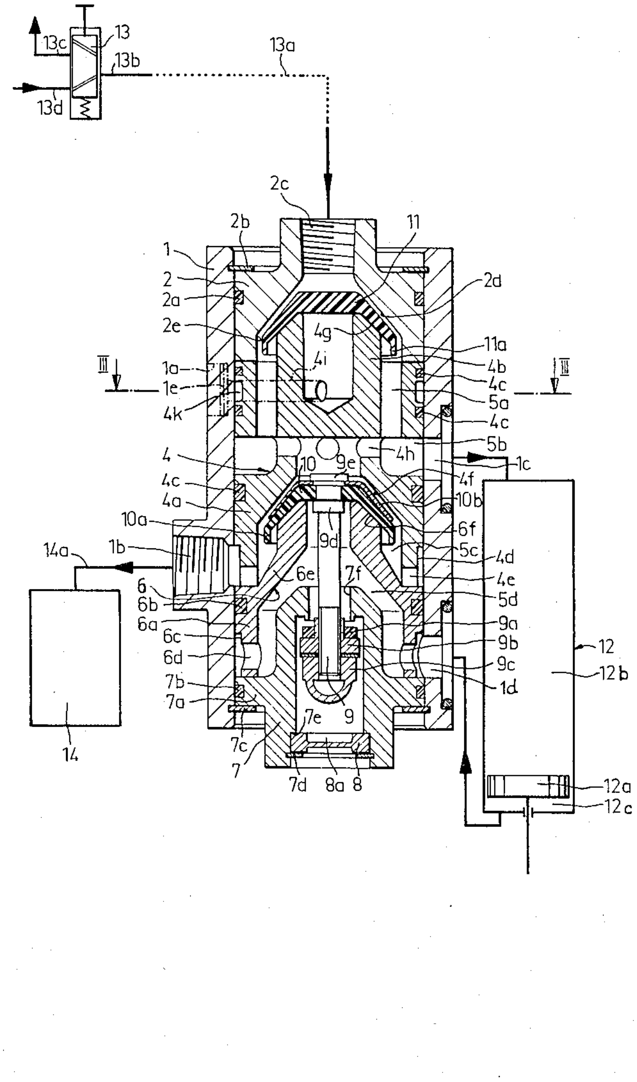
Assistant Examiner—William F. Woods

Attorney, Agent, or Firm—McGlew and Tuttle

[57] **ABSTRACT**

A fluid flow control element for use in apparatus for reciprocating a working piston in a pneumatic drive system includes a plurality of orifices interconnected within the element by passages through which flow is controlled by means of two cap-shaped seals. The seals are arranged in the spaces defined by two pairs of opposed generally conical surfaces. The apparatus includes a directional control valve 3/2 arranged to connect one of the orifices either to a source of pneumatic pressure or to atmosphere and a pressure reservoir connected to another orifice. Two further orifices are connected to opposite ends of a cylinder in which the working piston moves. The arrangement provides for control of the working piston by means of the directional control valve 3/2.

10 Claims, 3 Drawing Figures



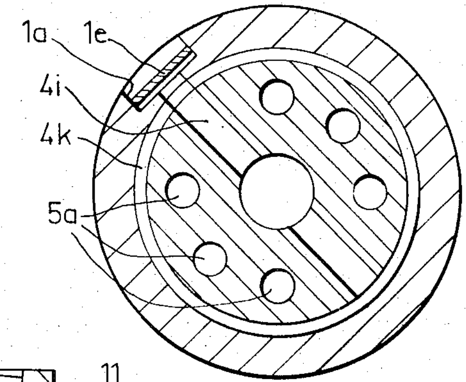
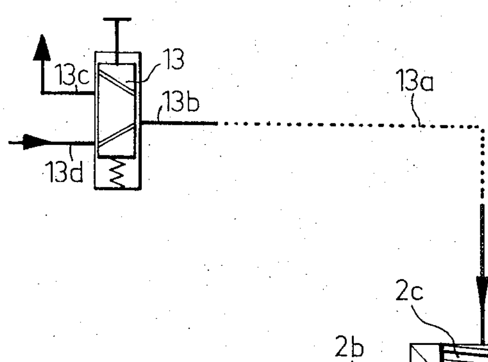

1a
1e
4i
4k
5a

Fig. 3


13
13a
13b
13c
13d

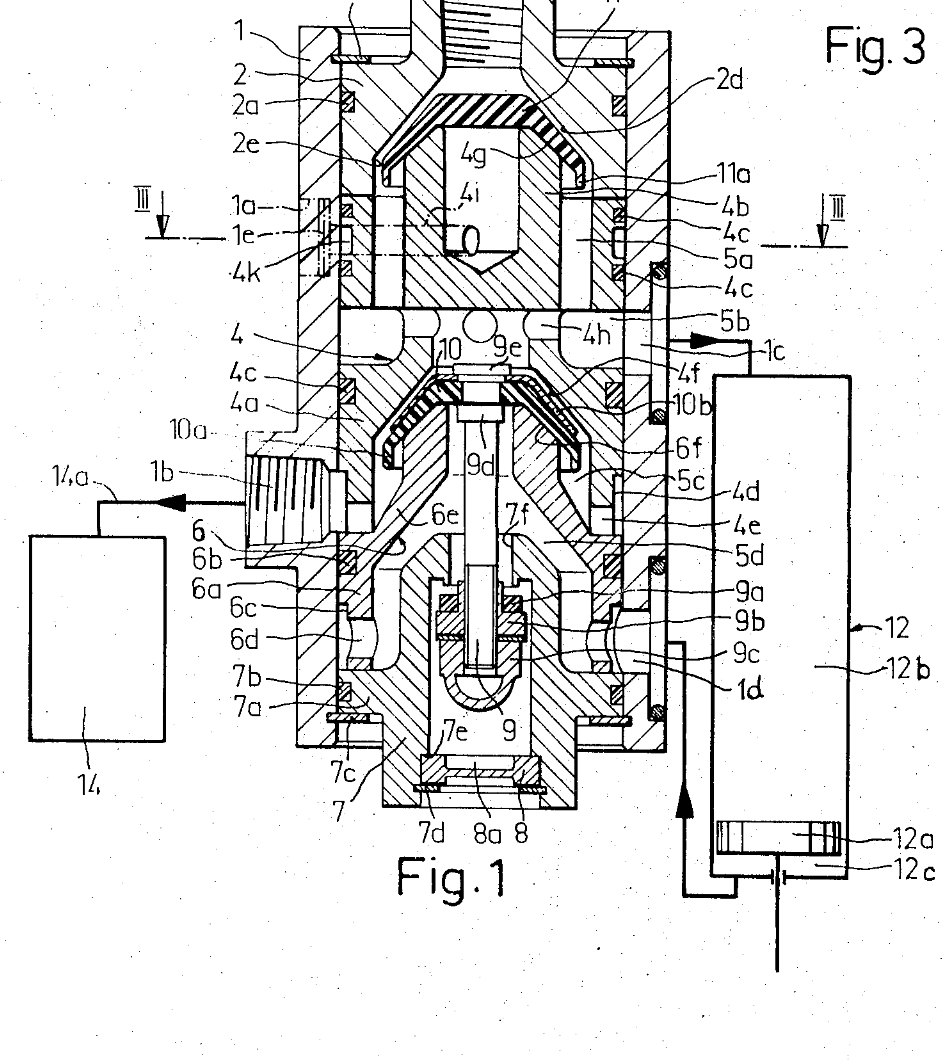

2c
2b
11
1
2
2a
2d
2e
4g
11a
4i
4b
1a
1e
4k
4c
5a
4c
5b
4
4h
1c
10
9e
4c
4f
4a
10b
10a
6f
9d
14a
1b
5c
4d
6e
7f
4e
6
6b
5d
6a
9a
6c
9b
12
6d
9c
7b
1d
12b
7a
9
7e
7c
7
7d
8a
8
12a
12c
14

Fig. 1

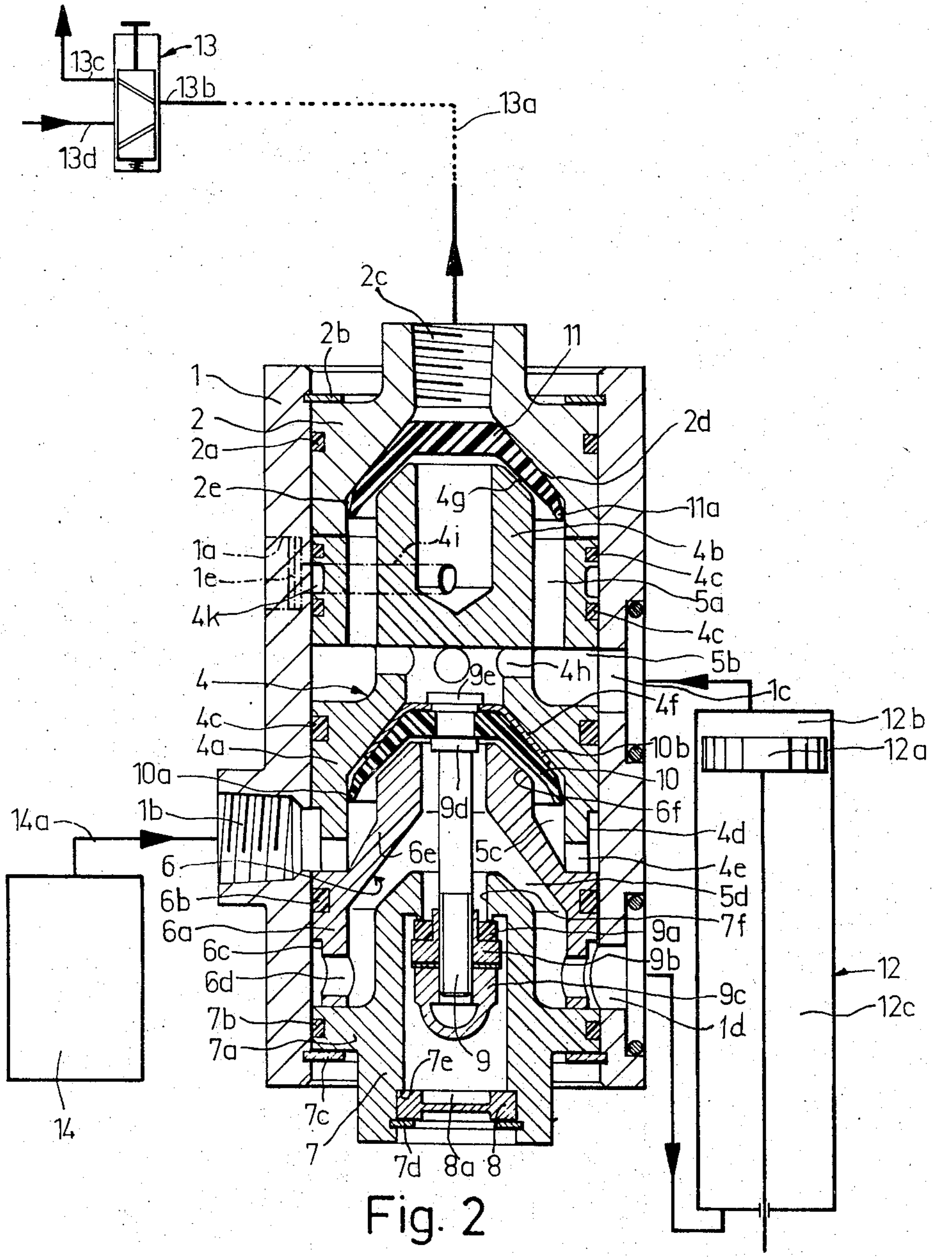

13
13c
13b
13d
13a
2c
2b
11
1
2
2a
2d
2e
4g
11a
4i
4b
1a
1e
4c
5a
4k
4c
5b
4
9e
4h
1c
4f
12b
4c
4a
10b
12a
10a
10
1b
9d
6f
14a
6e
5c
4d
6
4e
6b
5d
6a
7f
9a
6c
9b
12
6d
9c
12c
7b
1d
7a
7e
9
14
7c
7
7d
8a
8

Fig. 2

FLUID FLOW CONTROL ELEMENTS

This invention relates to a fluid flow control element and to apparatus for reciprocating a piston in a fluid drive system, the apparatus including a fluid flow control element.

BACKGROUND OF THE INVENTION

In order to reciprocate a piston in a pneumatic drive system, use is normally made of a mechanically actuated directional control valve 5/2, by means of which compressed air can be applied optionally to one of the two piston faces and at the same time the space on the other side of the piston can be connected to the atmosphere. Such arrangements are usually suitable when the distance from the directional control valve 5/2 valve to the drive system is short. However, if this distance is long the slow discharge of air into the atmosphere, resulting from the length of pipe necessary between the valve and the cylinder in which the piston acts, prevents rapid displacement of the piston under the action of the compressed air since the difference between the pressures at the two faces of the piston is too small. Where this particular problem exists, the disadvantage may be overcome by the use of solenoid valves arranged directly alongside the drive system. The electrical actuating member can then be placed at any convenient position. This arrangement suffers from the not inconsiderable disadvantage that electrical conductors are necessary in addition to the pneumatic pipes, so that the assistance of an electrician is necessary when carrying out installation, conversion and repair operations, and in many applications additional difficulties occur as a result of the safety measures that may be prescribed in premises that are damp or carry an explosion risk, for example. Electrical arrangements are therefore often not used and relatively slow operation of the pneumatic drive system is accepted.

In an unpublished proposal, apparatus for reciprocating a working piston avoids these disadvantages by utilizing a directional control valve 3/2 and a control element which element includes a differential piston having faces of different cross-sectional area and an intermediate reduced connecting part. The piston is displaceable in a bore comprising three stepped portions and each end of the bore is provided with a connecting orifice, the orifice at the narrower end being for direct connection to a compressed air source and that at the wider end being connected by way of a control pipe to the directional control valve 3/2. The valve itself is connected to a compressed-air source, the arrangement being such that the wider end of the bore is connected to the compressed-air source or to an air-discharge orifice depending upon the position of the directional control valve 3/2. That part of the stepped bore of largest diameter is provided with a bypass. An air-release opening communicates with that zone of the bore of medium diameter, and two orifices, each for connecting to the piston and cylinder device, are so arranged that, at each end position of the differential piston, one of the two connecting orifices communicates with the connecting orifice at the end of the bore adjacent to it, while the other communicates with the air-release opening. Although in this arrangement the control element can be fitted as close as possible alongside the drive system, the directional control valve 3/2 is connected to it by a single pipe which can be located at a relatively great distance without incurring the previous disadvantage since the air escapes directly from the control element. This unpublished apparatus, however, suffers from the disadvantage that its application is limited. This arises since a large number of O-rings are used for providing a seal between the differential piston and its guide, and this naturally causes large frictional resistance. Thus, to ensure reliable operation, a minimal difference between the working pressure and atmospheric pressure must be exceeded in order always to move the differential piston into its end positions without delay. Furthermore, two pressure leads running from the actuating valve to the control element are required for this equipment.

SUMMARY OF THE INVENTION

The present invention seeks to overcome all these disadvantages. Accordingly the invention provides a fluid flow control element including a body, first and second pairs of opposed generally conical surfaces formed within the body, a first space defined between the first pair of opposed surfaces and a second space defined between the second pair of opposed surfaces, and a passage formed in the body and terminating in the central region of each of the surfaces. A cap-shaped seal is received in the first space and a further cap-shaped is received in the second space, each of the seals being displaceable by fluid pressure and adapted to seal either of the passages terminating in the surfaces defining the respective space. The body includes a first outlet leading to the passage terminating in one surface of the first pair of opposed surfaces, a second outlet connected to the passage terminating in the other of the first pair of opposed surfaces, and a third outlet connected to the first space. The first space is also connected to the passage terminating in one surface of the second pair of opposed surfaces. The body has a fourth outlet connected to said second space, a fifth outlet connected to the passage terminating in the other surface of the second pair of opposed surfaces, a sixth outlet, and a further passage connected to the sixth outlet, this further passage being connected to the other passage connected to the fifth outlet. A valve seat is formed in the further passage and a valve element is adapted to seat on the valve seat and block the further passage. A rod connects the valve element to said cap-shaped seal in the second space, so that the position of the valve element in the further passage depends on the position of the cap-shaped seal in the second space.

The invention also provides apparatus for reciprocating a piston in a fluid drive system, including the fluid flow control element of the invention, a directional control valve 3/2 having an in-out orifice, the orifice being connected for fluid flow to or from the first outlet of the control element, a pressure reservoir, a fluid line connecting the pressure reservoir to the fourth outlet, and a piston-and-cylinder, said third and fifth outlets being connected to opposite ends of the cylinder.

It should be understood that use of the term "outlet" in relation to the present fluid flow control elements is not intended to necessarily imply the direction or intended direction of fluid flow.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 shows a longitudinal section through a fluid flow control element of the invention and illustrates diagrammatically apparatus comprising the element connected to a working cylinder, a compressed-air reservoir and a 3/2-way valve, the apparatus being in a first working position,

FIG. 2 shows a longitudinal section through the apparatus of FIG. 1 in a second working position, and

FIG. 3 shows a transverse section on the line III—III of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The control element illustrated in FIG. 1 is of substantially cylindrical form. It comprises an outer hollow cylindrical case **1** which has four openings **1***a*, **1***b*, **1***c*, **1***d*, extending through its periphery. Firmly fitted in one of its ends is a hollow member **2** of generally cylindrical form and having an outside diameter which corresponds to the inside diameter of the case **1**. This hollow member **2** has an O-ring **2***a* around its outer circumference for providing a seal between the member and the inner surface of the case. The member **2** is retained in the case **1** by a snap ring **2***b*. The outer end of the hollow member **2** is reduced to form an internally threaded pressured-pipe union **2***c*. Internally of the union **2***c* the inner surface of the member **2** widens at an included angle of about 90° to form a conical bearing face **2***d* leading into a cylindrical surface **2***e*. The member **2** occupies approximately one-fourth of the length of the case **1**.

Fitted adjacent the member **2** in the interior of the case **1** is another hollow member **4** consisting of two cylindrical portions **4***a*, **4***b* of different diameters, and a separating wall. The larger diameter cylindrical portion **4***a* fits in the case **1** and carries on its outer surface three sealing rings **4***c*. At that end of the portion **4***a* remote from the member **2** is an annular channel **4***d* which, with the inner wall of the case **1**, forms an annular passage. Terminating in this channel **4***d* and distributed around its periphery are bores **4***e* extending through the wall of the cylinder portion **4***a*. The channel **4***d* also connects with the bore of an internally threaded pressure-pipe union, constituting opening **1***b*, located in the wall of the case **1**. The inner wall of the portion **4***a* is cylindrical at its end remote from member **2** but then tapers inwardly at an included angle of approximately 90° to from a conical bearing face **4***f* leading into a further cylindrical bore of smaller diameter. The hollow cylinder portion **4***b* of smaller diameter is coaxially connected to the cylinder portion **4***a* by a separating wall. The cylinder **4***b* extends into the cylinder portion of member **2** defined by surface **2***e*. The end face of cylinder portion **4***b* is tapered parallel with the bearing face **2***d* and likewise takes the form of a conical bearing face **4***g*. The cylindrical portion **4***b* has a central bore extending from the face **4***g* as far as the level of the median O-ring **4***c*. In this way, this bore is separated from the interior of the cylinder portion **4***a* which extends about as far as the midway point along the hollow member **4**.

Provided in the outside periphery of the cylinder **4***a* is a channel which, together with the inner wall of the case **1**, forms an annular passage **5***b* into which run bores **4***h* extending through the wall of the cylinder **4***a*, for the purpose of communicating with the interior of the cylinder. Also communicating with the passage **5***b* is the opening **1***c* which is formed in the wall of the case **1**. This opening is connected to a chamber **12***b* on one side of a piston **12***a* working in a cylinder **12** of a pneumatic system. The smaller cylinder **4***b* contains two diametrically opposite bores **4***i* which are so arranged that they directly connect the interior of the cylinder **4***b* to an annular passage **4***k* formed between the member **2** and casing **1**. The outlet **1***a* fitted with a noise-reducing filter insert **1***e* is formed in the casing **1** in communication with the passage **4***k*. The cylindrical space enclosed by the inner surface **2***e* is connected to the annular passage **5***b* by six parallel connecting bores **5***a* which pass through the member **4**.

A further hollow member **6** is connected to the free edge of the larger cylinder **4***a* of member **4** and an O-ring **6***b* is fitted to provide a seal between a cylindrical outer wall of the lower part **6***a* of the member **6** and the inner wall of the case **1**. An annular passage **6***c* between the part **6***a* and the case **1** is arranged in communication with opening **1***d* in the case **1**. Peripherally distributed bores **6***d* extend through the wall of the part **6***a* to the passage **6***c*. The opening **1***d* is connected to the chamber **12***c* on the other side of the piston **12***a*. A portion **6***e* of the member **6** which extends into the interior of the cylinder portion **4***a* is tapered and terminates in a cylindrical tube, the end face of which is chamfered parallel with the bearing face **4***f* and is likewise formed as a conical bearing surface **6***f*. The outer wall of the tubular portion **6***e* is of such diameter that it forms, with the inner wall of the cylinder portion **4***a*, a passage **5***c* which communicates with the channel **4***d* by way of the bores **4***e*.

A hollow and substantially cylindrical valve carrier **7**, fitted in the bore of the case **1** by means of a flange **7***a* and sealed by means of an O-ring **7***b*, is located directly adjacent the hollow member **6**. The outer side of the flange **7***a* of the valve carrier is secured in the case **1** by means of a snap ring **7***c*. The outer end of the valve carrier **7** projects slightly beyond the end face of the case **1** and has a discharge orifice **8***a* fitted with a noise-reducing filter **8** which is retained in the orifice **8***a* by a snap ring **7***d* cooperating with a shoulder **7***e* formed in a central bore of the carrier **7**. On the side of the flange **7***a* facing the hollow member **6**, the valve carrier **7** forms the inner wall of the annular passage **5***d* leading into the bores **6***d*. The central bore of the valve carrier **7** has a cylindrical valve seat **7***f*. A corresponding valve member includes a cylindrical rod **9**, which extends axially through the valve seat **7***f* into the interior of the valve carrier and also through the hollow member **6** into the conical interior part of the larger cylinder portion **4***a*, and a sealing ring **9***a* which is bonded on to a carrier ring **9***b* screwed on to the rod **9** and held in position by means of the nut **9***c*. Both ends of rod **9** are screw-threaded. The region between the two bearing faces **4***f* and **6***f* contains a rubber or plastics cap-shaped seal **10**, having a lipped edge **10***a*, and a metal cap **10***b*. The rod **9** projects through the common central bore of the seal **10** and cap **10***b* and is secured thereto by means of two lock-nuts **9***d* and **9***e*. It should also be noted that a cap-shaped seal **11**, also having a lipped edge **11***a*, is located between the two bearing faces **2***d* and **4***g*.

In order to facilitate assembly of the control element, it is advantageous to manufacture the various hollow members 2, 4, 6 separately and then to insert them in the case **1**, but it is also possible for one or more of these inner members to be made integrally with the case.

In FIGS. **1** and **2**, the working cylinder **12** and its piston **12***a*, a directional control valve 3/2 **13** and a pressure reservior **14** are illustrated diagrammatically as connected to the control element. The directional control valve 3/2 **13** has three connections, of which a compressed-air supply line **13***d* and a pressure exhaust line **13***c* can be alternately connected to an in-out orifice **13***b* which is connected by way of a pipe **13***a* to the control element. To initiate the working stroke of the piston **12***a*, the directional control valve 3/2 **13** is so set that it connects the pressure union **2***c* to a compressed-air supply, not shown, by way of the pressure pipe **13***a*, orifice **13***b* and line **13***d*. The pipe **13***a* may be relatively long and does not need to be of particularly large cross-section. The compressed air then passes through the union **2***c* into the control element. The cap-shaped seal **11** between the faces **2***d* and **4***g* is pressed against the bearing face **4***g* so that a gap is created between the seal **11** and the bearing face **2***d*, through which gap the compressed air flows into the passages **5***a* and **5***b* and thence through the connecting orifice or opening **1***c* into the working chamber **12***b* of the cylinder **12**. The piston **12***a* is moved by the air into the position illustrated in FIG. **1**. Part of the compressed air does not flow into the working cylinder **12**, but passes from the passage **5***b* through the bores **4***h* and into the upper inner compartment of the larger cylinder portion **4***a*. There it strikes the seal **10** and presses this against its bearing face **6***f*. The rod **9** connected to the seal **10** is thus pushed downwards and the valve ring **9***a* is removed from its seat **7***f*. In this way the air flowing from the working chamber **12***c* of the cylinder **12** by virtue of the movement of piston **12***a* can escape extremely rapidly into the atmosphere through the connecting orifice **1***d*, the passage **6***c* and the bores **6***d* associated therewith, the passage **5***d*, the valve **7***f*, **9***a* and the interior of the valve carrier **7**, the air passing out of the element through the noise-reducing filter **8** in outlet **8***a*. Compressed air passing from the passage **5***b* flows through the cavity formed between the seal **10** and the bearing face **4***f* and into the chamber **5***c*. From here it passes through the bores **4***e* into passage **4***d*, and hence through the outlet in union **1***b* and the pressure pipe **14***a* into the compressed-air reservoir **14**. Flow into the reservoir **14** continues until a condition of balance has been reached.

For initiation of the idling stroke of the working piston **12***a*, the valve **13** is set so that it connects the pipe **13***a* directly to exhaust through line **13***c*. This situation is illustrated in FIG. **2**. The seal **11** is then pressed against its upper face **2***d* by the excess pressure obtaining in the control element, so that a cavity is now formed between the seal and its lower bearing face **4***g*. The air flowing from the working chamber **12***b* of the cylinder can therefore pass through the connecting orifice **1***c*, the passages **5***b* and **5***a* and the cavity between the seal **11** and its bearing face **4***g* and into the interior bore of the smaller cylinder part **4***b*. From there its path lies through the bores **4***i*, passage **4***k* and filter **1***e*, secured in the discharge outlet **1***a*, and into the atmosphere.

At the same time the compressed air in the interior of the cylinder **4***a* escapes through the bores **4***h*, so that the pressure from the air in the compressed-air reservoir **14** presses the seal **10** against its bearing face **4***f*, and the rod **9** connected to the seal **10** closes the valve **7***f*, **9***a*. The air in the compressed-air reservoir **14** now flows into the passage **5***d* by way of the union **1***b*, the passage **5***c* and the cavity now existing between the seal **10** and its lower bearing face **6***f*, and from the passage **5***d* the air passes through the bores **6***d* and the connecting opening **1***d* and into the chamber **12***c* of the working cylinder **12** so that it pushes the piston **12***a* back into the initial position, as shown in FIG. **2**.

It should be noted that, in the terms used herein to define the invention and with reference to the specific embodiment of fluid control element described herein by way of example, the first pair of opposed generally conical surfaces are faces **2***d*, **4***g* and the second pair of opposed generally conical surfaces are faces **4***f*, **6***f*. Similarly the first outlet is at **2***c*, the second outlet is at **1***a*, the third outlet is at **1***c*, the fourth outlet is at **1***b*, the fifth outlet is at **1***d*, and the sixth outlet is at **8***a*. It should also be noted that in the specific embodiment outlets **2***c* and **1***a* are equivalent.

I claim:

1. A fluid flow control element including a body, first and second pairs of opposed generally conical surfaces formed within said body, a first space defined between said first pair of opposed surfaces and a second space defined between said second pair of opposed surfaces, a passage terminating in the central region of each of said surfaces, a cap-shaped seal received in said first space and a further cap-shaped seal received in said second space, each of said seals being displaceable by fluid pressure and adapted to seal either of said passages terminating in the surfaces defining the respective space, said body including a first outlet leading to the passage terminating in one surface of said first pair of opposed surfaces, a second outlet connected to the passage terminating in the other of said first pair of opposed surfaces, a third outlet connected to said first space, said first space being also connected to the passage terminating in one surface of said second pair of opposed surfaces, a fourth outlet connected to said second space, a fifth outlet connected to the passage terminating in the other surface of said second pair of opposed surfaces, a sixth outlet, and a further passage connected to said sixth outlet, said further passage being connected to said other passage connected to the fifth outlet, and a valve seat in said further passage and a valve element adapted to seat on said valve seat and block said further passage, and a rod connecting said valve element to said cap-shaped seal in said second space, so that the position of said valve element in said further passage depends on the position of said cap-shaped seal in said second space.

2. A fluid flow control element according to claim **1** wherein said body is constituted by a hollow main body, and at least two hollow members tightly inserted in said main body, at least one pair of opposed surfaces being formed by one surface on one member and one surface on another member.

3. A fluid flow control element according to claim **1** wherein said body is constituted by a hollow main body, at least one of said generally conical surfaces being formed integrally as part of said main body.

4. A fluid flow control element according to claim **1**, wherein each of said cap-shaped seals extends beyond the periphery of the adjacent inner opposed conical surface, one seal being arranged to be moved by excess pressure applied to the first space through the third outlet and the other seal being arranged to be moved by excess pressure applied to the second space through the fourth outlet.

5. Apparatus for reciprocating a piston in a fluid drive system, including a fluid flow control element according to claim **1,** a control valve 3/2 having an in-out orifice, said orifice being connected for fluid flow to or from said first outlet of the control element, a pressure reservoir, a fluid line connecting said pressure reservoir to said fourth outlet, and a piston-and-cylinder, said third and fifth outlets being connected to opposite ends of said cylinder.

6. Apparatus according to claim **5** wherein said body of said fluid flow control element is constituted by a hollow main body, and at least two hollow members tightly inserted in said main body, at least one pair of opposed surfaces being formed by one surface on one member and one surface on another member.

7. Apparatus according to claim **5** wherein said body of said fluid flow control element is constituted by a hollow main body, at least one of said generally conical surfaces being formed integrally as part of said main body.

8. Apparatus according to claim **5,** wherein each of said cap-shaped seals of said fluid control element extends beyond the periphery of the adjacent inner opposed conical surface, one of said seals being arranged to be moved by excess pressure applied to the first space through the third outlet and the other of said seals being arranged to be moved by excess pressure applied to the second space through the fourt outlet.

9. Apparatus according to claim **5** wherein said second and sixth outlets of the fluid flow control element are fitted with noise reducing filters.

10. Apparatus according to claim **5** wherein said fluid is air.

* * * * *